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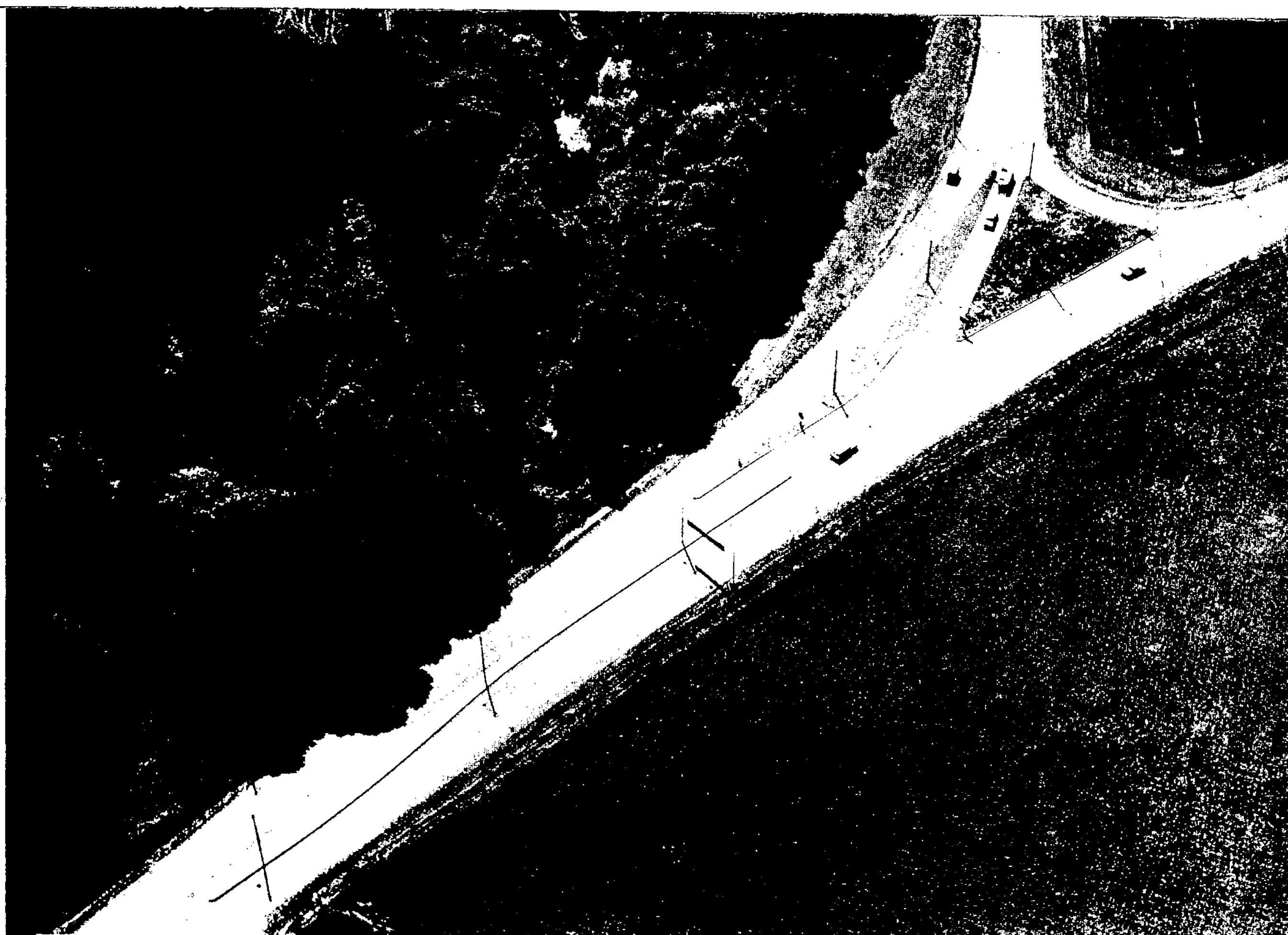

HIGHWAY RESEARCH BOARD

Special Report 74

CHANNELIZATION

The Design of Highway Intersections at Grade

National Academy of Sciences—
National Research Council
publication 1029

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HIGHWAY RESEARCH BOARD
Special Report 74

CHANNELIZATION

The Design of Highway Intersections at Grade

A Cooperative Project of

Committee on Channelization
Highway Research Board

Texas Transportation Institute
A. & M. College of Texas

Automotive Safety Foundation

National Academy of Sciences—
National Research Council
Washington, D.C.
1962

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Foreword

Highway Research Board Special Report 5 "CHANNELIZATION - The Design of Intersections at Grade" was published in 1952. It presented 59 examples of channelized intersections representing current design practices at that time. It was widely used and of benefit to highway and traffic engineers by providing an opportunity to review the works of others. Since channelization has become so much more widely used in recent years, the Committee has compiled this revision which includes more recent design examples of channelization to illustrate present design practice.

This new report represents the cooperative efforts of the Highway Research Board Committee on Channelization and many state and city engineers who furnished examples and supporting data. Much of the work of preparing the examples for publication and the coordination of the committee reviews, etc., have been handled by Prof. B.F.K. Mullins, Research Engineer, Texas Transportation Institute. One hundred and twenty examples were submitted for the Committee's consideration. Much of this material is included in the report in some form.

Progress is usually based on accumulated knowledge of principles and the known experience of their application. The publication of these examples of highway channelization, largely examples of good design, with critical analysis is presented in the hope that highway and traffic engineers may profit by a review of the work of others.

Acknowledgment is made most gratefully to the many individuals and organizations who contributed the basic data which have been used as the basis for this publication. The name of the person submitting the material is shown with each example, and special appreciation is expressed for the splendid cooperation in furnishing the information requested by the Committee.

Appreciation is expressed to the Automotive Safety Foundation for substantial financial support in assembling and organizing the basic material in preparation for its publication by the Highway Research Board.

Contents

CHANNELIZATION

The Design of Highway Intersections at Grade

Introduction

The rapid and continued postwar increase in motor vehicle production and use, the attendant record of traffic accidents and congestion, and public clamor for some relief are forcing highway and traffic engineers to consider every possible means of attacking the mounting highway transport problem.

Freeways and expressways are providing essential relief on an increasing mileage of important arteries. However, recognition must be given to the important fact that the major portion of motor vehicle traffic for years to come will move on existing streets and highways. These facilities, many of which are obsolescent, must be used to their maximum efficiency and capacity.

Important and satisfying progress is being made in many localities through the employment of restrictive traffic controls. These include one-way streets, parking prohibition and regulation traffic signal control, pavement marking, through streets, turn prohibition, regulation of transit operation, pedestrian control, truck routing and control of loading and unloading operations, and the use of traffic islands.

Recognizing the intersection as the area of major conflict and congestion, traffic and highway engineers are focusing particular attention upon these critical areas. Channelization has been employed with success at many locations, but it has also failed at other locations where the design has been inadequate or where the basic principles of channelization have been violated.

BASIS OF REPORT

This report is not intended to establish principles of channelization design, but rather to present current design practice in the form of examples which have received the test of performance under varying conditions of traffic in the hope that highway and traffic engineers may profit by a review of the work of others.

Cities and states were requested to furnish examples of channelized intersections for inclusion in the report. Detailed specifications were provided to indicate the data desired. The requested data included:

Location

Type of Intersection

Physical Data

1. Geometric Design
   a. Plan of conditions after design or redesign, showing graphic scale.
   b. Negatives and/or glossy prints of the following:
      1. Aerial photographs of "after" conditions or photographs taken from an elevated position.
      2. Aerial photographs of "before" conditions.
      3. Several photographs of important design features such as curbs, islands, approach-end treatment, etc.
2. Grades: Grades over 3% on plan sheet; also vertical curve data if critical to channelization design.
3. Surface Type: Roadways, islands, shoulders; also type and height of curbs and islands, and detail if unusual.
4. Cross Section: Typical cross section if of unusual design.
5. Traffic Control Devices
   a. Signs: Type, size, location of warning and regulatory signs.
   b. Signals: Type, location, timing - including a phasing diagram.
   c. Markings: Type, location, color.
   d. Lighting: Location of poles and luminaires, type and size of luminaires.
   e. Other control devices: Guide posts, reflectorized delineators, etc.
6. Abutting property: Roadside culture, property or land use, location of entrances to property.
7. Transit operations: Location of transit, taxi and other passenger loading zones.
8. Right-of-Way: R/W limits on plan sheets where R/W critically influenced the design.

Traffic Data

1. Volumes: Present traffic volumes. One-way approach A.D.T.; design hourly volume if available; and AM and PM peak hour turning movement counts.
2. Indicate Design Vehicle: P, SU, C43, C50.

3. Speeds: Approach speed - 85 percentile off-peak, otherwise posted speed.
4. Accidents: Collision diagrams, for 12-month period before and after, or number of fatal, personal injury and property damage accidents for 12-month period before and after.

5. Pedestrian: Cross-walks and other provisions for pedestrians, and pedestrian volume where significant in design or operation of the facility.

Operational Characteristics

1. Comment on over-all operation of channelized intersection.
2. Comment on elements of the design which contribute to any unsatisfactory operation, such as sight distance, limitations on available right-of-way, etc.
3. Causes of concentrations of accidents or unusual accidents.

Channelization Defined

Like the design of the channelized intersection, the definition of "channelization" is subject to considerable difference of opinion. The following definition was adopted by the Committee on Channelization as being representative of the Committee's area of investigation and research:

"Channelization of intersections at grade is the separation or regulation of conflicting traffic movements into definite paths of travel by the use of pavement markings, raised islands, or other suitable means to facilitate the safe and orderly movements of both vehicles and pedestrians."

Types of Intersection

The commonly accepted definitions for intersection types have been used in categorizing the "examples" of channelized intersections.

The six basic types of intersections are:

1. Three-way Intersections (Figure 1).
   a. Y Intersection.
   b. T Intersection.

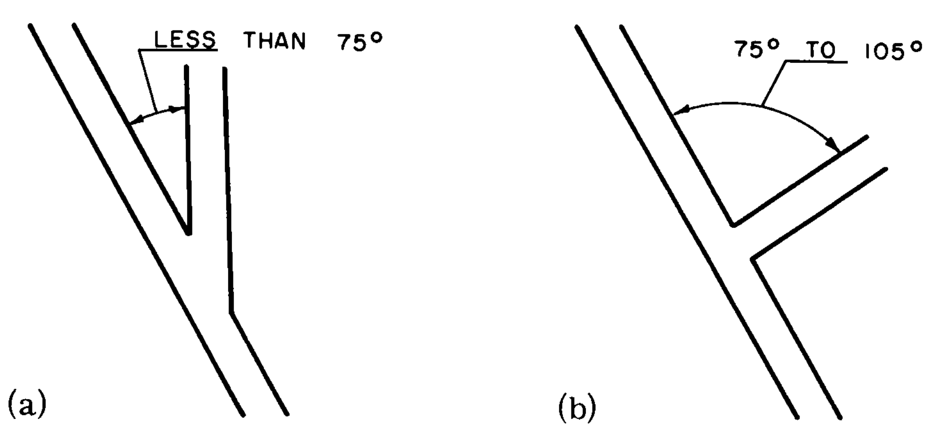


Figure 1.

2. Four-way Intersections (Figure 2).
   a. Right-Angle.
   b. Offset.
   c. Oblique.

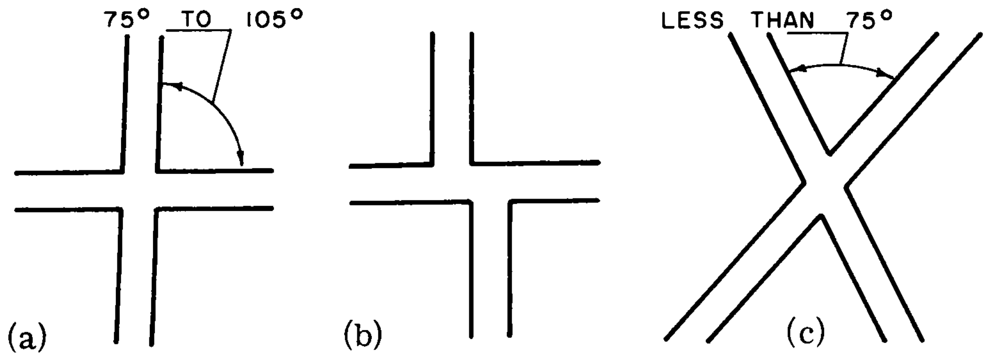


Figure 2.

3. Multiway Intersection (Figure 3).
   (5 or more legs).

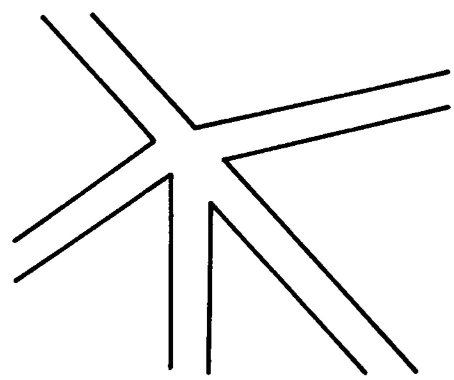


Figure 3.

Functional Classes

1. Directional.
2. Divisional.
3. Refuge.

The 1961 edition of the Manual on Uniform Traffic Control Devices for Streets and Highways lists the following three classifications. Islands may be classified functionally and physically as follows:

1. Vehicular and pedestrian.
2. Traffic divisional islands.
3. Traffic channelizing islands.

Channelization Types

Generally islands are delineated by one of the following methods:

1. Raised and outlined by curbs and filled with pavement, turf, or other material.
2. Formed by pavement markings, buttons or raised bars on all paved areas, used in urban districts where speeds are low and space is limited.
3. Unsurfaced flush with the travel way, sometimes supplemented by guideposts, stanchions, or other delineators, used for large islands.

Warrants for Channelization

The Committee suggests that the warrants for channelization as published in the earlier report include the factors generally considered in the design of channelized intersections. Channelization is generally employed for one or more of the following purposes:

1. Separation of conflicts.
2. Control of angle of conflict.
3. Reduction of excessive pavement areas.
4. Regulation of traffic and indication of proper use of the intersection.
5. Arrangements to favor predominant turning movements.
6. Protection of pedestrians.
7. Protection and storage of turning and crossing vehicles.
8. Location of traffic control devices.
9. Need for reference points.
10. Prohibition of specific movements.
11. Control of speed.

Objectives

The central objectives of intersection channelization are to assure orderly movement, increase capacity, improve safety, and provide maximum convenience. When the design provides for orderly movement and adequate capacity, improved safety and convenience will result.

The 1961 Manual on Uniform Traffic Control Devices states: "The island design should be carefully planned so that the shape of the island will conform to the natural vehicular paths and so that the raised island will not constitute a hazard in the roadway. A judiciously placed island at an intersection on a wide street may eliminate the need for traffic signal control by channelizing traffic into orderly movements."

Principles of Channelization

In the analysis of motor-vehicle movements through intersectional areas and in the development of the principles of channelization, consideration must be given to the following:

Factors to be Considered in the Design of Channelization

Human

1. Habit
2. Ability of drivers to make decisions.
3. Element of surprise.
4. Decision and reaction times.
5. Conformance to natural paths of movement.

Traffic

1. Possible and practical capacities.
2. Turning movements.
3. Size and operating characteristics of vehicles.
4. Control of movements at points of intersection, convergence, and divergence.
5. Vehicle speeds and pedestrian movements.
6. Transit operations and accident experience.

Physical

1. Character and use of abutting property.
2. Roadway grades.
3. Surface type and cross section.
4. Sight distance.
5. Total intersectional area.
6. Angles of intersection.
7. Divergence and convergence.
8. Areas of conflict.
9. Speed-change areas.
10. Island design.
11. Traffic control devices.
12. Lighting.

Economic

1. Cost of the improvement.
2. Economic effect on abutting business (where channelization restricts or prohibits certain vehicle movements within the intersectional area).

Budget limitations many times delay the implementation of permanent channelization. Accordingly, much can be accomplished by the use of paint in these instances. Further, in instances where lay authorities have difficulty in understanding the merits of channelization, paint can be used to demonstrate its advantages. This is particularly true in "snow" areas where permanent channelization is sought by the engineer; orderly movement resulting from good delineation when pavements are clear compared to relative disorder on snow covered pavements often provides obvious testimony to the positive effects of channelization. Hence, the engineer "proves" his point, thus accelerating the approval of permanent channelization.

In the design of an intersection, the engineer must consider both the objectives and the principles of channelization. The central objectives of intersection channelization are to assure orderly movement, increase capacity, improve safety and provide maximum convenience. When the design provides for orderly movement and adequate capacity, improved safety and convenience will result.

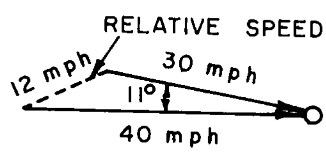
The more important principles of channelization which are presented in the following discussion must be observed if an effective design is to be achieved. The degree to which these principles are applied will depend upon traffic and physical features of the over-all design. For example, if traffic signal control is to be incorporated in the design, the angle at which traffic streams may cross without merging and weaving may be less than the right-angled crossing recommended for nonsignalized intersections (Principle No. 3).

Similarly, the separation of conflict points may be undesirable and impractical if the intersection is to be controlled by traffic signals (Principle No. 8).

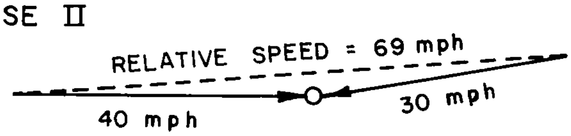
The designer must clearly understand, however, these principles of channelization. Experience will indicate the degree to which they may be modified to meet conditions at particular intersections. If, on the other hand, the principles of channelization are disregarded, the objectives of channelization will not be achieved and the resulting design will be hazardous and inefficient.

1. The relative speed and impact energy of intersecting vehicles are functions of vehicle speeds and angle of intersection.

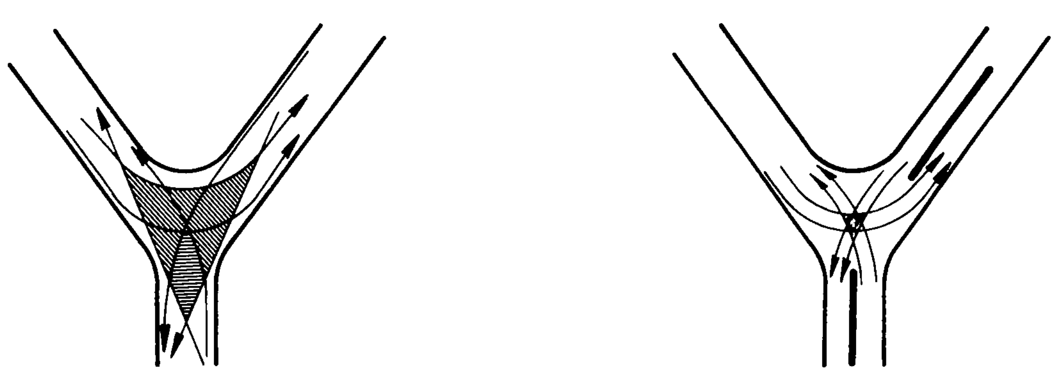
CASE I



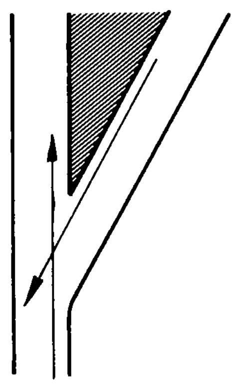
CASE II

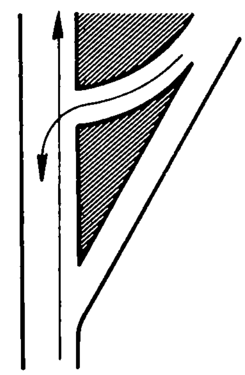


2. Channelization reduces the area of conflict.



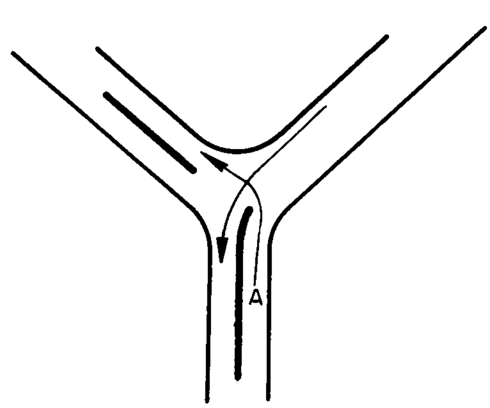
3. When traffic streams cross without merging and weaving, the crossing should be made at or near right angles.



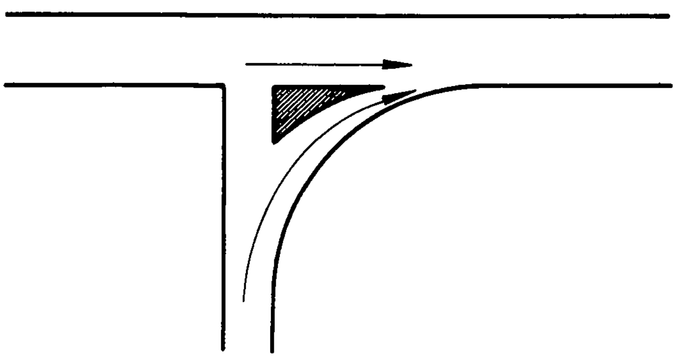


4. Merge traffic streams at small angles.

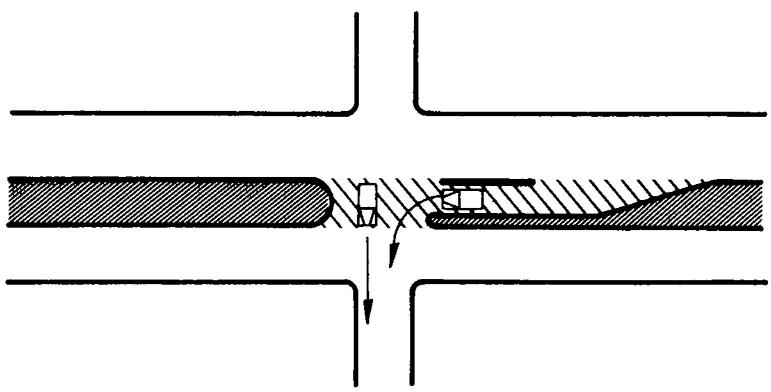
5. The speed of a traffic stream entering an intersection may be controlled by bending.



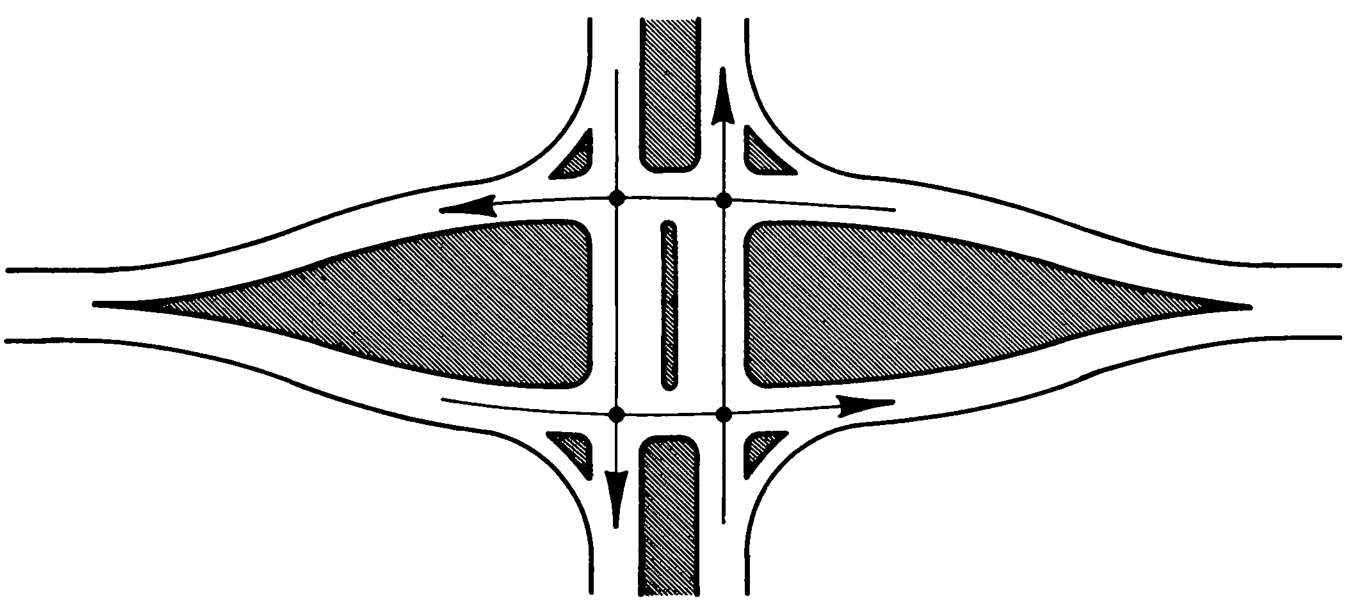
6. The speed of a traffic stream entering an intersection may be controlled by funneling.



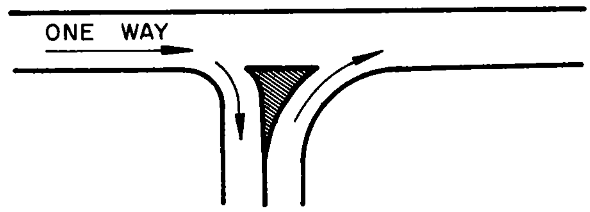
7. Channelization provides refuge (shadowing) for turning and crossing vehicles.



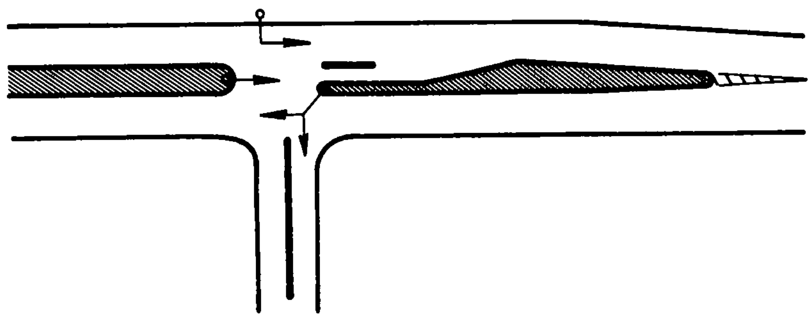
8. Channelization separates conflict points within an intersection.



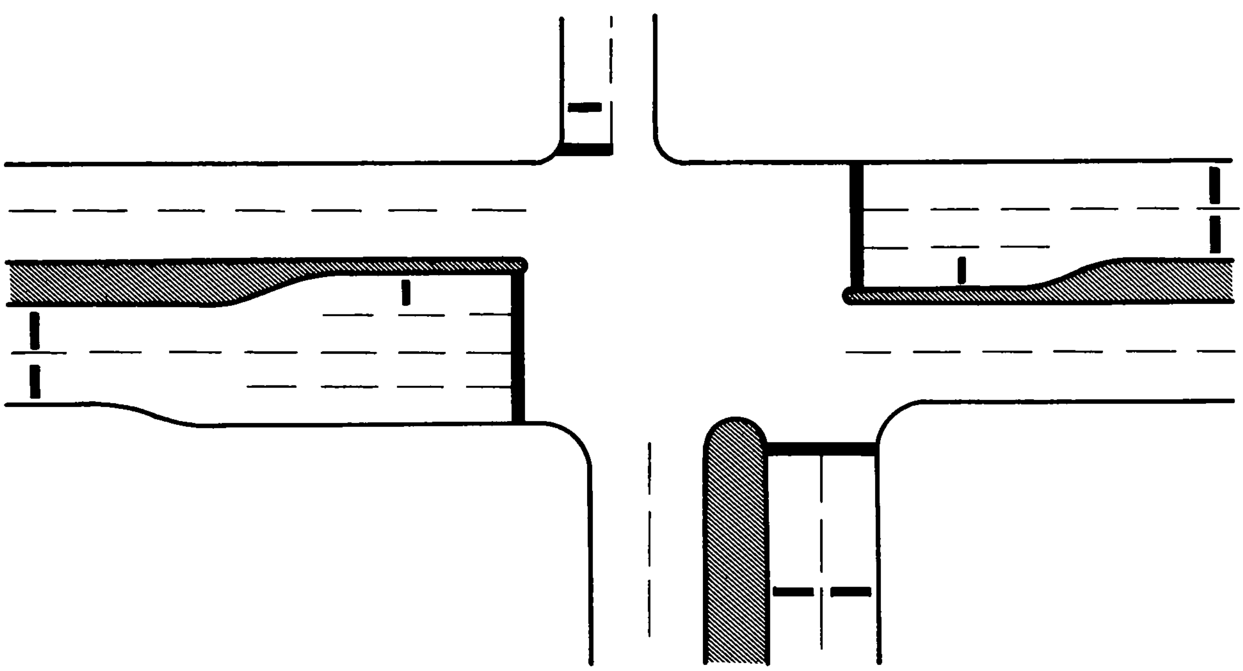
9. Channelization blocks prohibited turns.

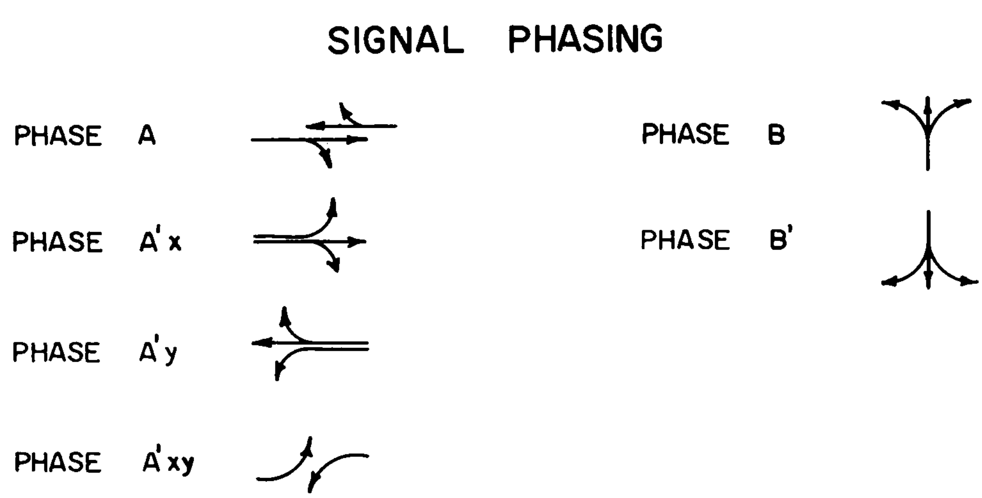


10. Channelization may provide locations for the installation of essential traffic control devices.



11. Channelization is required for effective signal control at intersections with complex turning movements.





Comments by Committee Members and Submitters

The Committee recognizes that current channelization design is based, to a large degree, upon the judgment and experience of the designer in the application of the general principles of highway and traffic design to the problem of the intersection. In presenting the examples, the Committee believes that in the absence of qualifying remarks, some designs might be accepted as good practice. To prevent a misinterpretation of the examples by those readers whose experience in channelization may be limited, comments by two Committee members have been included with each example.

Admittedly, this critique, or review, is not intended to supersede the work of the authors. The analyses accompanying the examples should be accepted only as the considered opinion of the reviewer based upon the supporting data furnished and do not necessarily reflect the accuracy or effectiveness of the design. It must also be recognized that the reviewer did not have the designer's intimate knowledge of the local conditions which so greatly influence the ultimate design.

The critiques prepared by Committee members were furnished to the person who submitted the example and additional comments were solicited. For many of the examples, these additional comments provided important data relating to the design and operation of the intersection and have been included in the textual material.

In addition, Committee members have suggested the following comments as being pertinent to the study, planning, and design of channelization.

<u>Channelization "Pitfalls" - by Donald H. Sides</u>

1. Be sure channelization is necessary, first of all, for traffic volumes, etc.

2. Avoid isolated channelization unless of major proportions.

3. Avoid multiple maneuvers--merging three movements into one--one movement offered three or more simultaneous choices.

4. Be sure islands, etc., are readily visible on approaches.

5. Avoid numerous small islands in favor of a few large ones where possible. Don't forget raised portions of islands should be offset from edge of travel path and raised portion itself should be reasonable in size. Avoid minimum sizes suggested in MUTCD where possible.

6. As plan develops, consult with MUTCD to insure proper placement of signs or signals if possible. Don't forget possibility of future signals.

7. On unsignalized intersections, in particular, provide sufficient width of median to shadow design vehicles.

8. Visualize channelization under all conditions, particularly during periods of high snow storage on islands.

List of "Cautions" for Channelization Designer - by Irving B. Weinberg

1. Never introduce islands on curves or hillcrests.

2. Remember that drivers and pedestrians take most convenient paths.

3. Avoid too many too small islands (50 square feet).

4. Channelization should appear open and natural.

5. Adequate signing and illumination are important features in good channelization design and operation.

6. Approach end of channelization island should be offset left of center-line and should be adequately reflectorized, painted, and/or illuminated for demarcation.

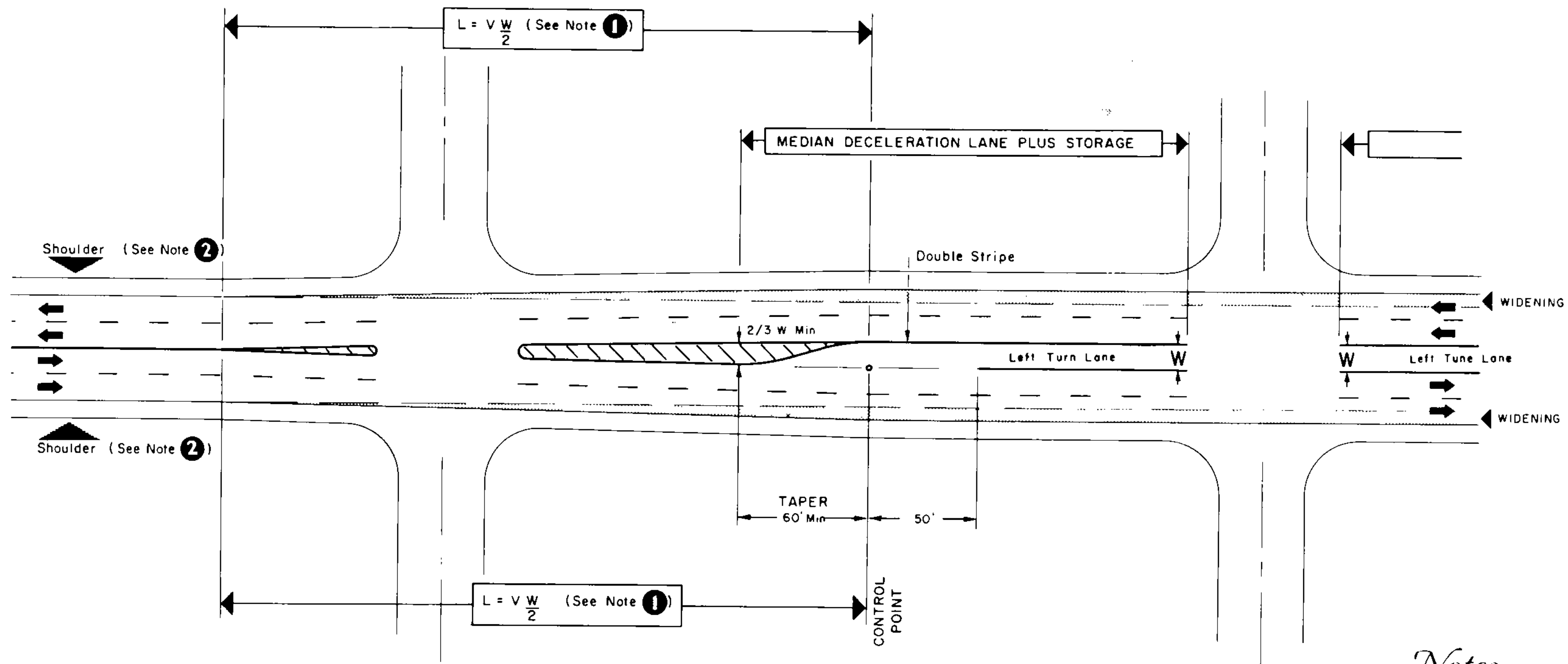
Median Channelization in California

"It is my opinion that the very word 'channelization' is apt to result in young engineers becoming over-eager and introducing many narrow turning lanes and small islands where the proper solution would be an open intersection. About the only channelization that is done now on the California Highway System is the provision of left-turn median lanes.

"The principal points that we would like to bring out, as shown on the enclosed standards, are: (1) The transition taper of the approach nose when widening an undivided highway should be a function of the design speed. (2) As little area as possible should be used for islands, meaning that as large an area as possible remains for the use of automobiles. (3) One thing that seems to be overlooked by many designers is the fact that the control point for the transition taper should be located at the point where the left-turn lane becomes full-width instead of at the point where the island becomes as wide as the left-turn lane. In fact, the island rarely has to be as wide as the left-turn lane.

"(4) Another point that is emphasized in the new standard is that the angle defining the beginning of the left-turn lane is increased and the corresponding length of taper is shortened in order to give a more positive indication or 'clear cue' as to where the left-turn lane begins. It has been observed that long, smooth tapers at this part of the left-turn lane have a tendency to entice through-vehicles as well as to result in doubt on the part of drivers desiring to make a left turn.

"On the exhibit indicating widening on one side, the pavement has been widened on the side approaching the intersection to better illustrate the point of control in the transition. It is also to be noted that the transition length has been made a function of the median width in lieu of the amount of widening. This was necessary because the amount of widening and the median width are not necessarily equal."



DEFINITIONS

L = LENGTH OF TRANSITION - FT

W = WIDTH OF MEDIAN LANE - FT

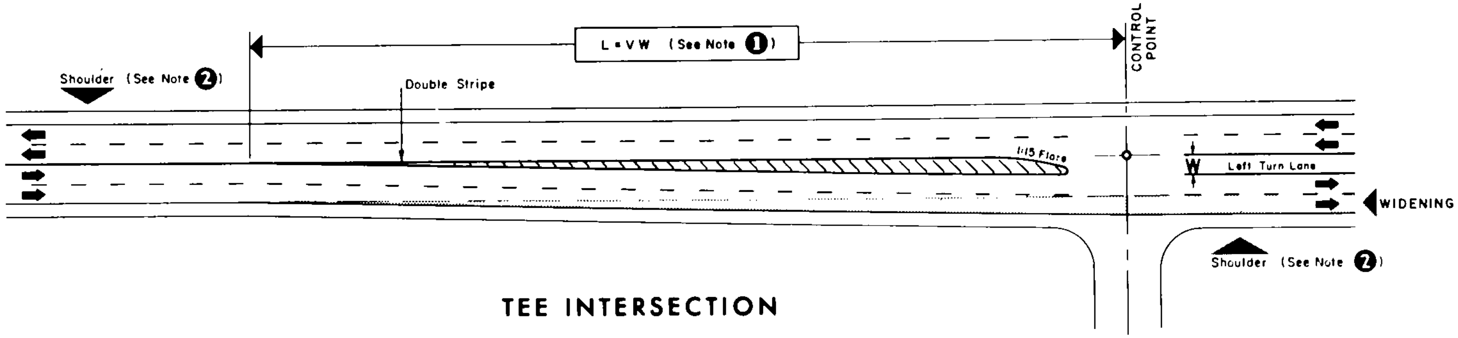
V = DESIGN SPEED - MPH

Notes

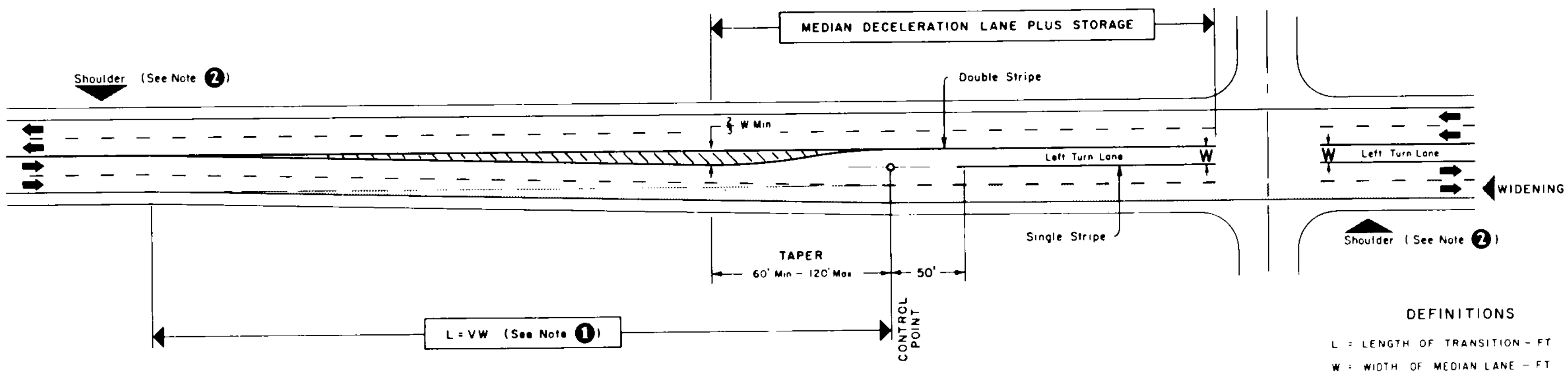
1. L = 500' MAXIMUM
2. WHERE CONDITIONS DO NOT PERMIT, SHOULDERS MAY BE OMITTED AND PARKING RESTICTED

MINIMUM MEDIAN LEFT-TURN CHANNELIZATION

Widening on Both Sides in Urban Areas with Short Blocks



TEE INTERSECTION



4-LEG INTERSECTION

DEFINITIONS

L = LENGTH OF TRANSITION – FT

W = WIDTH OF MEDIAN LANE – FT

V = DESIGN SPEED – MPH

Notes

1. L = 500' MAXIMUM
2. WHERE CONDITIONS DO NOT PERMIT, SHOULDERS MAY BE OMITTED AND PARKING RESTRICTED

MINIMUM MEDIAN LEFT-TURN CHANNELIZATION

Widening on One Side in Suburban and Rural Areas

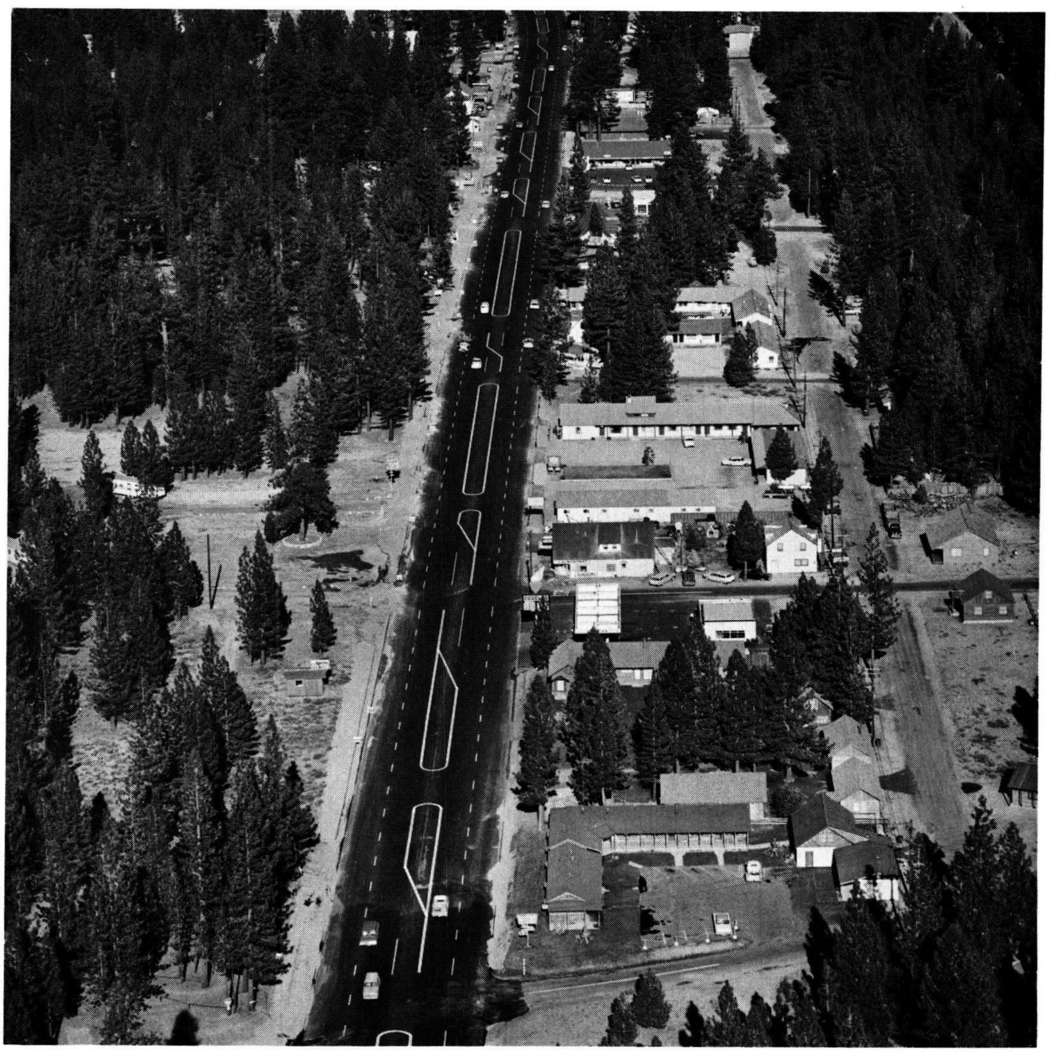
"The photograph which follows is of a stretch of road, U.S. 50 at Lake Tahoe, California, showing channelization for strip development with many minor cross-roads.

"I believe this is a fine example of simple channelization that accomplishes a great deal of good; namely, it almost eliminates left turn accidents and accidents associated with left turn maneuvers, and vastly improves traffic flow as compared with an undivided highway where turning vehicles stop in the through lanes.

"The pavement is 64 feet wide between asphalt dike curbs. The median is 12 feet, the outer lanes are 14 feet each, and the inner lanes are 12 feet. The highway operates very smoothly with summer traffic and volumes of around 25,000 vehicles per day.

"The median is flush, being marked by double stripes on each side. You may note that it is possible with paint to be much more precise than curbs when dealing with frequent openings.

"There is very little violation of the median in this particular case because legal openings are provided frequently enough so that there is very little call for violation. It is possible to reach every abutting property by means of a legal opening without making a U-turn." — Karl Moskowitz.



U.S. 50 at Lake Tahoe, Calif.

Divided section with left turn bays, shadowing, location of traffic control devices, separation of conflicts, and pedestrian refuge by channelization. (Toronto, Canada).

Channelized intersection with addition of island and left turn lane. Note controlled access design to shopping area. (Toronto, Canada).

General illustration of channelization in New Jersey.

"While this report is properly concerned with design, the committee recognizes the operating problems associated with the introduction of channelization at a location where none existed previously. Thus, the implementation of channelization, particularly in cases of raised islands, in most instances requires an indoctrination effort aimed toward acquainting 'repeat' drivers with the new situation." — Warren Travers.

Examples of Channelization

Example Number	Three-Way Intersections - T Type
T-1	Michigan, Lansing: Grand River Avenue (US 16) - Marshall Street.
T-2	Michigan, Pontiac: US 10 - Scott Lake Road.
T-3	Illinois, near Greenview: Illinois Route 123 - Illinois Route 29.
T-4	Wisconsin, Eau Claire: US 53 - Presto Gate.
T-5	New Mexico, Tularosa: US 54 - US 70.
T-6	Montana, Whitefish: US 93 - Montana 40.
T-7	California, San Francisco: Laguna Honda Boulevard - Clarendin Avenue.
T-8	California, San Francisco: Main Drive - Bridge Drive (Golden Gate Park).
T-9	Delaware, Christiana: Delaware 7 - Delaware 273.
T-10	California, Berkeley: Derby Street - Warring Street.

Three-Way Intersections - Y Type

Y-1	Wisconsin, Fond Du Lac County: US 151 - Wisconsin 26.
Y-2	Nebraska, Omaha: 42nd Street - Q Street.
Y-3	California, San Diego: Nimitz Boulevard - Sunset Cliffs Boulevard.
Y-4	New Jersey, Hudson County: US 1 and 9 - New Jersey Route 3.
Y-5	Pennsylvania, Trout Run, Lycoming County: US 15 - Pennsylvania 14.
Y-6	Connecticut, Columbia: US 6 - US 6A.
Y-7	Connecticut, East Litchfield: Route 8 - Route 116.
Y-8	Delaware, Keidel's Corners: Newport Gap Pike (Delaware 41) - Lancaster Pike.
Y-9	Delaware, Little Heaven: US 113 - 113A.
Y-10	Oregon, near Salem: Oregon 22 - Oregon 223.
Y-11	Texas, Dallas: East Grand Avenue - Gaston Avenue - Garland Road.

Four-Way Intersections - Right-Angled Type

FR-1	Michigan, Dearborn: US 24 (Telegraph Road) - Ford Road.
FR-2	Illinois, near Normandy: Illinois Route 92 - Illinois Route 88.
FR-3	Texas, Austin: US 183 (Airport Boulevard) - US 290 (Koenig Lane).
FR-4	Arkansas, Little Rock: Meadowcliff Road - US 67 and 70.
FR-5	Idaho, Eagle Junction: US 20 and 26 - Idaho 69.
FR-6 (Offset)	New Mexico, near Clovis: Cannon Air Force Base Entrance - US 60 and 84 - New Mexico 277.
FR-7	Colorado, Denver: Colorado Boulevard - East 46th Avenue.
FR-8	California, San Diego: 54th Street - University Avenue.
FR-9 (Offset)	Connecticut, West Hartford: US 44 - Connecticut Route 185 - North Main Street.

Example Number	Four-Way Intersections - Oblique Type
FO-1	Michigan, Lansing: US 16 (Grand River Avenue) - Saginaw Street.
FO-2	Washington, Seattle: 1st Avenue Bridge, S. - East Marginal Way, S. (US 99).
FO-3	Delaware, Hockessin: Lancaster Pike - Yorklyn Road.
FO-4 (Offset)	Massachusetts, Seekonk: Fall River Avenue - Highland Avenue - Mink Street.

Multiway Intersections

M-1	California, Modesto: H Street - Scenic Drive - Burney Street - Downey Street - Kimble Street.
M-2	Arkansas, Magnolia: Courthouse Square.
M-3	Idaho, Twin Falls: East Five Points.
M-4	Oregon, Portland: US 26 - SW 58th Avenue - SW Skyline Boulevard - SW Canyon Court - SW Humphrey Boulevard.
M-5	District of Columbia, Washington: Constitution Avenue - Maryland Avenue - 2 nd Street.

OTHER TREATMENTS

Example Number	Three-Way Intersections - T Type
T-A	Texas, Bastrop: State Highway 71 - State Highway 95.
T-B	District of Columbia, Washington: 6th Street - Constitution Avenue.
T-C	New Jersey, Metuchan: Holly Street - Central Avenue.
T-D	California, San Diego: Route 77 - Pomerado Road.
T-E	Canada, Toronto: Highway 27 - Highway 2.

Three-Way Intersections - Y Type

Y-A	Michigan, Shepherd: US 27 - Shepherd Road.
Y-B	Rhode Island, Pawtucket: Smithfield Avenue - Power Road.
Y-C	District of Columbia, Washington: 28th Street - M Street - Pennsylvania Avenue.
Y-D	Indiana, Fort Wayne: Indiana 14 - US 24.
Y-E	Missouri, Springfield: Chestnut Street Trafficway - College Street.
Y-F	New York, Wayne County: New York 5290 (Wolcott - Red Creek) - New York 5290 (Westbury).
Y-G	Kentucky, Alexandria: US 27 - City Street.
Y-H	Canada, Toronto: Unidentified.

Four-Way Intersections - Right-Angled Type

FR-A	Arkansas, Little Rock: Markham Street - University Avenue.
FR-B	Montana, Great Falls: 1st Avenue North - Park Drive.
FR-C	Delaware, Wilmington: Limestone Road - Kirkwood Highway.
FR-D	Arkansas, Hot Springs: Central - Grand.
FR-E	Massachusetts, Natick: Route 9 - Oak Street - Rhode Island Avenue.
FR-F	Rhode Island, Providence: State Route 2 - Division Street.

FR-G Rhode Island, Providence: State Route 2 - Frenchtown Road.
FR-H Canada, British Columbia, Vancouver: Cassiar Street - Hastings Street.
FR-I Alabama, Huntsville: Jordan Lane - Alabama 20.
FR-J Texas, Bastrop County: Texas 95 - Texas 71 (Loop Road).
FR-K Kentucky, Hart County: US 31 - Kentucky 218.
FR-L Nevada, Reno: Kietzke Lane - East Second Street.
FR-M Canada, Toronto: Keele Street - Lawrence Avenue.
FR-N Canada, near Huntsville: New Highway 11 - Old Highway 11 Relocation.

Example Number

Four-Way Intersections - Oblique Type

FO-A Michigan, Saginaw: Washington Avenue - Rust Street.
FO-B Arkansas, Little Rock: Markham Street - Kavanaugh - Booker.
FO-C Texas, Lubbock: US 87 - US 82.
FO-D Kentucky, Carlisle County: Kentucky 440 - Kentucky 307.
FO-E Oklahoma, Northwest of Shawnee: Oklahoma 3 - Future US 270.
FO-F Texas, San Antonio: Nogalitos Street - Laredo Highway - Zarzamora Road.
FO-G Pennsylvania, Loyalsock Township, Lycoming County: East Third Street - Washington Boulevard - Faxon Parkway.

Multiway Intersection

M-A Minnesota, St. Paul: University Avenue - Robert Street - Aurora Avenue.
M-B Kansas, Kansas City: Central Avenue - Wilson Boulevard - 13th Street - Reynolds.
M-C District of Columbia, Washington: Dupont Circle.
M-D Texas, San Antonio: Romana Plaza.

Approach-End Treatments

AE-A Arkansas, Jonesboro: Caraway Road - Johnson Street.
AE-B Connecticut, Ashford: US 44 - US 44A.
AE-C Illinois, near Ashmore: Illinois Route 16 - Illinois Route 49.
AE-D Oklahoma, South of Lindsay: Oklahoma 29 - Oklahoma 76.

Location

MICHIGAN, Lansing
Grand River Ave. (US 16, M-78)
at Marshall Street

Submitted by

Harold G. Bauerle
Director of Traffic Division
Michigan State Highway
Department
Lansing, Michigan

Type of Intersection

3-Way Tee

Date Opened to Traffic

November, 1957

Physical Data

Grades: Not of any consequence
Surface Type
Roadways: 9" concrete with bituminous cap
Islands: Bituminous curb with bituminous cap
Shoulders: Class A compacted 4" sloping 1 on 4
Curbs: Bituminous concrete 7" high, where indicated on plan
Traffic Control Devices

Traffic Data

Volume: 17% increase between "Before" and "After" channelization
Design Vehicle: C50

Operational Characteristics

Marshall Street is the temporary ending of an east-west one-way street system. Within the next year or so, this island construction will be removed and the one-way street system extended on westward. The design shown, however, does indicate what can be done with very tight controls with one-way streets, turning roadways, radius, and a weaving section in which the majority of drivers must weave.

The before and after accident comparison shows the moderate improvement. However, considering the 17% increase in traffic in this area, the improvement is considerable.

NOTE: See Textual Data Sheet of EXAMPLE FO-1 for Sketch of General Vicinity including this EXAMPLE.

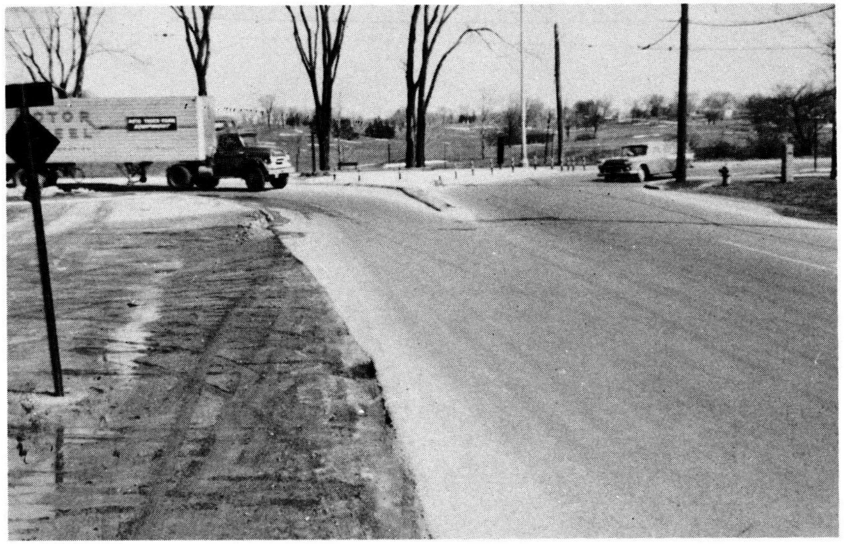


Figure 2: Looking north from the south leg of Marshall Street toward the Grand River Avenue intersection.

SUPPLEMENT TO BEFORE AND AFTER ACCIDENT STUDY OF EXAMPLE T - 1
US 16 (GRAND RIVER) AT MARSHALL STREET, LANSING, MICHIGAN

CHANNELIZATION Construction: Oct. 17, 1957 through Nov. 30, 1957

BEFORE PERIOD: 1 Year, Oct. 17, 1956 through Oct. 16, 1957

SUMMARY OF ACCIDENTS	ACCIDENT RATE per million vehicles
8 Accidents	1.3
1 Injured	

6 Accidents in Light Conditions
2 Accidents in Dark Conditions
3 Accidents on Wet Surface

AFTER PERIOD: 1 Year, Dec. 1, 1957 through Nov. 30, 1958

SUMMARY OF ACCIDENTS	ACCIDENT RATE per million vehicles
5 Accidents	1.1
0 Injured	

3 Accidents in Light Conditions
2 Accidents in Dark Conditions
2 Accidents on Wet Surface

****

SUPPLEMENT TO BEFORE AND AFTER ACCIDENT STUDY OF EXAMPLE T - 1
SAGINAW (M-78) AT MARSHALL STREET, LANSING, MICHIGAN

CHANNELIZATION Construction: Oct. 17, 1957 through Nov. 30, 1957

BEFORE PERIOD: 1 Year, Oct. 17, 1956 through Oct. 16, 1957

SUMMARY OF ACCIDENTS	ACCIDENT RATE per million vehicles
6 Accidents	1.3
1 Injured	

5 Accidents in Light Conditions
1 Accident in Dark Conditions
3 Accidents on Wet Surface

AFTER PERIOD: 1 Year, Dec. 1, 1957 through Nov. 30, 1958

SUMMARY OF ACCIDENTS	ACCIDENT RATE per million vehicles
8 Accidents	1.1
2 Injured	

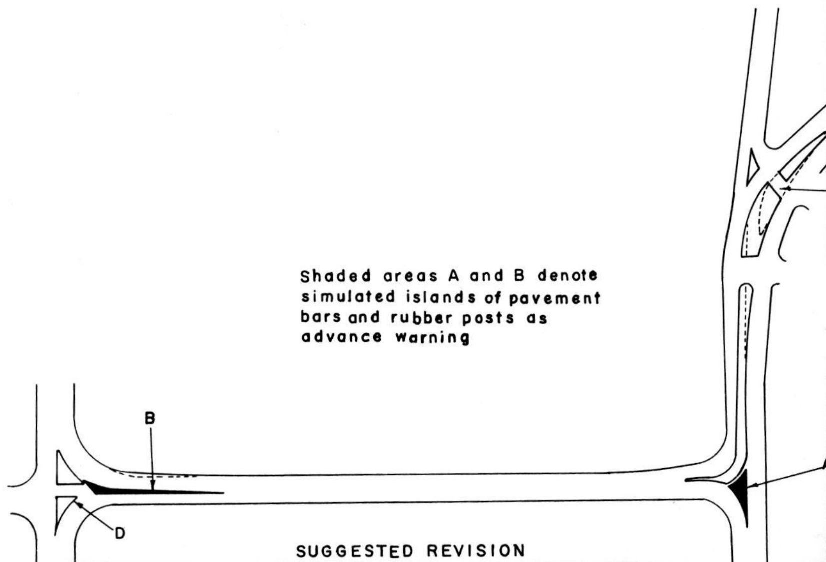
5 Accidents in Light Conditions
3 Accidents in Dark Conditions
0 Accidents on Wet Surface

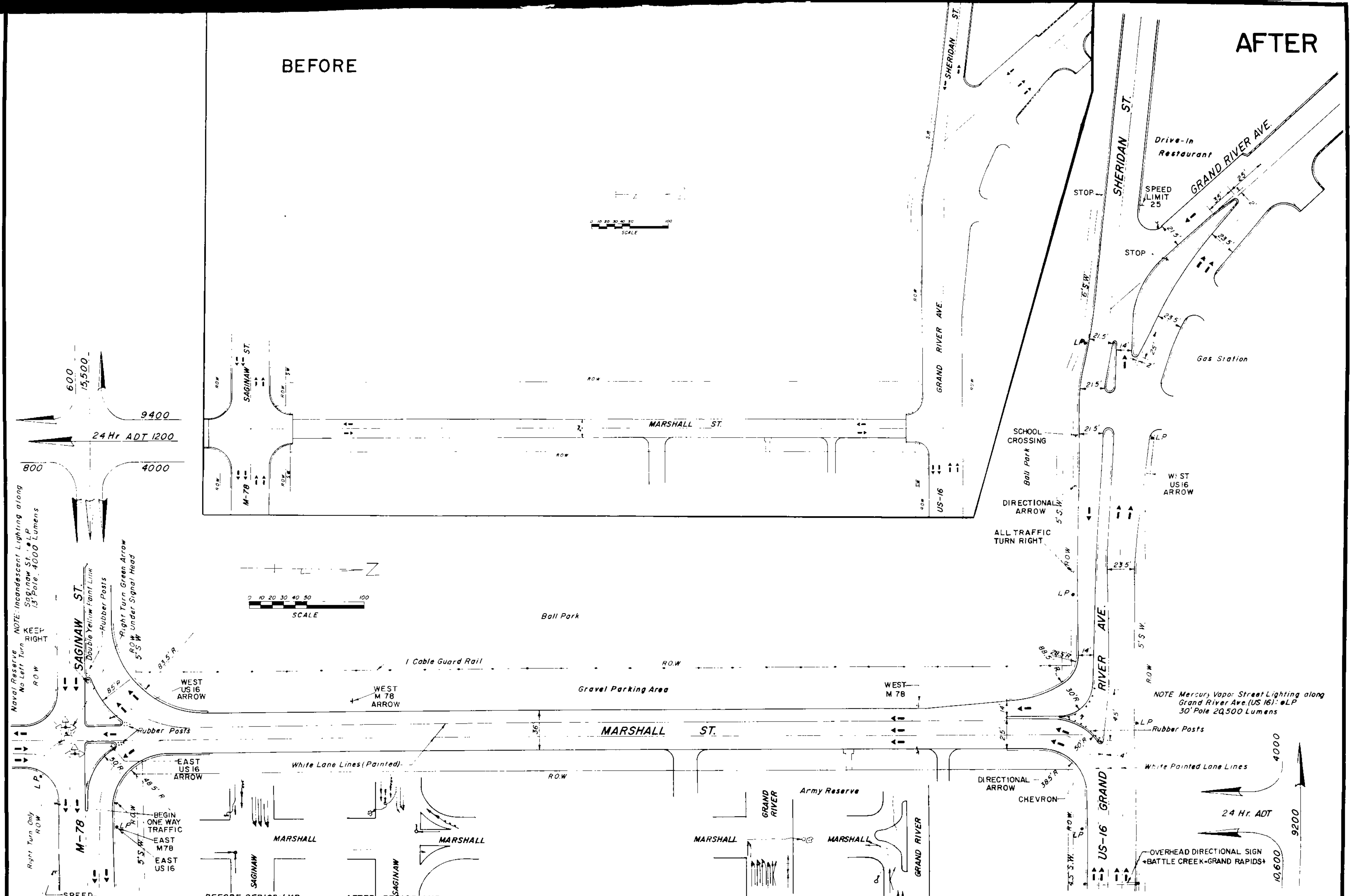
Comments by Committee Members

1. EUGENE MAIER - This is an excellent example of the use of channelizatio in the solution of the complex traffic movements resulting in the tempo termination of a one-way couplet. The channelization at Grand River av and Sheridan Street reduced an unnecessarily large intersection and mini mized the conflict between southbound Grand River traffic and northboun traffic into Sheridan Street.

2. R. T. SHOAF - In principle this is a very fine use of channelization fo traffic routing. Regardless of the good accident rate and an improveme in the rate after channelization, the after accident experience raises three questions in my mind which can only be checked by examination of detailed accident reports.
First, I question the need for traffic signals at Saginaw and Mars I suspect that part of the increase in accidents is a result of rear-en accidents due to signals.
I feel that if signals are to be used with channelization, an im- portant feature is the placement of the heads. Overhead signals placed as close to the stop line as those shown on the drawing appear to me as conducive to accidents and certainly do not appeal from a standpoint of convenience to the motorists.
Second, at least two islands are introduced in the center of one-w roads, and I question if there is adequate advanced island introduction or warning for what are probably high-speed roads. The small sketch il lustrates at A and B a possible design using raised pavement bars and rubber posts in advance of the physical island.
Third, again only a refinement of design, but I would be inclined shorten the crossing distance for the conflicting movements at Grand Ri and Sheridan. I think a more nearly right-angle crossing would provide better stop locations and a smaller intersection. At the same time, it appears to better delineate the curve of Grand River Avenue by replacin one long gap with two smaller gaps in the center island. (See C on ske
At Saginaw and Marshall, the sketch (See D) segregates the two sma flows from the major right turn and might be considered for the delicat problem of minimizing the introduction of islands into the stream of on way traffic. I would want to study traffic accidents, however, before concluding that such a change would have been any help at all.
In conclusion, other than the use of traffic signals, I consider m suggestions in light of the accident experience to be refinements. The basic elements of the channelization are excellent.

Additional Comments by H.H. COOPER, Director of Traffic Division, December,
In the comments by Mr. R. T. Schoaf, he mentioned that two islands were troduced in the center of one-way roads, and he questioned if there were adequate advanced island introductions or warrant for what were probabl speed roads. Actually, there are advanced warning signs and the speeds relatively low, being in the range of 25 to 35 miles per hour. Eastbour Saginaw traffic is very heavy during peak hours. Without a signal, sout bound Marshall traffic would be hard pressed to find a gap to cross.





EXAMPLE T-1

MICHIGAN, LANSING
GRAND RIVER AVENUE (US 16, M 78) AT MARSHALL STREET

Location

MICHIGAN, Pontiac
US 10 - Scott Lake Rd.

Submitted by

Harold G. Bauerle
Director of Traffic Division
Michigan State Highway
Department
Lansing, Michigan

Type of Intersection

3-Way Tee

Date Opened to Traffic

October, 1959

Physical Data

Grades: 1.28% East of intersection
Surface Type
Roadways: 9" concrete with bituminous cap
Islands: Grass sodded and ditched
Curbs: White concrete curb on outer edge of right quadrant left turn.
Yellow painted bituminous curb on inner edge of right quadrant left turn.
Traffic Control Devices
Signs: NO LEFT TURN case sign at the intersection for all directions
Signals: Two-phase signalization with dual indications
Lighting: One street light at intersection
Abutting Property
Character of land use: Residential on North side of US 10.
Scattered commercial on South side of US 10.

Traffic Data

Volumes: See Peak Hour Flow Diagram for 1956.
Design Vehicle: C50

Operational Characteristics

Traffic volumes at this location had reached the point requiring signalization. Volumes on US 10 were such that left-turning vehicles could not be permitted to store on the highway.

The channelization shown is very tight due to severe right-of-way limitations.

Accidents about doubled at this location, which is normal for the addition of signal control to the intersection. However, congestion, which previously occurred even without a signal, was eliminated and the intersection operates freely.

Figure 1: Looking Eastward from the West leg of US 10

Figure 3: Looking Northeast from the West leg of US 10

BEFORE AND AFTER ACCIDENT STUDY OF EXAMPLE T - 2
US 10 AT SCOTT LAKE ROAD, Pontiac, Michigan

Second Signal Head Installed and Left Turn Facility Constructed October, 1959

BEFORE PERIOD: 1 Year, 10-1-58 through 9-30-59

SUMMARY OF ACCIDENTS	ACCIDENT RATE per Million Vehicles
6 Accidents	0.6
0 Injured	

5 Accidents in Light Conditions
1 Accident in Dark Conditions
1 Accident on Wet Surface

AFTER PERIOD: 1 Year, 11-1-59 through 10-31-60

SUMMARY OF ACCIDENTS	ACCIDENT RATE per Million Vehicles
13 Accidents	1.2
9 Injured	

11 Accidents in Light Conditions
2 Accidents in Dark Conditions
7 Accidents on Wet Surface
2 Accidents on Icy Surface

Figure 2: Looking Westward from the East leg of US 10

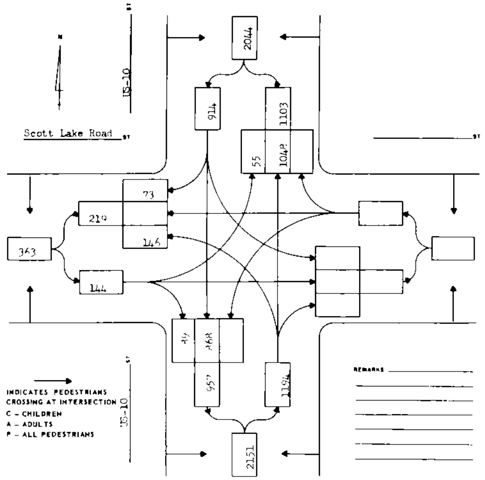
Comments by Committee Members

1. KARL MOSKOWITZ - This method of eliminating the left turn at a signalized intersection has been used effectively in California. However, our experience is based on a T-intersection without the additional street nearby.
   Traffic count does not indicate traffic to second intersecting road, but must be very light if the signalized intersection operates freely.
   Readers should be wary of using this method at a simple T-intersection because it calls for stopping mainline traffic in both directions for left turns from the main line. A left-turn lane in the median calls for stopping opposing main line traffic only, and generally requires less right of way and pavement.
   If the left-turn volume is light and the cross traffic is light, the treatment shown in this example is excellent, since the "minimum green" can be utilized to dispose of both cross traffic and left-turning traffic during one minimum red against the main line.

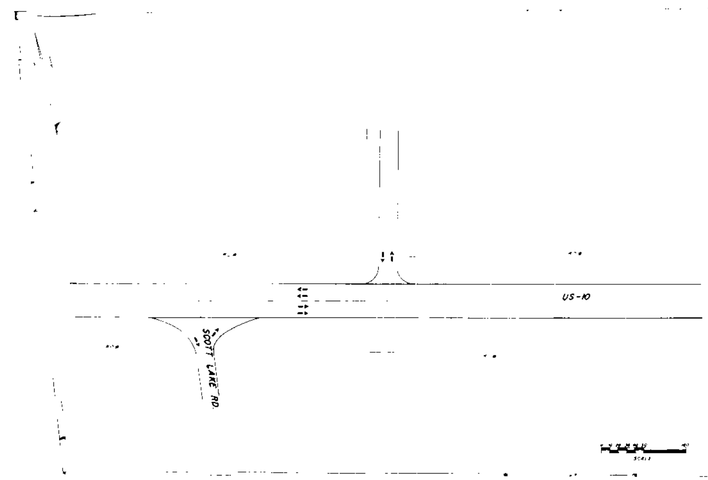
2. DONALD H. SIDES - This general type of intersection is described in some detail in the AASHO Policy on Geometric Design of Rural Highways. See figure VIII-25D and pages 342 - 343. The policy indicates it is an effective treatment particularly for unusually high peak flows of relatively short duration.
   This "jug handle" design has been employed with 4-way intersections. Sometimes the minor crossroad is split and the pattern becomes a tight rotary with the main road carried directly through. Usually this design is adopted because of the large cost of providing median lanes for left turning vehicles.
   Sometimes this design is referred to as the "New Jersey left turn" because it is used rather extensively in that State.

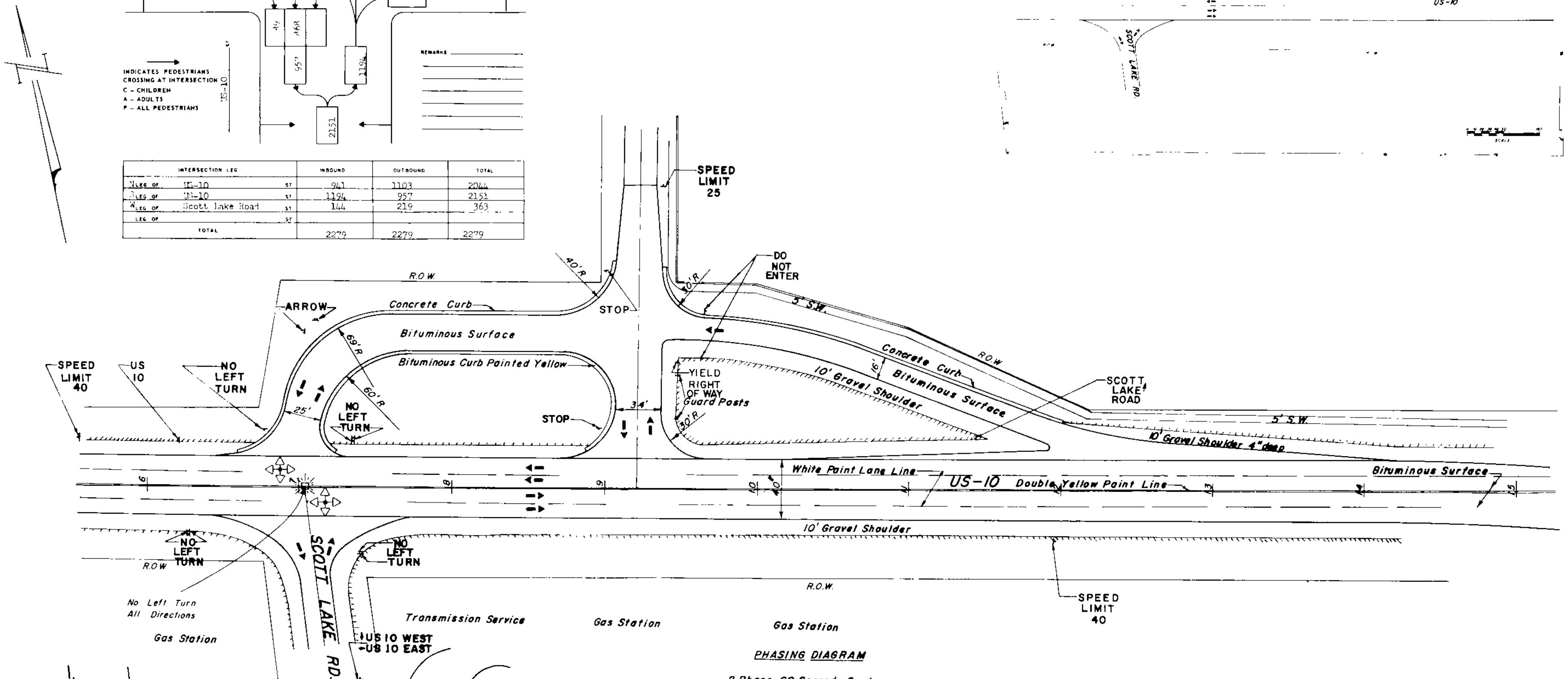
VEHICLE VOLUME COUNT
GRAPHIC SUMMARY SHEET

DATE 3-2-56 DAY ____ WEATHER ____ TIME Peak Hour TO ____
COUNTY Oakland TWP., VILLAGE OR CITY Waterford
INTERSECTION OF US-10 AND Scott Lake Road



INTERSECTION LEG		INBOUND	OUTBOUND	TOTAL
N LEG OF	US-10 ST	941	1103	2044
S LEG OF	US-10 ST	1194	957	2151
W LEG OF	Scott Lake Road ST	144	219	363
LEG OF	ST			
TOTAL		2279	2279	2279

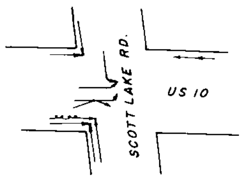




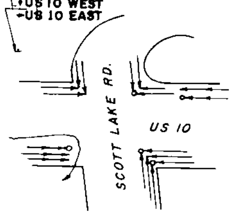
PHASING DIAGRAM

2 Phase 60-Second Cycle
67-33% Split
Flashing from 12:00 Midnight to 6:00 A.M.
US 10 Yellow, SCOTT LAKE RD. Red

0 10 20 30 40 50 100
SCALE



BEFORE PERIOD: 1 YR.



AFTER PERIOD: 1 YR.

COLLISION DIAGRAMS

EXAMPLE T-2

MICHIGAN, PONTIAC
US 10 AT SCOTT LAKE ROAD

Location

Illinois, Menard County, near Greenview
Illinois Route 123 - Illinois Route 29

Submitted by

M. K. LINGLE, Engineer of Traffic
Illinois Division of Traffic
Springfield, Illinois

Type of Intersection

3-Way Tee

Date Opened to Traffic

November, 1959

Operational Characteristics

Comments on over-all operation of the channelized intersection:

"Elements controlling design: Illinois 29 is the preference route. Stop control on Illinois 123. Channelization is for operational safety. Length of left-turn lane is based on speed change requirement.

"In the photograph we are looking southeast at the intersection of Illinois Route 123 and Illinois Route 29 south of Greenview in Menard County. From the "oil slicks" we can see that the through movements are predominant. A left-turn lane has been added on the south approach for operational safety even though the turning volume is light.

Figure 1: Aerial view of the intersection

Comments by Committee Members

1. C. J. KEESE - This design represents a good standard treatment for a low volume rural "T" intersection.
   Although traffic volume is extremely light, consideration might be given to providing additional width for southbound traffic on Illinois 29 to reduce the speed differential between right-turn vehicles (Movement E) and three vehicles (Movement F).

2. R. T. SHOAF - I concur with the comments of C. J. Keese.

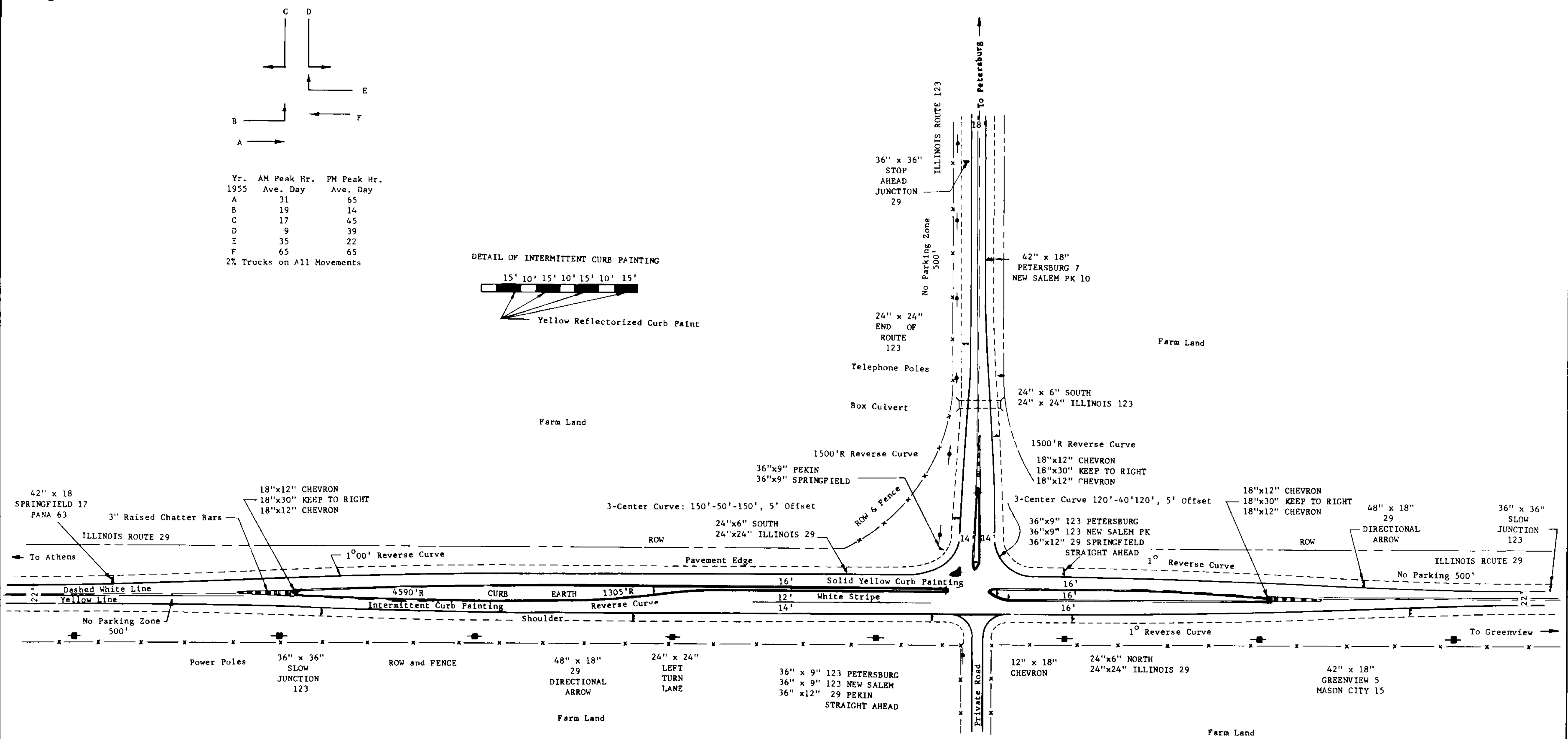
Additional Comments by M. K. LINGLE - We concur with Mr. C. J. Keese's comments. In view of the light volumes a separate right-turn lane was not provided at this intersection. Had the volumes been higher at this intersection, a right-turn lane in all probability would have been provided. To make things clear, the state of Illinois does not widen the through pavement a few feet to provide a right-turn lane, as suggested in Mr. Keese's comments. We normally provide an extra full-lane width for this right-turn lane. We are not sure of Mr. Keese's intent with regard to "additional width for south-bound traffic."

With regard to the signs shown on the plan layout, we wish to make it clear that the striped panels above and below the "Keep To Right" signs at the nose of the channelization are silver reflective sheeting and orange fluorescent sheeting. All other striped panels are black stripes on silver reflective sheeting.

We wish to call your attention to the fact that the signs as shown are as presently posted and substantially conform to the 1958 edition of the State of Illinois Manual on Uniform Traffic Control Devices. It may be apparent to you that the signs do not conform to the 1961 edition of the Federal Manual on Uniform Traffic Control Devices. The State of Illinois is presently revising its manual to conform with the new federal manual which, when published, will cause the signing at this intersection to be completely revised.

Yr. 1955	AM Peak Hr. Ave. Day	PM Peak Hr. Ave. Day
A	31	65
B	19	14
C	17	45
D	9	39
E	35	22
F	65	65

2% Trucks on All Movements



DESIGN DATA

Road Surfaces: Bituminous
Shoulders: 3' Gravel, 7' Earth, Total 10'
Date Opened to Traffic: November, 1959
All Grades Less than 1%
All Curbing 6" High
All Signs Reflectorized

The Island and Portions of the Median (as shown) are Painted with Glass Bead Reflectorization.
Island and Medians are filled with Concrete except where shown otherwise.
Speed Limits on All Approaches:
Cars 65, Buses 60, Trucks under 4 tons 55, Trucks over 4 tons 50 MPH
Statewide Rural Speed Check indicates 85 percentile about 57 MPH(All Vehicles)

Accidents: None - 1 Year Before Construction
None - 1st Year After Construction

0' 50' 100'
SCALE

EXAMPLE T-3

ILLINOIS, near GREENVIEW
ILLINOIS ROUTE 123-ILLINOIS ROUTE 29

Location

WISCONSIN, Eau Claire
US 53 - Presto Gate

Submitted by

Wayne N. Volk
Engineer of Traffic Services
Wisconsin State Highway Commission
State Office Building
Madison 5, Wisconsin

Type of Intersection

3-Way Tee

Date Opened to Traffic

August 27, 1957

Physical Data

Grades: Nearly flat. Sight distance: adequate.
Surface Type
Roadways: Portland cement concrete (PCC), except asphaltic concrete (AC) at certain approach areas and on frontage road.
Islands: Grass, with vertical curb.
Transit Operations: There is a bus line, but it goes directly into the plant and then out again on the normal roadways.

Traffic Data

Volumes: Specific information is not available at this time for traffic into and out of the large manufacturing plant. There are heavy peak-hour movements into and out of the plant and on US 53. Inbound morning peak traffic comes from the northeast and southwest since workers at the plant live both in Eau Claire and Chippewa Falls. Traffic exits in the evening in both directions. Very little traffic enters the plant when a shift is leaving the plant. There is, however, rather heavy traffic on Highway 53 at both shift change times. "Stop" signs control traffic from the northeast turning left across the northeast-bound lanes of US 53. Traffic outbound from the plant making a left turn to southwesterly is also required to stop before crossing the northeast-bound lanes of US 53. All other movements merge with the main traffic flows.
Design Vehicle: C50
Speeds: Posted speeds 65 MPH for passenger cars, daytime; 55 MPH for passenger cars, night; 45 MPH for trucks.

Operational Characteristics

The plant entrance has adequate capacity for incoming vehicles so there is no back-up into the main roadways. Traffic coming from the southwest and entering the plant is about twice as heavy as traffic from the traffic from northeast. Vehicles making those two movements seem to merge on the approach to the plant entrance without difficulty. The unnamed road leading southwesterly from the Presto gate is a frontage road. The two ramps to Highway 53, one merging with traffic going northeast and the other crossing traffic going northeast serve as the terminal connections for this frontage road. The plant lies in an open suburban area of small homes and few other business places. There are no nearby manufacturing plants. This was a munitions plant during World War II.

Occasionally a traffic officer is required to direct traffic at the afternoon peak, but this is generally limited to summer afternoons when volume on US 53 is heavy. This highway carries substantial tourist traffic as well as commuter and inter-city traffic between the two nearby communities.

Figure 2: Looking West from frontage road across extreme Southwest end of intersection

Figure 3: Looking North across intersection from frontage road at extreme Southwest end

Comments by Committee Members

1. R. T. SHOAF - This channelization design appears to be good for the conditions involved. The flat crossing conflicts could cause difficulty under high volume conditions. However, these volume conditions are not expected since peak volumes and shift changes are not likely to occur at the same time.

2. ROBERT E. DUNN - This is a good example of one of several ways to channelize this type of an intersection.
   This "T" type intersection design effectively blends conflicting traffic streams into controlled merging, weaving and right-angle crossings. The condition warranting channelization is appropriately handled by application of all principles involved.

Additional Comments by WAYNE N. VOLK - Under Traffic Data, I am attempting to secure some traffic volume data for the plant entrance during one of the recent periods of substantial manufacturing activity. We understand that the business which was operating this plant during the past several years transferred most of its operations to another city during late 1960 and there was very little activity during 1961 at this establishment. We believe, however, that the plant may be used again and that data on traffic entering or leaving the plant some three or four years ago might be repeated if the plant is reopened, and further that these data should be included in the discussion of the example, if possible. Volumes probably representative of traffic on the Presto Entrance roadways (not US 53) for the last several years are shown in the accompanying 1948 volume data.

With regard to Mr. Shoaf's comment on the need for traffic officers, we are inclined to agree. However, Presto workers represented a substantial percentage of industrial employment for Eau Claire and were anxious to get home as quickly as possible at the end of their shift; hence the City of Eau Claire furnished traffic officer control. Mr. Shoaf is correct that the flat crossing conflict between inbound and outbound flows was no problem because there was virtually no movement in one direction when the other movement into or out of the plant was taking place.

TRAFFIC VOLUMES
ON PRESTO PLANT ENTRANCE ROADWAYS
February, 1948
12-Hour Counts

	From Eau Claire Northbound		From Chippewa Southbound		From Plant Westbound		Totals		
Time	Ahead	Right	Left	Ahead	Left	Right	N-S	W	All
6AM-7AM	253	24	73	110	26	4	460	30	490
7AM-8AM	76	89	26	137	22	5	328	27	365
8AM-9AM	28	77	2	82	3	1	190	4	194
9AM-10AM	96	21	3	118	23	4	238	27	265
10AM-11AM	106	14	2	93	27	2	215	29	244
11AM-12N	78	12	1	67	21	4	158	25	183
12N-1PM	78	19	6	67	21	5	170	26	196
1PM-2PM	99	16	4	127	12	1	246	13	259
2PM-3PM	116	34	6	174	15	2	330	17	347
3PM-4PM	209	54	11	107	228	61	381	289	670
4PM-5PM	203	54	3	203	46	12	463	58	521
5PM-6PM	194	2	2	121	45	9	319	54	373
Total	1537	416	139	1406	489	110	3498	599	4097
	1953		1545		599				

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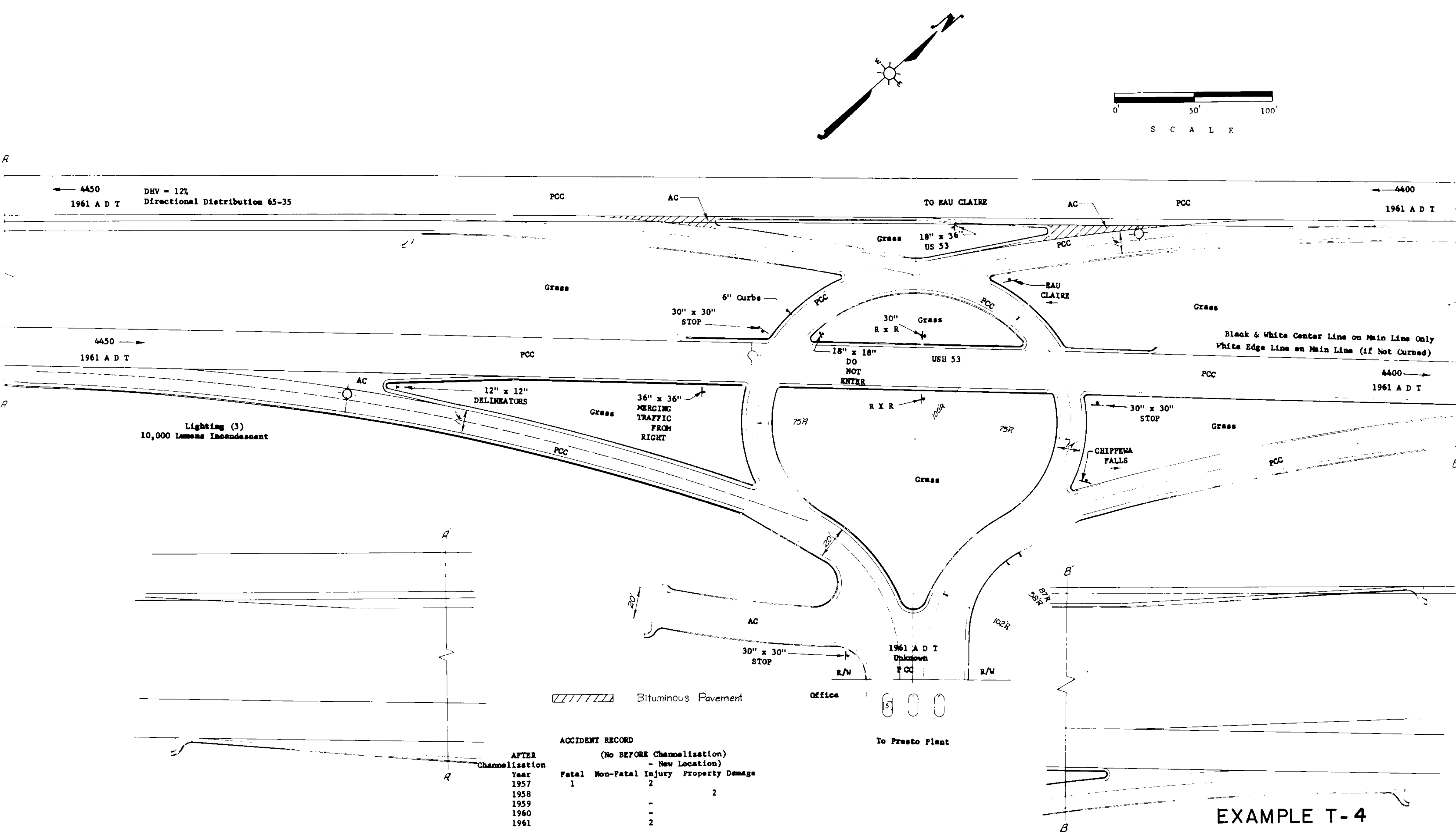
15-Minute Count February 2, 1948

AM									
3:35-3:50	78	3	1	42	237	56	124	293	417



ACCIDENT RECORD

AFTER Channelization

(No BEFORE Channelization) – New Location)

Year	Fatal	Non-Fatal Injury	Property Damage
1957	1	2	
1958			2
1959		-	
1960		-	
1961		2	

EXAMPLE T-4

WISCONSIN, EAU CLAIRE
US 53 - PRESTO GATE

Location

NEW MEXICO, Tularosa
US 54 - US 70

Submitted by

Hurley Von Ehrenkrook
Traffic Engineer
New Mexico State Highway Department
Santa Fe, New Mexico

Type of Intersection

3-Way Tee

Date Opened to Traffic

May, 1961

Physical Data

Grades: Flat; maximum profile grade is 1.1%
Surface Type
Roadways: Plant mix asphalt
Islands: 6" Concrete curb; within islands - chips on one course of asphalt
Shoulders: Curbed parking lane

Traffic Data

Design Vehicle: C-50
Speeds: Speeds generally up 5 m. p. h. in urban area after new construction. About the same in suburban area.
Pedestrian: No pedestrian cross-walks; no significant pedestrian movement.

Operational Characteristics

Comments on Overall Operation of the Channelized Intersection:
The overall operation is generally satisfactory. The intersection was designed to stay within the existing right-of-way and serve the major traffic flow which is turning (east-south) with the flattest curvature possible, and to more definitely define the motorist's right-of-way at the "Y's". This was especially true of the southbound US 70 motorist's conflict with the northbound US 54 motorist at the south wye.

It would have been desired to superelevate the through lanes to a greater degree, but this could not be accomplished due to drainage and the necessity of matching existing property frontage. Circulation to and from a minor cross street cutting into the south tip of the wye may create a slightly unsatisfactory condition. It would be more desirable to locate the driveways to the central development (Gulf Station) farther from the intersections, as they have induced some wrong-way maneuvers to and from the intersections.

Accident experience is meager. This is partially due to poor accident reporting coverage in this community.

Figure 2: Aerial view After channelization

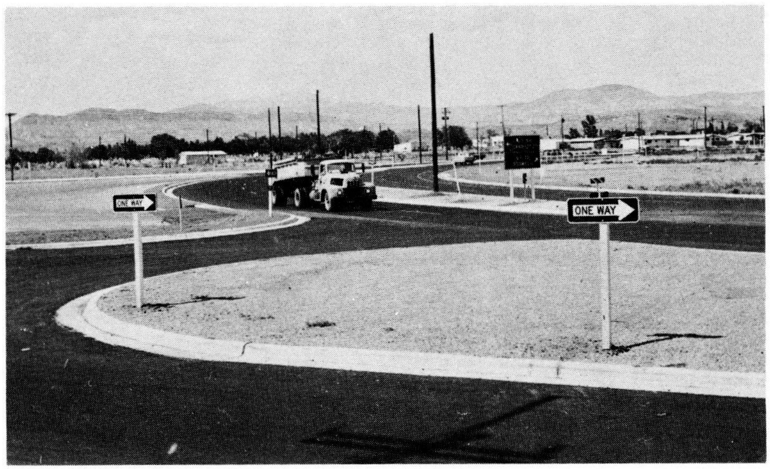


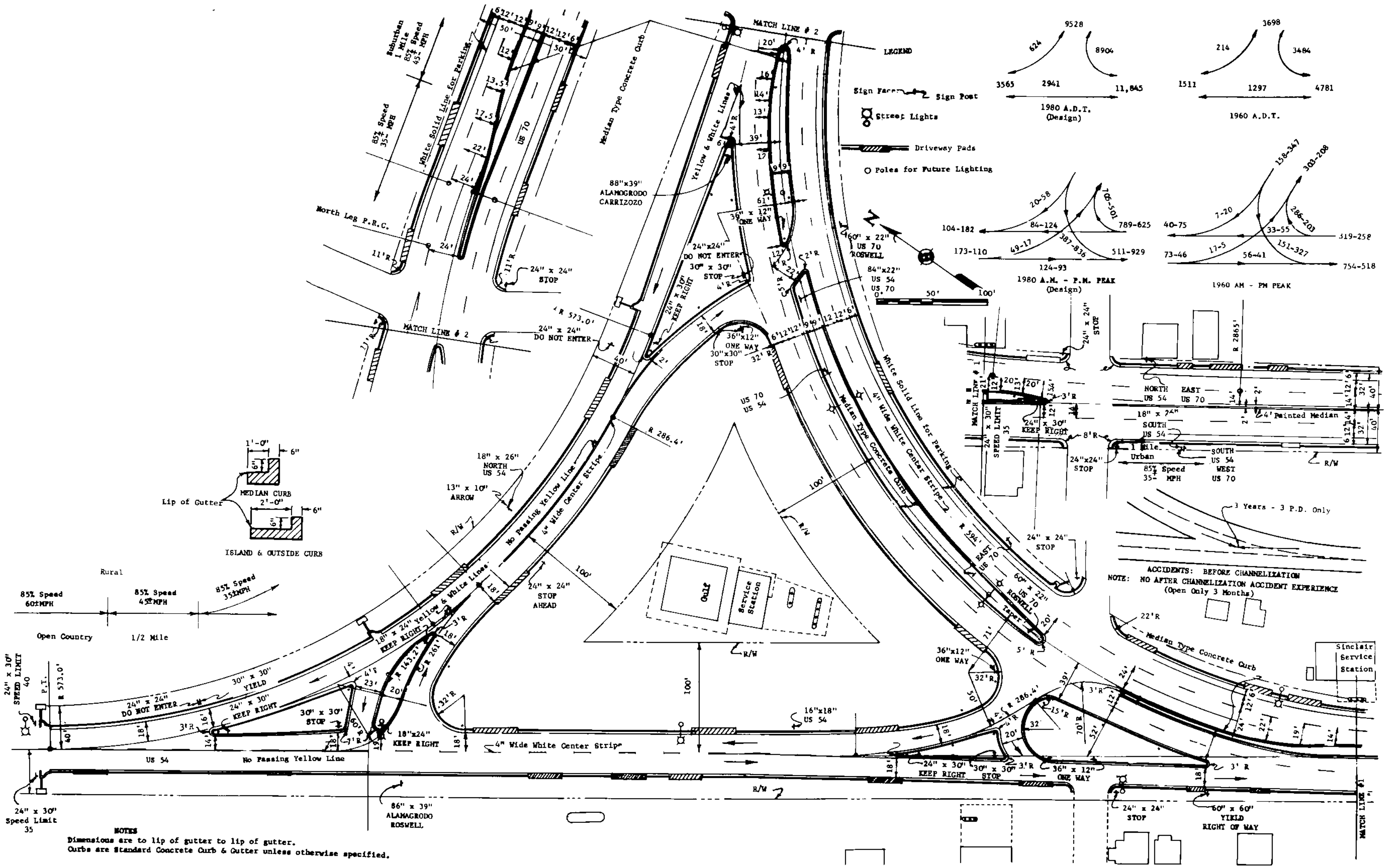
Figure 3: Looking East from Texaco Service Station
After channelization

Figure 4: Looking South from Texaco Service Station
After channelization

Comments by Committee Members

1. WESLEY R. BELLIS - A very good type of design treatment of "T" intersection. Note that at points of cross-traffic there is positive definition of driver intention to aid the other driver. This is very often non-existing at this type of intersection, thereby causing misunderstanding of the other driver's intention which results in unnecessary delays and possibly accidents. This design can carry many more vehicles than expected in 1980. With simple revisions it can carry double the 1980 volumes.

2. KARL MOSKOWITZ - This is a good solution to the T-intersection of two routes where the majority of the traffic is turning traffic. It is unfortunate that here, as in so many similar cases, there is so much private development in the immediate vicinity and that access must be provided for all of these developments. This is a situation that often must be lived with and the solution looks good. It is also noted that the intersections are adaptable for future progressive signalization if traffic volumes become heavy enough to require it. Spreading the conflicting movements out into three separate locations rather than concentrating them at one location will provide much better capacity than would have been possible had the east leg been brought into a perpendicular intersection with the north-south road.



EXAMPLE T-5

NEW MEXICO, TULAROSA
US 54-US 70

Location

MONTANA, Whitefish
US 93 - Montana 40

Submitted by

Maurice Richey, Traffic Engineer
Montana State Highway Department
Helena, Montana

Type of Intersection

3-Way Tee

Date Opened to Traffic

August 22, 1960

Physical Data

Surface Type
Roadways and Shoulders: Bituminous surfaced islands and median-4" of gravel over a plant mix surface, outlined by a 6" mountable curb painted yellow.
Markings: White for lane lines and yellow for no-passing barrier lines approaching median islands.
Abutting Property: Timber land except for service station. See aerial photographs.
Right-of-way did not influence design.

Traffic Data

Design Vehicle: C50
Speeds: Approach speeds 50 to 60 MPH
Accidents: No accidents of record before or after channelization.

Operational Characteristics

The principal reason for channelizing this intersection is to provide a protected left-turn bay for a relatively heavy left-turn volume. We have had operational difficulties when we have introduced a median at an intersection on a two-lane highway. This is probably due to a lack of illumination and adequate approach treatment for the end of the medians. However, for the short life of this installation there has been no record of reported accidents.

The former intersection was located 800 feet north of the present one. Montana Route 40 intersected US 93 at a skew angle of about 40 degrees and the intersection was located behind a crest vertical curve.

Figure 2: Looking East along Montana Route 40

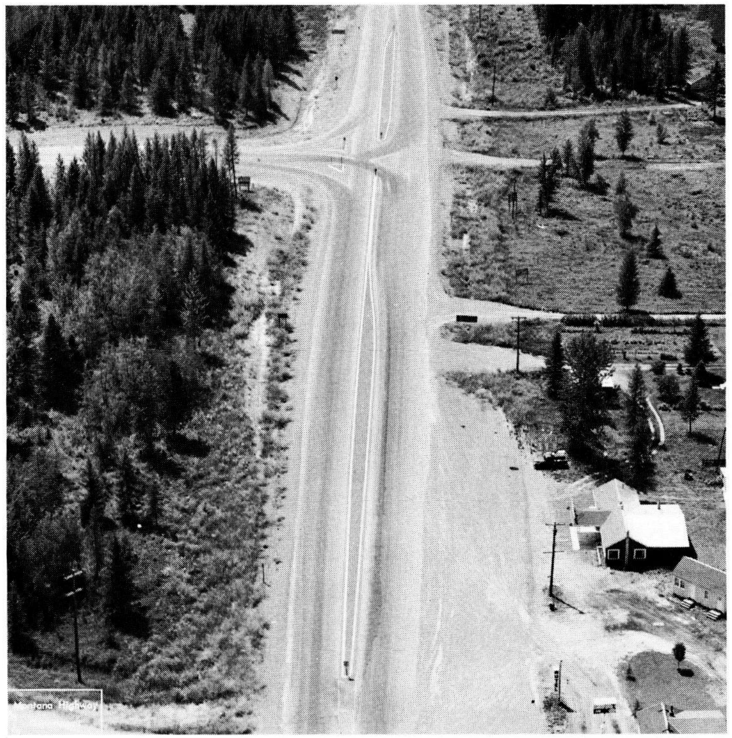


Figure 3: Looking South along US 93

Comments by Committee Members -

1. GEORGE J. FISHER - Standard treatment well used.

   Paint markings are needed at ends of medial islands on US 93. The drawing shows these but the photographs do not.

   Traffic channels between two small islands at entrance to Montana 40 are pretty narrow for turning traffic.

2. CHARLES J. KEESE - This appears to be a good realignment to eliminate a bad skew angle and sight distance problem.

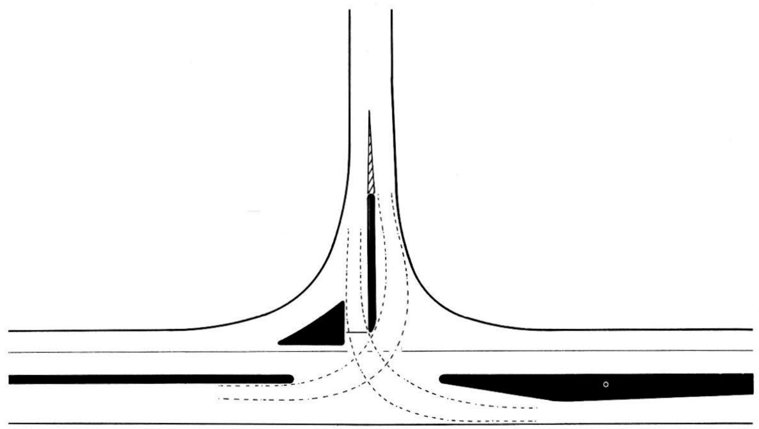
   Judging from the photographs, there appears to be enough area to widen the approach on Montana Route 40 (note the unused area around the two small islands) and provide a divisional island. This would ease turns and reduce the head-on conflict in the narrow space between the two small islands. The photographs show the conflict point to be at the location of the "stop" on Route 40. A sketch of the suggested revision is shown below.

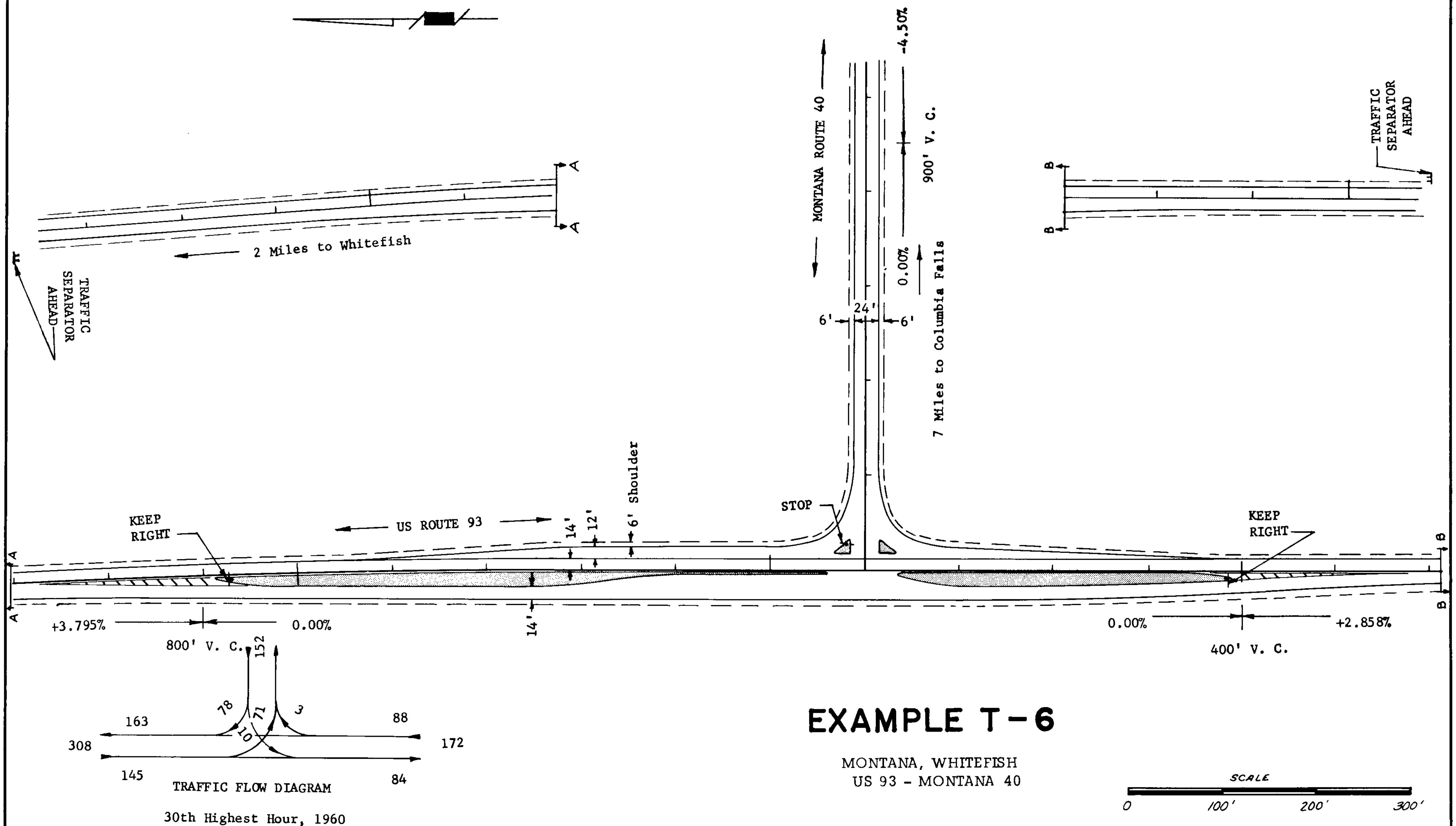
Additional Comments by MAURICE RICHEY -

1. Pavement markings and perhaps jiggle bars would help to delineate ends of medial islands. The markings are shown in the photographs; however, poor maintenance has reduced their effect. It is believed that the addition of lane markings and edge-of-pavement markings would help to channelize traffic in a more definite pattern.

2. It is believed the 30' opening between the small islands on Montana 40 is adequate. It is observed from the photos that the left turning traffic from US 93 is cutting the "stop" traffic lane on Montana 40 south onto US 93. The traffic lane is unoccupied most of the time. It is noted that there are still several feet between the islands that are not being used.

3. The addition of a traffic separator on Montana 40 to channel the left turns from US 93 would decrease any possibility of a conflict between the islands. It would not, however, ease the turning movements since the radius of the turning movement is presently larger than it would be with the separator.





EXAMPLE T-6

MONTANA, WHITEFISH
US 93 - MONTANA 40

Location

CALIFORNIA, San Francisco
Laguna Honda Boulevard - Clarendon Avenue - Seventh Avenue

Submitted by

Ross T. Shoaf, Traffic Engineer
Department of Public Works
460 McAllister Street
San Francisco, California

Type of Intersection

3-Way Tee

Date Opened to Traffic

February 5, 1954

Physical Data

Grades: The approaches are flat.
Surface Type: The roadway surfaces are asphaltic concrete.
The islands are concrete and are raised six inches above the road surface.
Traffic Control Devices
Markings: White
Lighting: The luminaires are 6000 lumen incandescents with Type V distribution mounted 26' high.
Abutting Property: The residence shown in the photograph was owned by the San Francisco Water Department and upon the death of the residence was torn down.

Traffic Data

Design Vehicle: The California Division of Highways semi-trailer, 48-foot minimum radius.

Operational Characteristics

The intersection of Laguna Honda Boulevard and Clarendon Avenue shows the typical treatment we use at the intersection of a heavily traveled road with a light to moderately traveled road. The area surrounding it is undeveloped and there is no pedestrian problem, although sidewalks are provided. The intersections of minor roads are controlled by STOP signs and the major road is uncontrolled. The accident experience, as you can see, is very light and the delays encountered by traffic are also very light. The average delay through the intersection in a normal or peak hour is 1.01 seconds of stop delay per vehicle. I feel that this accident and delay record is much better than we could ever hope to achieve if the intersection was signalized, and so far we have resisted efforts on the part of some of the public to have it signalized.

Figure 2: An intermediate stage in channelization

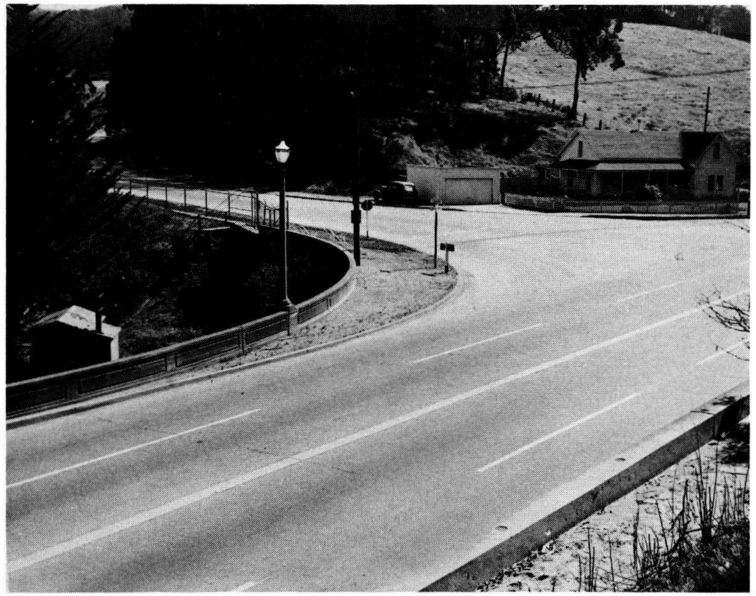
Comments by Committee Members

1. W. R. BELLIS - This is a good design but it is being taxed to the limit in carrying the indicated volumes without traffic signals. A slight increase in traffic and the signals can be deferred no longer. The signals will give a greater capacity, but an increase in accidents and an increase in delays, compared to past experience, can be expected. This increase in accidents and delays will be less than the accidents and delays that would prevail without the signals after the traffic volume has increased.

2. DONALD H. SIDES - The treatment provided is effective in carrying large volumes with only slight delay and hazard. Apparently the channelization was introduced within the confines of existing pavement. The presence of retaining walls, a reservoir and steep slope seem to have made it impractical to widen the west approach for the purpose of lengthening the Laguna Honda Boulevard left-turn slot and easing the somewhat tortuous westbound travel path.

Additional Comments by R. T. SHOAF - True, the channelization near the reservoir was dictated by the existing retaining walls on each side of the roadway. The saving feature probably is the fact that the curving alignment and narrow lanes preceding the intersection have adjusted the motorist's driving senses.

With the existing 5-second average per lane headway of crossing conflicts in the peak hour, we feel that there is at least a 25% allowance for growth without signals. This judgement is based on another intersection of similar design but without any stop signs or signals operating at an average per lane peak hour headway of 2.9 seconds, without back up and with an extremely low accident experience.



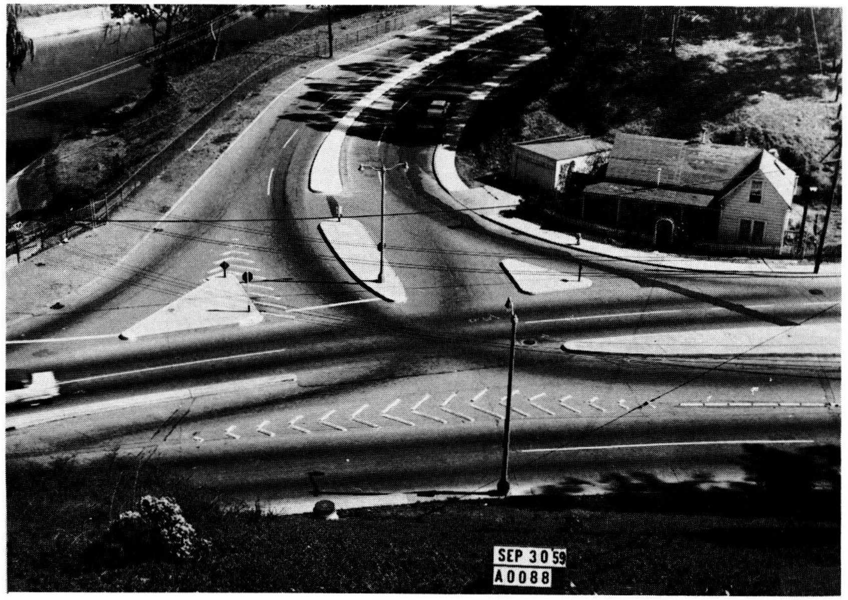
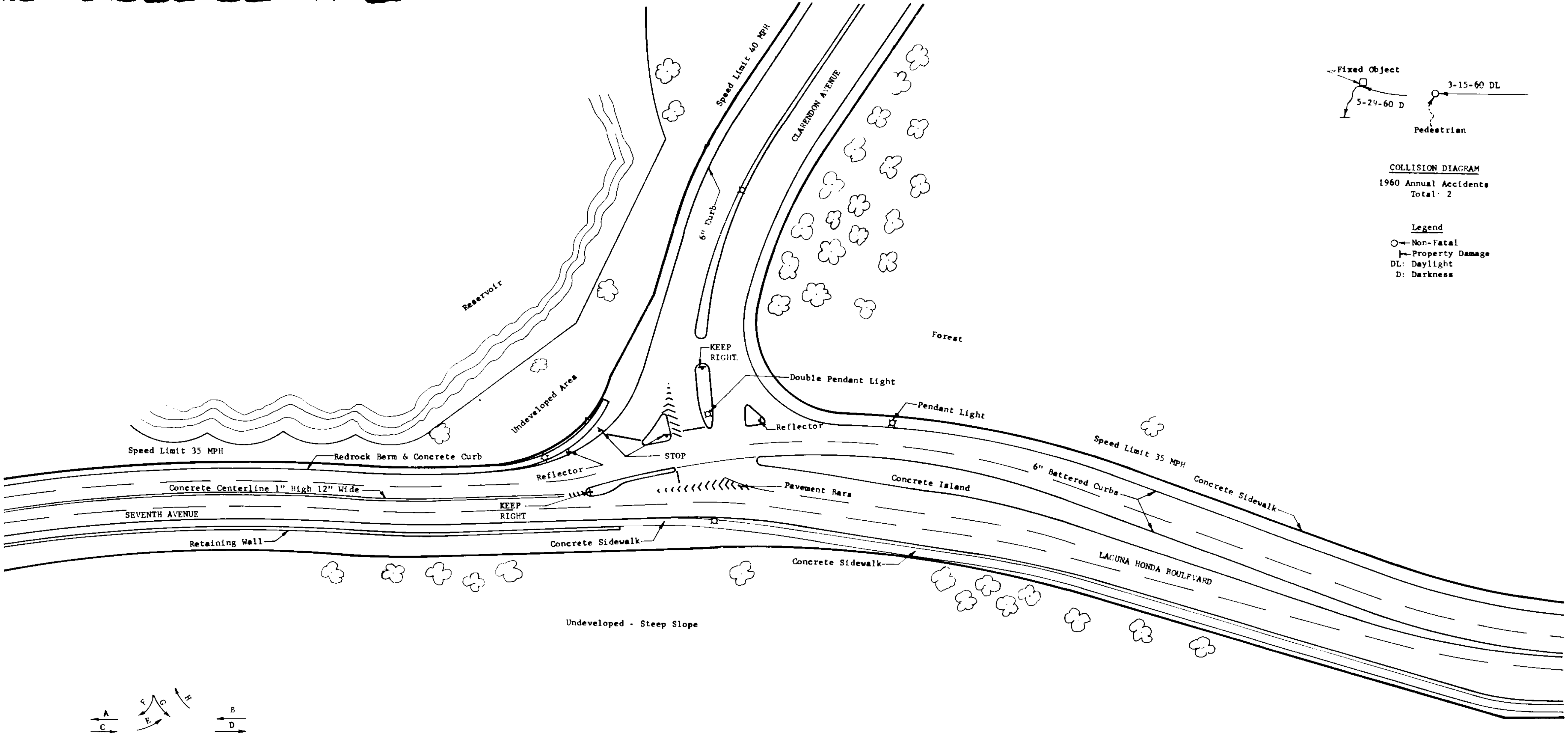


Figure 3: Latest view, After channelization

LAGUNA HONDA and CLARENDON
INTERSECTION DELAY

	VOLUMES Stopping	Total	% STOPPED	STOPPED DELAY (Veh.-Sec.)	DELAY PER. TOTAL (Sec.)	PER. STOPPED (Sec.)
SOUTHBOUND LAGUNA HONDA						
2:00 to 2:15	9	115	0.8	135	1.2	15
2:15 to 2:30	0	87	0	0	0	0
2:30 to 2:45	2	140	0.1	30	0.2	15
2:45 to 3:00	4	115	0.3	60	0.5	15
	15	456	0.3%	225	0.5	15
NORTHBOUND LAGUNA HONDA						
2:00 to 2:15	0	154	0	0	0	0
2:15 to 2:30	0	146	0	0	0	0
2:30 to 2:45	4	156	0.3	60	0.4	15
2:45 to 3:00	2	147	0.1	30	0.2	15
	6	603	0.1%	90	0.1	15
WESTBOUND CLARENDON						
2:00 to 2:15	27	32	84	210	6.6	7.8
2:15 to 2:30	23	30	77	180	6.0	7.8
2:30 to 2:45	31	35	89	330	9.4	10.6
2:45 to 3:00	33	36	92	165	4.6	5.0
	114	133	86%	885	6.6	7.8

TOTAL DELAY - 1200 Veh. - Sec.
Per Stopped Vehicle - 8.9 Sec.
Per Total - 1.01 Sec.



TRAFFIC VOLUMES

Movement	Ave. Daily Vol.	AM Peak Hr. Ave. Day	PM Peak Hr. Ave. Day
A	9150	1105	800
B	10250	1310	850
C	9150	630	1110
D	10250	615	1300
E	700	105	60
F	670	50	100
G	1800	90	250
H	2000	255	150

EXAMPLE T-7

CALIFORNIA, SAN FRANCISCO
LAGUNA HONDA BOULEVARD - CLARENDON AVENUE - SEVENTH AVENUE

Location

CALIFORNIA, San Francisco
Main Drive - Bridge, Golden Gate Park

Submitted by

Ross T. Shoaf, Traffic Engineer
Department of Public Works
460 McAllister Street
San Francisco, California

Type of Intersection

3-Way Tee

Date Opened to Traffic

August 24, 1955

Physical Data

Grades: Not significant
Surface Type: Roadways are asphaltic concrete and there are no shoulders since the lawn runs right down to the edge of the roadway. There are also no curbs and the islands are painted.
Traffic Control Devices
Markings: White paint
Lighting: The luminaires are 6000 lumen incandescents with Type IV distribution mounted 26 feet high.
Right-of-Way: This did not affect the design since all adjacent right-of-way is owned by the Park Department.

Traffic Data

Design Vehicle: The California Division of Highways semi-trailer, 48-foot minimum turning radius.
Pedestrian: Volumes are not significant.

Operational Characteristics

This wye is at the intersection of Main Drive and Bridge in San Francisco's Golden Gate Park. There is a certain amount of pedestrians, but they do not appear to have any trouble crossing and the channelization is only of the painted type. This is in keeping with the character of the Park which generally avoids the use of both curbs and traffic islands, and it seems to work very well since automobiles, almost without exception, keep in the lined paths designated for them. The accident record is very good, especially considering the extremely heavy volumes of traffic, and the delay situation is even better than that at Laguna Honda and Clarendon (Example T-7). The average stop delay per vehicle through the intersection in the normal or peak hours is approximately 0.4 of a second, and it increases only slightly during the heavy peak hours. As you can see, there is no designated form of control, although the stop bar indicates the majority of motorists traveling eastward on Main Drive are to yield the right of way to motorists turning onto Bridge Drive. This seems to work very well.

I am hopeful that H. R. B. Report No. 5 can contain something about painted channelization because I think too often traffic engineers overlook the fact that good traffic control does not always have to be costly. Many times major problems can be solved without having to wait for a budget appropriation.

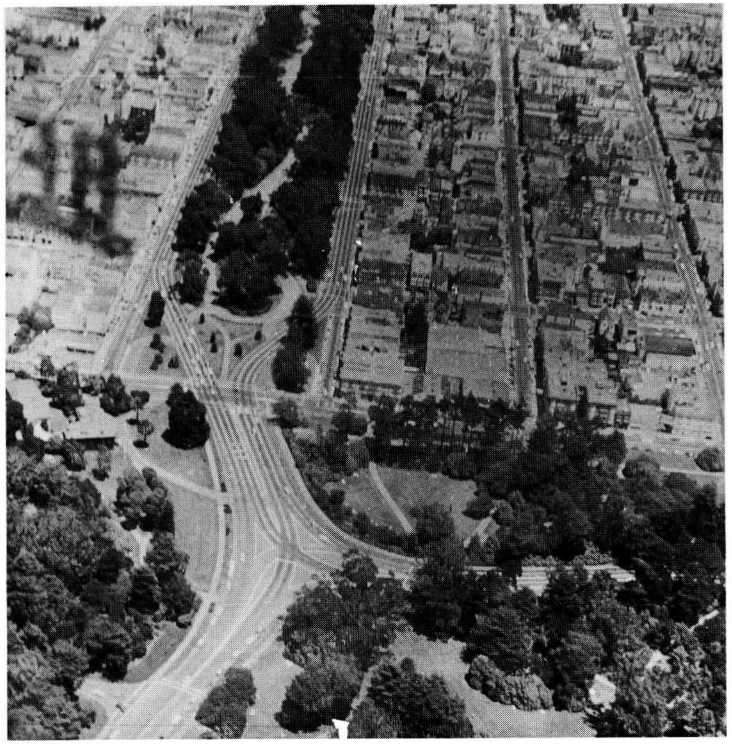


Figure 2: Aerial view, After channelization, looking Northeast

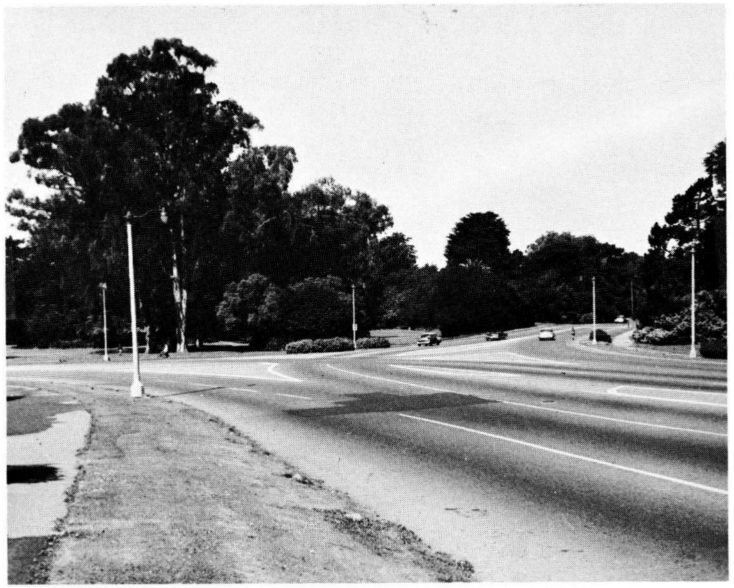


Figure 3: Looking West, across the painted islands

Comments by Committee Members

1. IRV. WEINBERG - It should be noted that painted islands are not suitable in areas where snow-fall is heavy enough to cover and remain on pavement as there is no demarcation. Also serious thought should be given to using painted areas as pedestrian refuge islands. The question of protection is not adequately answered by using paint.
   From the operational point of view (using paint or curbing), flow B (a through flow) on pavement width for 2 vehicles merges with flow D on pavement width adequate for 2 vehicles and they, (the 4 lane width total) become 2 lanes in about 50 feet. (I cannot see why pavement width for flow D is so wide for so short a length of curvature when the approach is for single lane turn.) More merge-area pavement should be provided.
   Similarly approach pavement for flow F & E appears to be single lane, widening to 2 lanes for flow E turn. I would recommend single vehicle operation lane width only for low F from where flow E branches off to where flow F merges with flow C because it is doubtful that flow F would approach a merge with flow C in a 2 cars-abreast pattern as traffic density increases on flow C.

2. WARREN TRAVERS - I agree substantially with Mr. Weinberg's comments, although there can be little criticism of the channelization as originally submitted, based on the effectiveness of the operation as experienced thus far.
   Virtually all of the "islands" are sufficiently large to be raised, thereby permitting the installation of guide and control signs at their respective optimum locations. Also, there is a question of legality in some states whereby it is required that stop bars be supplemented with the appropriate control signs. Mr. Shoaf notes that raised islands would be out of character with the park. This, of course, may be the opinion of others and not necessarily that of Mr. Shoaf. In any event, however, I do not concur. Islands can be esthetically pleasing if properly treated, and often are an asset to a landscaped environment, particularly if they are large and not cluttered with a multitude of signs.
   I heartily agree with Mr. Shoaf on more extensive use of paint generally, even in snow areas, in lieu of "waiting" for budget approvals, etc.

Additional Comments by ROSS T. SHOAF - General: I must agree that a painted island covered with snow would give no delineation. However, I wonder if, in addition to Mr. Travers' concurrence with the idea of "engineering with paint" in lieu of waiting for budgets, there might not be an additional advantage. At a location with an almost exclusive use by commuters, is it not possible that the painted pattern followed the major portion of the year will be sufficient to carry over the winter season so that problems will never be created to warrant a budget appropriation? (This question is asked by a traffic engineer with no snow experience at all - or should this be mentioned?)

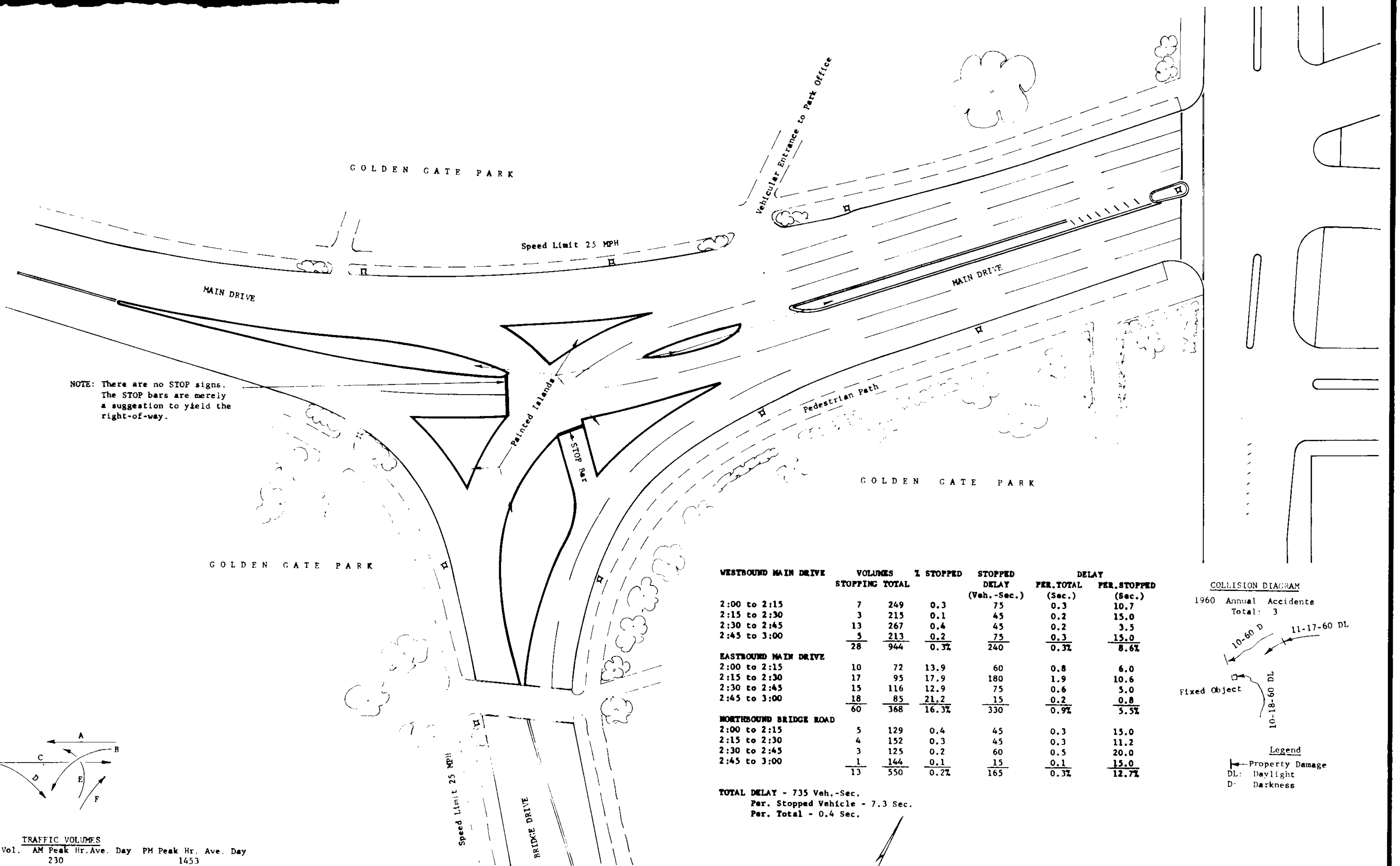
Reply to specific comments by Irv. Weinberg: Flow D which merges with B is so light that practically it can be ignored. Why then two lanes? Only because we were not confident that raised islands would not be eventually required and if so, even a very, very light flow might be plugged by a breakdown or parking if only one lane wide. As a basic criticism, without knowledge of local condition I would agree with Mr. Weinberg. Again, Mr. Weinberg's criticism regarding flows E and F is sound. Our drawing is misleading - a draftsman's error.

The restriction in Bridge Drive is approximately 800' south of the intersection and while we do have an offset centerline because of the restriction, traffic flow F has already started to use two lanes even though the wider area is not so striped.

I do not so readily agree with Mr. Weinberg's criticism regarding pedestrian crosswalks. Outside of the one crosswalk that is painted, there is little, if any, O-D need for pedestrians to cross in this area - and pedestrians seldom do cross even though the age-old path opening shown indicates a possible use. I feel that many times not only is it impossible to physically prohibit pedestrian crossings but at times it is necessary to allow light pedestrian crossings, yet the greatest safety for the pedestrian is to NOT paint a crosswalk. I believe many times pedestrians are encouraged to ignore safe crossing periods when crosswalks are painted. This is not an argument against the use of crosswalks but for careful consideration as to when they should be used.

Reply to specific comments by Warren Travers: While it is true that the question of esthetics in Golden Gate Park is not a responsibility of the Traffic Engineer, I feel that I would not suggest raised islands for their esthetic quality even if landscaped.

The point about stop bars is well taken. They have no legal status in California and there was some question if they would work without a sign which would have required a raised island for protection. As a result of the acceptance by the public of these bars without legislation or sign and without enforcement, the use has been increased with much success.



WESTBOUND MAIN DRIVE	VOLUMES STOPPING	VOLUMES TOTAL	% STOPPED	STOPPED DELAY (Veh.-Sec.)	DELAY PER.TOTAL (Sec.)	DELAY PER.STOPPED (Sec.)
2:00 to 2:15	7	249	0.3	75	0.3	10.7
2:15 to 2:30	3	215	0.1	45	0.2	15.0
2:30 to 2:45	13	267	0.4	45	0.2	3.5
2:45 to 3:00	5	213	0.2	75	0.3	15.0
	28	944	0.3%	240	0.3%	8.6%
EASTBOUND MAIN DRIVE						
2:00 to 2:15	10	72	13.9	60	0.8	6.0
2:15 to 2:30	17	95	17.9	180	1.9	10.6
2:30 to 2:45	15	116	12.9	75	0.6	5.0
2:45 to 3:00	18	85	21.2	15	0.2	0.8
	60	368	16.3%	330	0.9%	5.5%
NORTHBOUND BRIDGE ROAD						
2:00 to 2:15	5	129	0.4	45	0.3	15.0
2:15 to 2:30	4	152	0.3	45	0.3	11.2
2:30 to 2:45	3	125	0.2	60	0.5	20.0
2:45 to 3:00	1	144	0.1	15	0.1	15.0
	13	550	0.2%	165	0.3%	12.7%

TOTAL DELAY - 735 Veh.-Sec.
Per. Stopped Vehicle - 7.3 Sec.
Per. Total - 0.4 Sec.

COLLISION DIAGRAM

1960 Annual Accidents
Total: 3

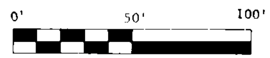
10-60 D
11-17-60 DL
Fixed Object
10-18-60 DL

Legend
Property Damage
DL: Daylight
D: Darkness

A
B
C
D
E
F

TRAFFIC VOLUMES

Movement	Ave.Daily Vol.	AM Peak Hr.Ave. Day	PM Peak Hr. Ave. Day
A	7000	230	1453
B	9400	Not Available	1644
C	6300	1400	330
D	300	Not Available	15
E	600	Not Available	31
F	9400	Not Available	466



S C A L E

EXAMPLE T-8

CALIFORNIA, SAN FRANCISCO
MAIN DRIVE - BRIDGE DRIVE (GOLDEN GATE PARK)

Location

DELAWARE, Christiana
Delaware Route 7 -
Delaware Route 273

Submitted by

Ernest A. Davidson, Chief Engineer
Delaware State Highway Department
Dover, Delaware

Type of Intersection

3-Way Tee

Date Opened to Traffic

November 15, 1960

Physical Data

Surface Type
Roadways and Islands: Bituminous concrete
Shoulders: Delaware Route 7 - Select borrow, 8'; Delaware 273 - Bituminous surface treatment, 10'.
Curb: Delaware Routes 7 and 273 from intersection north - barrier type; in channelization: mountable type.
Abutting Property: Rural, but developing slowly

Traffic Data

Speeds: Delaware Route 7 - 50 MPH
Delaware Route 273 - 45 MPH
Delaware Routes 7 & 273 - 45 MPH
Accidents: The accident record here is minor.
Pedestrian: Volume is negligible.

Operational Characteristics

This intersection was designed to accommodate traffic of which the majority runs to and from the north and east. The turn from east to south is quite minor. The design was intended to serve turning traffic with the least hindrance to straight traffic. To date, this objective has been reached.

The one drawback to this intersection is that some southbound drivers (especially some truckers) tend to begin their left turn before the end of the barrier lines, and as a result hit the point of the center island. As a result, the entrance is scheduled to be widened to 20 feet.

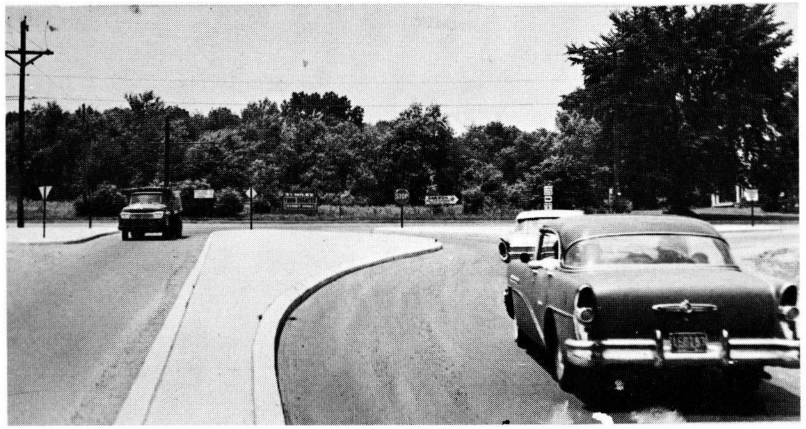


Figure 1: Looking West on Hare's Corners Road (Delaware Route 273), showing the dead-end condition and approach to the turning

Figure 2: Looking from Delaware Route 7 across on Delaware Route 273, showing the southern approach to the intersection. Christiana to the left.
Note: Two apparent discrepancies: One, the present change-over from three-line to two-line system of road painting shows two apparent barrier lines and a skip line. One barrier line is the old mark. The other discrepancy is the lack of a flasher on the pole as shown in the drawing. This is to be installed shortly, in order to give full double indication here.

Figure 3: Looking Southeast from North approach, showing right-turn channelization and further painting, allowing a merge condition instead of the yield or stop which would be necessary if both through lanes were used. Christiana to the extreme right.

Comments by Committee Members

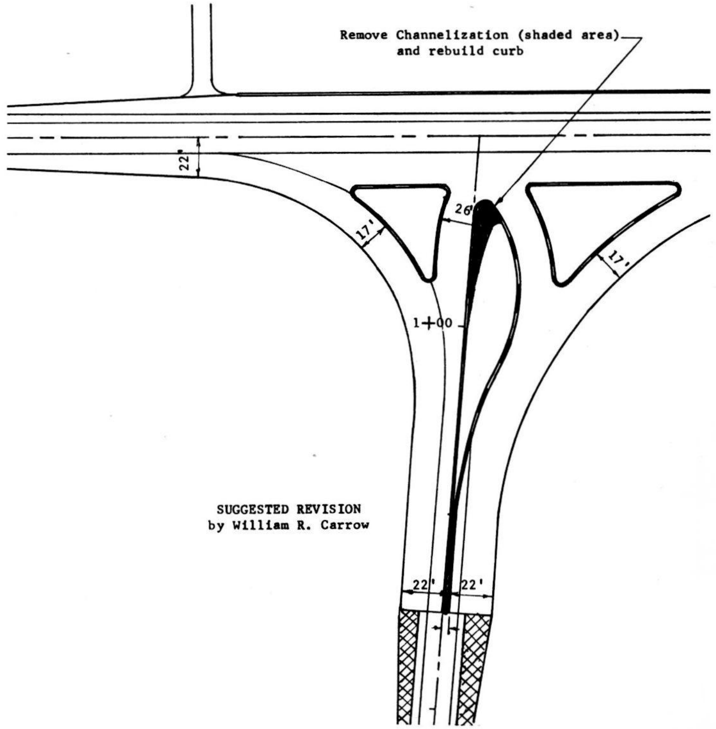
1. EUGENE MAIER - The design appears to be minimum for southbound vehicles turning onto Route 273 and this fact is confirmed in the discussion under "Operational Characteristics". Good visibility of the islands has been achieved by the use of contrasting color between the island and the roadway surfaces. In rural areas where speeds are in the range of 45 to 50 MPH, some designers choose to use a mountable curb on the islands in preference to the barrier type used at this intersection.

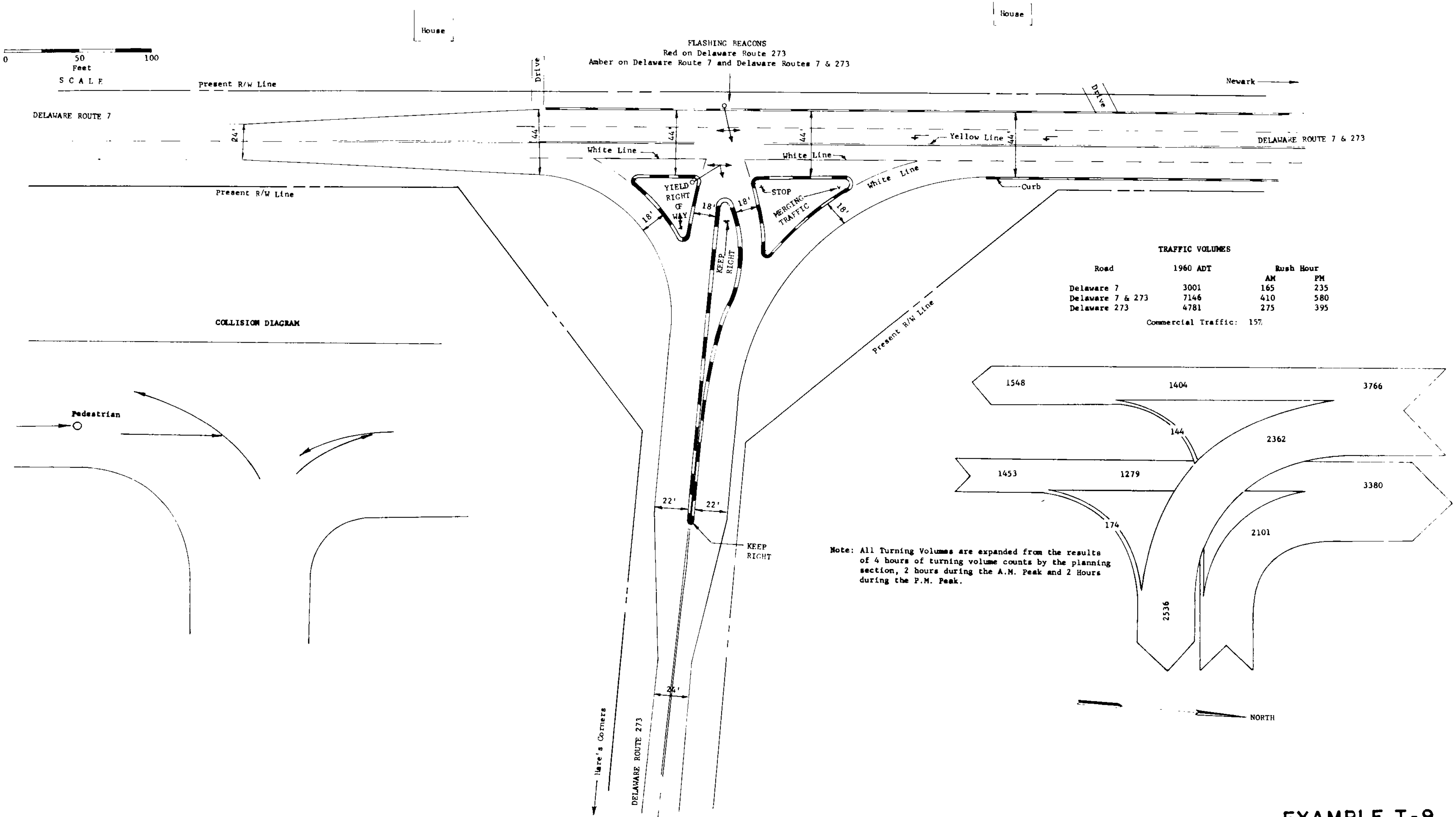
2. IRVING B. WEINBERG - The design as it exists should work well; it performs its function of minimizing the maneuver for south to east. Another feature that is worth emphasis is the adequate road width at merge locations. Merging flows are not squeezed into a "point" of merge.

   My only comment about the design itself is that an unnatural reverse curve maneuver is required by westbound to south flows (and it is doubtful that this course would be followed) but instead, a curve-cutting direct route would probably be taken. This would result in the entire pavement between "bull-noses" (median and channelization islands) being commanded by the east southbound vehicle instead of the pavement being available to a decelerating reverse-curving minor flow vehicle and an east to north major flow vehicle. This condition of improper lane occupation could affect capacity.

   It is therefore suggested that the bulbing-out of the center island be streamlined to encourage the minor flow to keep left and follow a designed path rather than a convenient (and in this case, more direct) path.

<u>Additional Comments by WILLIAM R. CARROW</u>, Traffic Engineer, Delaware State Highway Department - The revised sketch showing a proposed change in channelization at the intersection of Delaware Route 273 and Delaware Route 7 would facilitate easier turns for larger tractor trailers (73' radius). This change would considerably widen this lane (approximately 26'). Should this be done properly, the removal of channelization should extend back to Station 1 + 00 on Route 273 (as shown on print).





TRAFFIC VOLUMES

Road	1960 ADT	Rush Hour AM	Rush Hour PM
Delaware 7	3001	165	235
Delaware 7 & 273	7146	410	580
Delaware 273	4781	275	395

Commercial Traffic: 15%

Note: All Turning Volumes are expanded from the results of 4 hours of turning volume counts by the planning section, 2 hours during the A.M. Peak and 2 Hours during the P.M. Peak.

EXAMPLE T-9

DELAWARE, CHRISTIANA
DELAWARE ROUTE 7 - DELAWARE ROUTE 273

Location

CALIFORNIA, Berkeley
Derby Street - Warring Street

Submitted by

Roy E. Oakes, Traffic Engineer
Department of Public Works
Berkeley, California

Type of Intersection

3-Way Tee

Date Opened to Traffic

August 9, 1956

Physical Data

Surface Type
The traveled roadways are asphalt surfaced and delineated by 6"-high standard concrete curbs. The concrete island itself is poured monolithically on the pavement and is 6" high.
Traffic Control Devices
a. Signals: There are no traffic signals at this intersection.
b. Markings: Pavement markings are white.
Transit Operation: Transit does not operate on either street.

Traffic Data

Design Vehicle: C43
Pedestrian: Pedestrian volumes are extremely light at the intersection.

Operational Characteristics

The example selected is .... on one of the major traffic routes that serve the University of California. The channelization itself is minor, consisting of one concrete island and a painted island. Yield Right-of-Way Signs are used in order to keep the heavy turning volumes moving and to control only the minor movements.

Prior to the channelization there was considerable hesitancy on the part of the southbound left-turning movement to make a turn since they did not know whether a vehicle from the east was going to make a right turn or go straight through.

It is our opinion that the channelization with the Yield Right-of-Way signs has clarified the motorists' responsibility and traffic does move through the intersection quite freely.

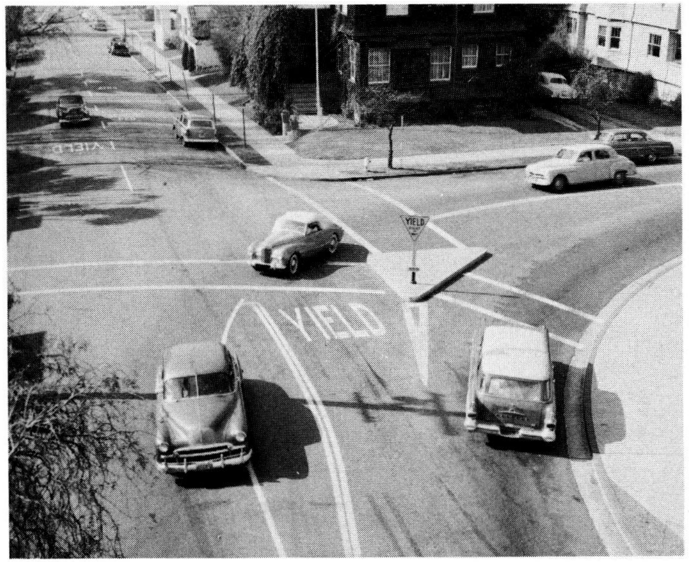


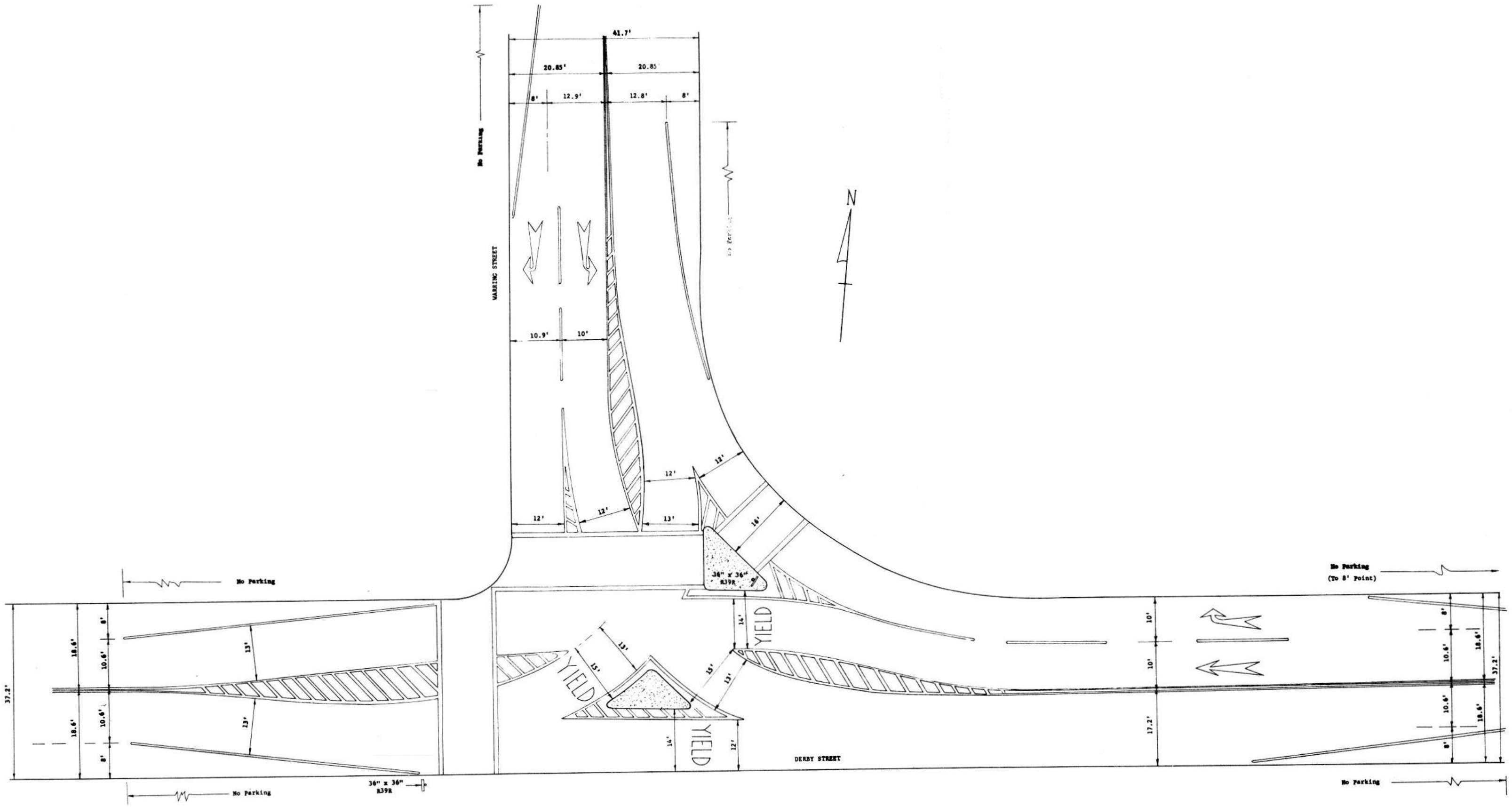
Figure 1: Looking West along Derby Street

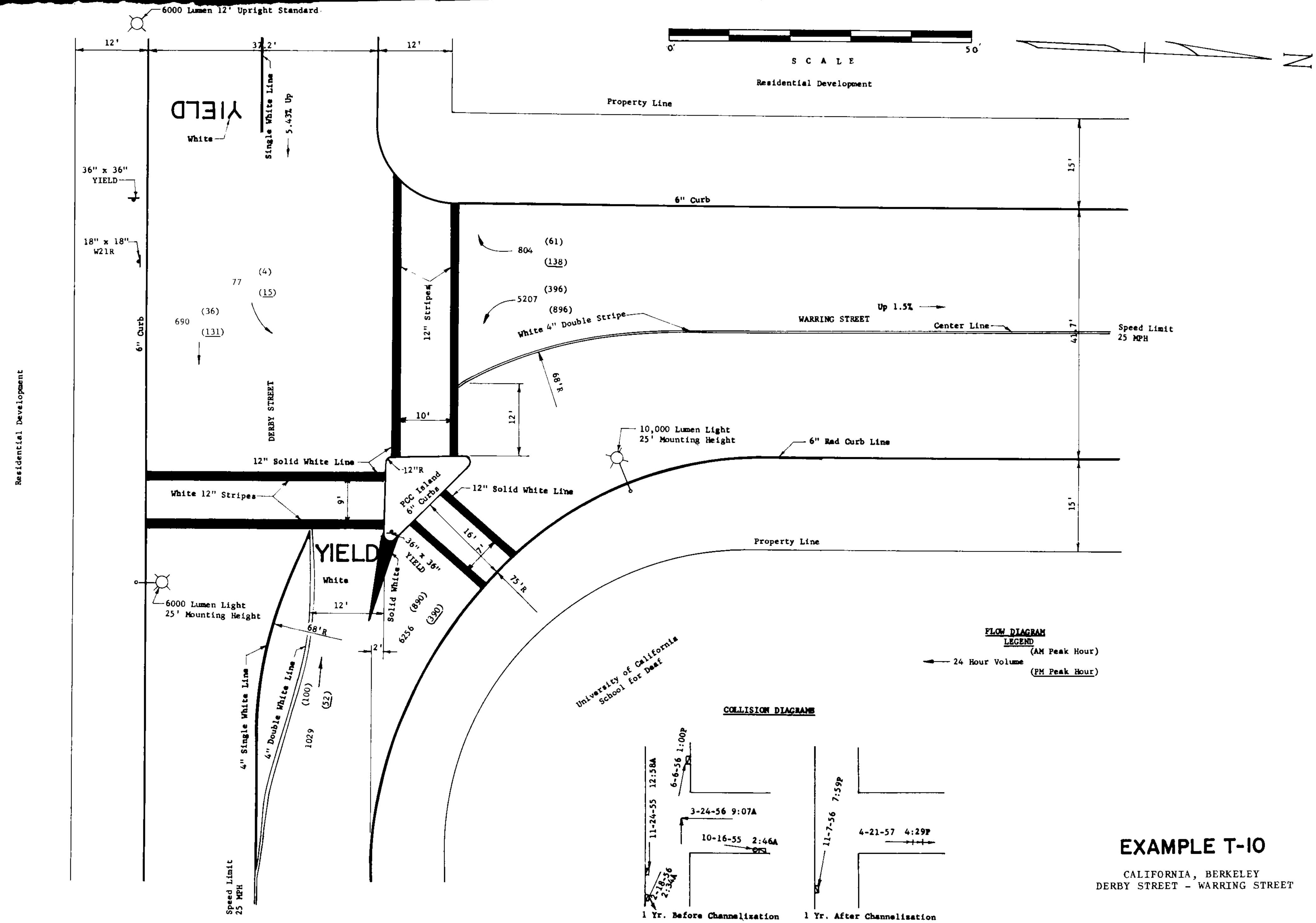
Comments by Committee Members

1. WARREN TRAVERS - It is assumed that any suggested revisions are to be kept within the confines of the curb lines as shown on the illustration originally submitted. It is further assumed that no turning movement(s) may be prohibited, regardless of magnitude.
General: An attempt is made in the revised sketch to give better definition to vehicular paths and to reduce the size of the area of conflict through more extensive use of painted channelization. Except for provision of additional vehicular storage and relocation of one crosswalk, all other operating functions are essentially the same.
Derby Street--East Approach - The centerline has been offset to provide two (2) lanes on the approach--one for heavy right-turning traffic (6256) and one for the very moderate through traffic (1029). The through traffic is required to yield. Hence, since it is in its own lane, it will not interfere with right-turning traffic.
Warring Street--North Approach - Same as above.
Derby Street--West Approach - Traffic on this approach is extremely light (767); hence, a one-lane approach is adequate. Of the total ADT of 767 vehicles, 77 turn left and 690 go through, with both of these movements being required to yield. It was felt that the original design did not provide adequate definition of vehicular path from the viewpoint particularly of interference with the heavy left-turning traffic on the Warring Street approach.
Crosswalk Across Derby Street - The revised plan shows the crosswalk to be relocated to the west side of the intersection. This forces pedestrians crossing between the northeast corner and the south side of Derby Street to cross and recross the traffic flows in the northwest quadrant, which they otherwise would not have to do. In this same regard, however, pedestrians crossing from the northwest corner to the west side of Derby Street presently must cross and recross the heavy left-turning traffic from the Warring Street approach.
Pedestrian counts were not submitted; further, it is impossible to determine which direction they are predominantly traveling along the west side of Derby Street. Hence, it is not possible to determine whether the revision will result in a net addition to person/vehicle conflict or whether the revision prescribes a circuitous routing which may be impractical to control. It does not appear likely, however, that the number of pedestrian/vehicular conflicts will be increased, since there would have to be more than six times the number of pedestrians crossing Derby Street from the northeast corner as cross from the northwest corner, all other factors equal. Perhaps more important, however, particularly in the case of pedestrians crossing Derby Street from north to south, is that the original design does not provide a good crossing angle with respect to the heavy left turn from Warring Street. Further, the original location is not good with respect to this same traffic movement, since the sespective drivers would be less cautious at this location than at the crosswalk on their immediate approach. The latter is compounded, since the basic design encourages efficiency of vehicular flow for this heavy movement. The relocation of this crosswalk appears to be principally a matter of whether the routing is too circuitous, hence the practicality of controlling it.

2. GEORGE J. FISHER - Mr. Oake's revision of the operational characteristics are logical and inexpensive.
Mr. Traver's revised design is a further improvement and should make operation safer and simpler.

Additional Comments by ROY E. OAKES - Mr. Traver's design appears to be a satisfactory modification where the additional suggested prohibition of parking would not present a problem, and where the additional islands would not interfere with any driveway entrances.





EXAMPLE T-10

CALIFORNIA, BERKELEY
DERBY STREET - WARRING STREET

Location

WISCONSIN, Fond Du Lac County
US 151 - Wisconsin 26

Type of Intersection

3-Way Wye

Traffic Data

Design Vehicle: C50
Speeds: Posted Speeds 65 MPH daytime;
55 MPH night for passenger vehicles;
45 MPH for trucks

Submitted by

Wayne N. Volk
Engineer of Traffic Services
Wisconsin State Highway Commission
State Office Building
Madison 5, Wisconsin

Date Opened to Traffic

November 9, 1954

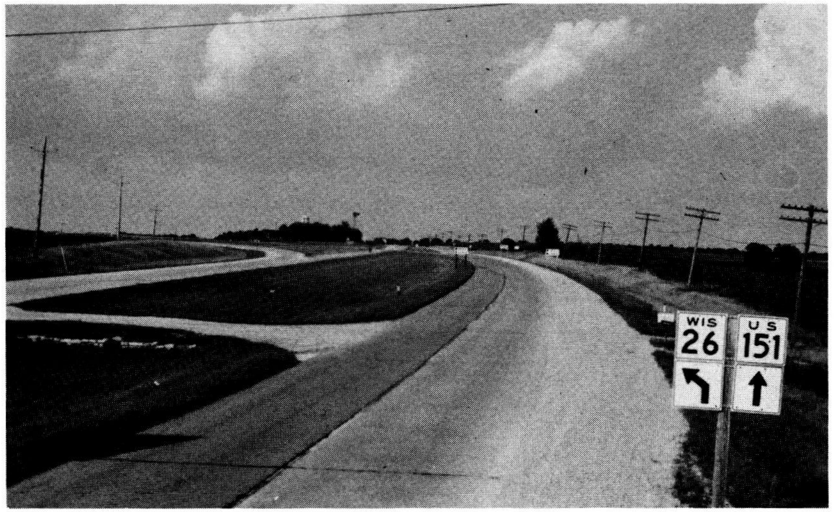


Figure 2: Looking Northeast across islands from US 151

Comments by Committee Members

1. EUGENE MAIER - This is a good example of the use of channelization at a Y-type intersection to define and control the two major points of conflict. Very few reported accidents occurred at the intersection either before or after the channelization. I would question the use of the YIELD sign where eastbound traffic on Route 151 turning left onto Route 26 conflicts with westbound traffic on Route 151. A more positive control would appear desirable but this observation is not supported by the accident experience.

2. DONALD H. SIDES - This pattern of channelization is typical of that evolved in many areas where an intersecting road joins a through highway at an angle of about 45 degrees. The designer has made good use of moderately curved alinement to introduce the divided sections.
   The accident record does not prove the point but it would appear desirable that somewhat greater curvature could have been placed in westbound US 151. This would have provided more separation between the decision points where US 151 traffic turns to the north on Wisconsin 26 and the crossing of westbound US 151. Also, the very flat angle crossing of the roadways would have been reduced.
   The pictures indicate somewhat deficient signing. Possibly speed zone signs should be provided to encourage speeds lower than the legal 65 MPH.

Additional Comments by WAYNE N. VOLK - The "Yield to Traffic from Right" sign is not a standard "Yield" sign. It is not possible under our statutes to use the standard sign. The sign used merely reminds motorists of the statutory requirement to yield to traffic from the right. It is a horizontal rectangle. We are inclined to agree with Mr. Maier that it would appear that a more positive control might be desirable, but we have found this type of control to be entirely satisfactory in a dozen or more situations located throughout the state. In several instances we have removed stop signs at such crossings.

The number of southbound motorists on Highway 26 turning left to go east on Highway 151 and the reverse movement is very small. This is probably the major reason for the successful operation of these two turning lanes.

The short bituminous wedges were intended to induce through movements to stay in the right-hand lane and to identify the left-hand lane as being for the left turn. Since most motorists stay in the right lane and avoid the bituminous surface, this has not worked out as planned.

We have added some direction signs which were not shown on the original drawing, which may answer Mr. Side's criticism.

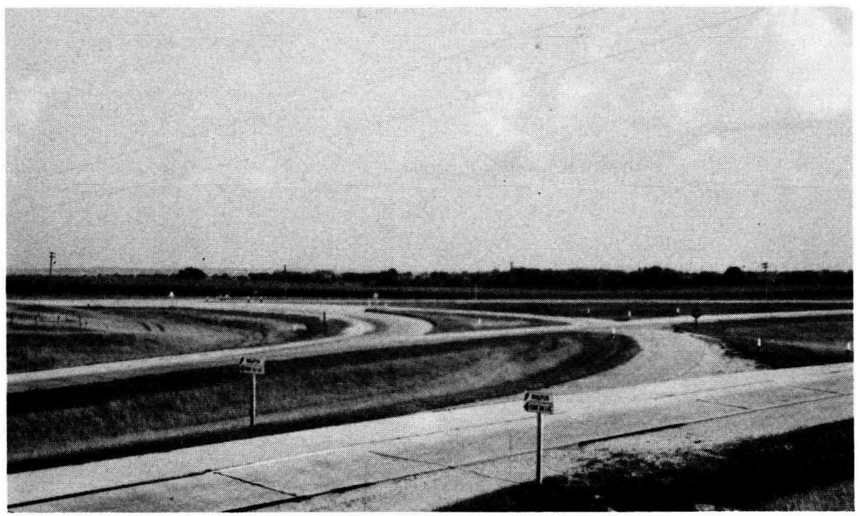
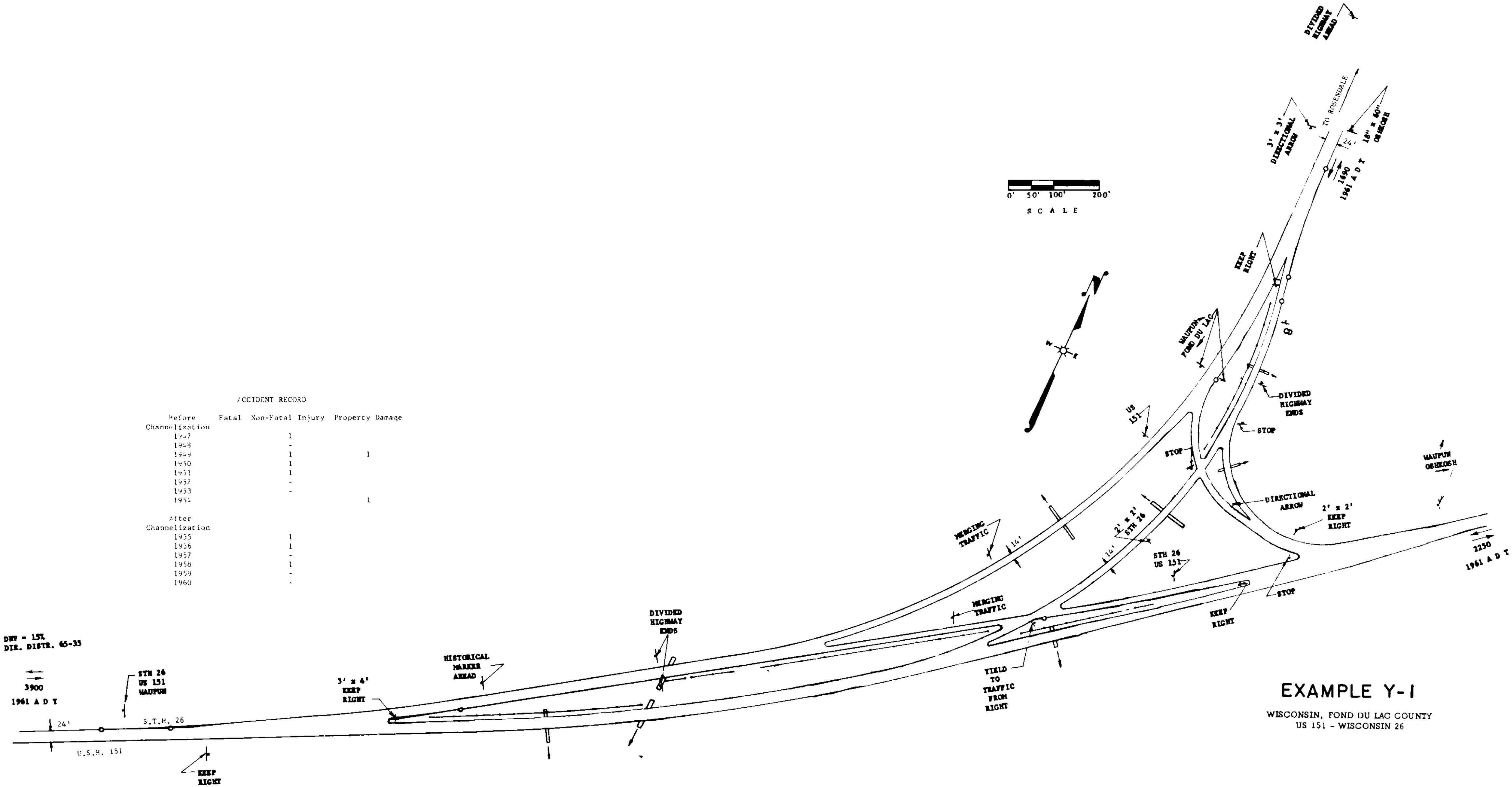


Figure 1: Looking South across islands from State Highway 26

Figure 3: Looking Northeast from US 151



ACCIDENT RECORD

Before Channelization	Fatal	Non-Fatal Injury	Property Damage
1947		1	
1948		-	
1949		1	1
1950		1	
1951		1	
1952		-	
1953		-	
1954			1
After Channelization			
1955		1	
1956		1	
1957		-	
1958		1	
1959		-	
1960		-	

EXAMPLE Y-1

WISCONSIN, FOND DU LAC COUNTY
US 151 - WISCONSIN 26

Location

NEBRASKA, Omaha
42nd Street - Q Street

Submitted by

Burt Whedon, City Traffic Engineer
504 City Hall
Omaha 2, Nebraska

Type of Intersection

3-Way Wye

Date Opened to Traffic

October 2, 1960

Physical Data

Surface Type
Roadways: Portland cement concrete
Islands: Grass
Shoulders: Grass
Curbs: 6" vertical curb at all paving edges
Right-of-way Limits: Not critical

Traffic Data

Design Vehicle: C50
Speeds: Posted Speed Limit: 35 MPH
Pedestrian: No Cross-Walks. Sidewalks on south side of Q Street only.

Operational Characteristics

Seems to operate satisfactorily, based on limited experience. Elements of design which contribute to any unsatisfactory operation: "Some indecision on the part of drivers on Q Street stopping for signal,--unsure just where to stop; no "Stop" line marked.

Figure 1: North leg looking Southwest

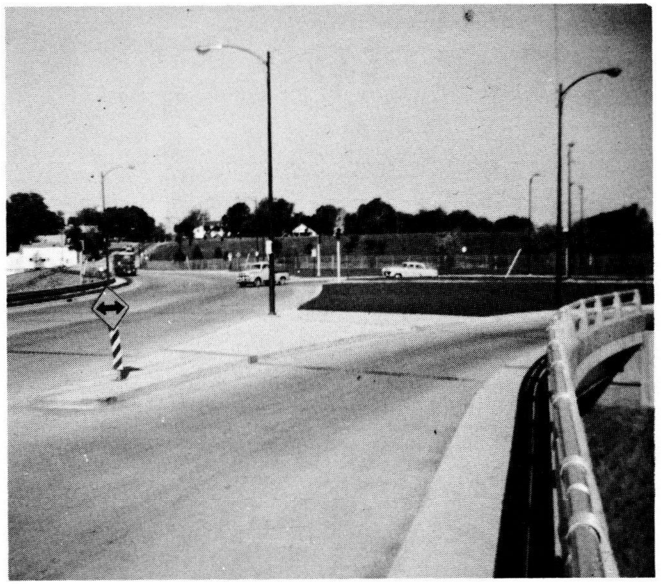


Figure 2: East leg looking West

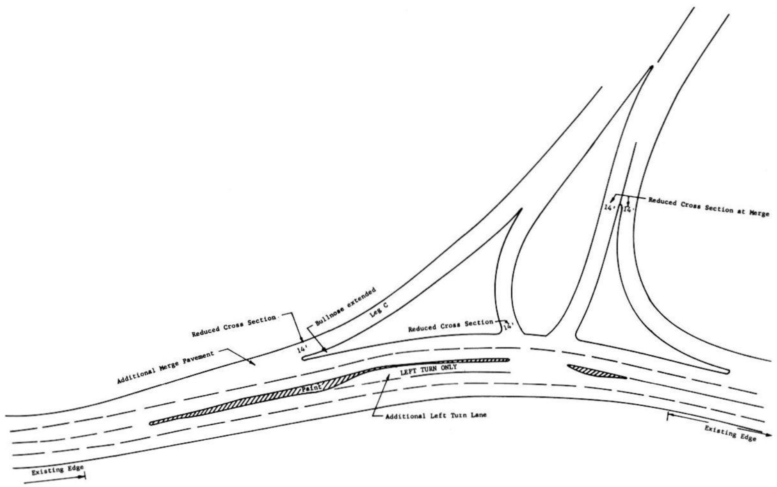
Comments by Committee Members

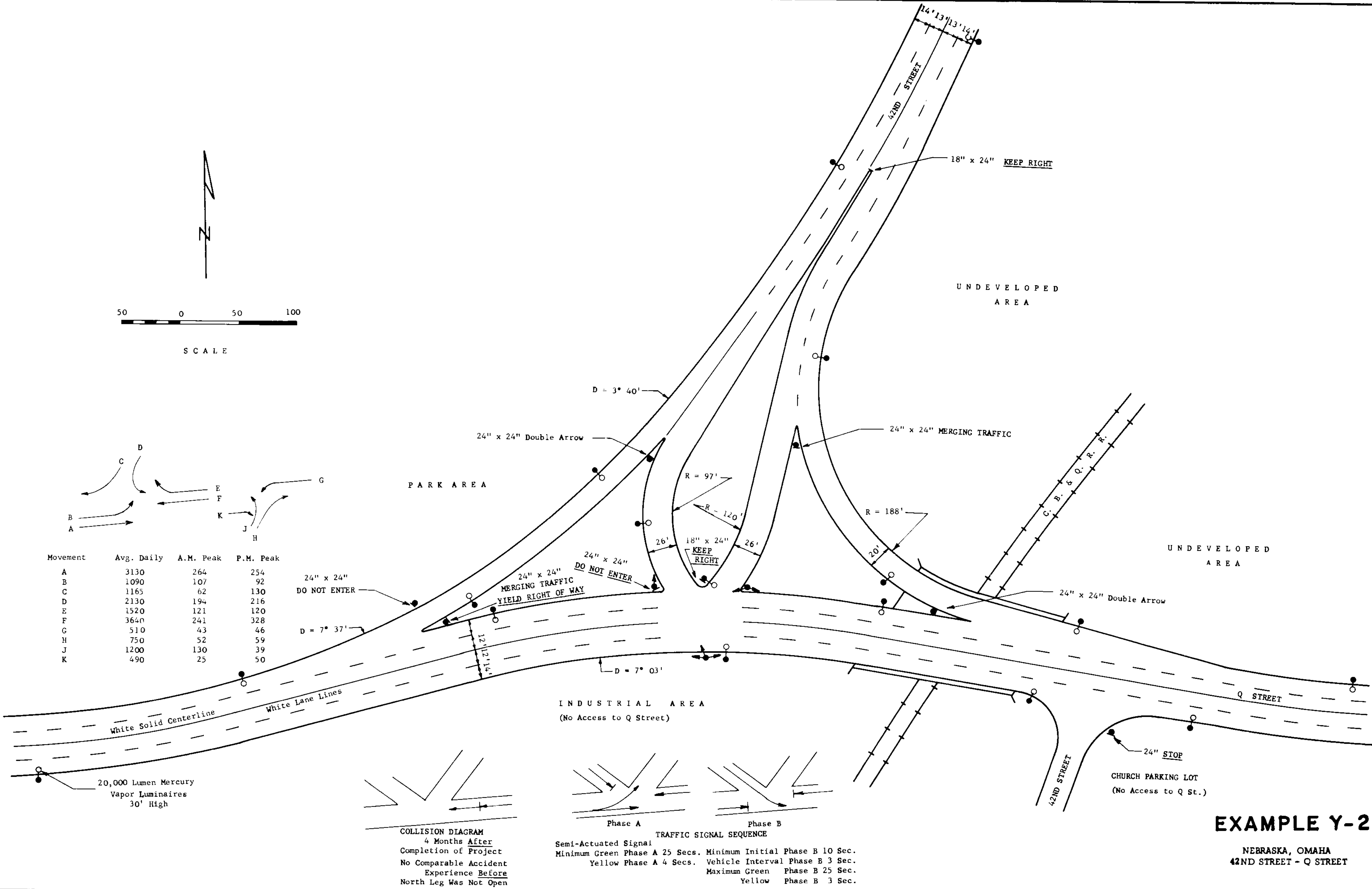
1. IRV. WEINBERG - I feel that separate left turn space will become a necessity soon. This could be accomplished by flattening the through curve and producing about a 100' of full left turn lane. (Perhaps advance green time on signal may suffice for a period).
   An extended "bull nose" for traffic on Leg "C" at junction of main flow plus additional acceleration and gap-finding pavement will reduce the possibility (in my opinion) of a stopped condition under the present sharp angle of merge with limited gap-finding pavement.
   I favor single lane operation at merge points and therefore single lane (plus clearance) pavement width at merge points: (a) From Q St. to North (merge point of flows B & E). Also at merge of flows C & F. (b) Southbound on 42nd St. turning left on Q St. could result in two abreast at the "STOP" light before left turn begins. Could cause conflict due to double left on green.

2. W. R. BELLIS - A good design which should serve satisfactorily with volumes considerably greater than those shown. Painted stop lines should be used. As traffic volumes increase, it may be advisable to use a three phase signal timing.

Additional Comments by BURT WHEDON - I believe that I subscribe to all the comments made by the reviewers except the very last one made by Irv Weinberg. The southbound movement on 42nd and turning left onto Q Street was designed for two lane operation at least for passenger cars which predominate at present. There seems to be no conflict caused by this since all the vehicles entering Q Street at this point are making the left turn onto Q. It seemed necessary in designing the intersection to provide two lane operation at this point in order to achieve the desired capacity.

I may have neglected to mention when I originally sent this Example that the traffic volumes shown do not reflect the design figures because 42nd Street north of this location was closed for some time after the opening of the intersection of 42nd and Q Street. 42nd Street is now open to traffic for the entire distance north of Q and I believe this has substantially increased the traffic at this intersection.





Movement	Avg. Daily	A.M. Peak	P.M. Peak
A	3130	264	254
B	1090	107	92
C	1165	62	130
D	2130	194	216
E	1520	121	120
F	3640	241	328
G	510	43	46
H	750	52	59
J	1200	130	39
K	490	25	50

EXAMPLE Y-2

NEBRASKA, OMAHA
42ND STREET - Q STREET

Location

CALIFORNIA, San Diego
Nimitz Blvd. - Sunset Cliffs Blvd.

Submitted by

Martin J. Bouman, Traffic Engineer
City of San Diego
San Diego, California

Type of Intersection

3-Way Wye

Date Opened to Traffic

May, 1959

Physical Data

Grades: Less than 1% on all legs
Surface Type
Roadway: Asphalt
Height of Curbs and Islands: 8"
Cross Section: Standard
Traffic Control Devices
Signals: Traffic Signal Standards are Type F-51 with 8" green, amber and red indications.
Markings: Double lines are yellow.
Lighting: Street Light Standards are Type III, 400 watt, 20,000 lumen mercury vapor with Type III distriaution. Mast arms for street lights are 6'; for traffic signals 12', with 12" red and 8" green and amber indications. All other indications are 8".
Abutting Property is city park land that is at present new sand and adobe dredge fill. No planning schedule or ultimate use plans are available.
Right-of-way: No limits; city park land.

Traffic Data

Volumes: Nimitz Boulevard was built May 2, 1959. Prior to this Sunset Cliffs Boulevard had an A. D. T. of 7000 cars. The weekday A. D. T. on Nimitz Boulevard is 8,300.
Design Vehicle: C50
Speeds: Speed Limit is 40 MPH on all legs
Pedestrians: None

Operational Characteristics

Nimitz Boulevard was constructed primarily to provide a direct connection between the area at the north end of San Diego Bay and the new Mission Bay Recreational Park three miles to the north. On special occasions and summer weekends, the traffic volumes double. Overall operation is highly satisfactory.

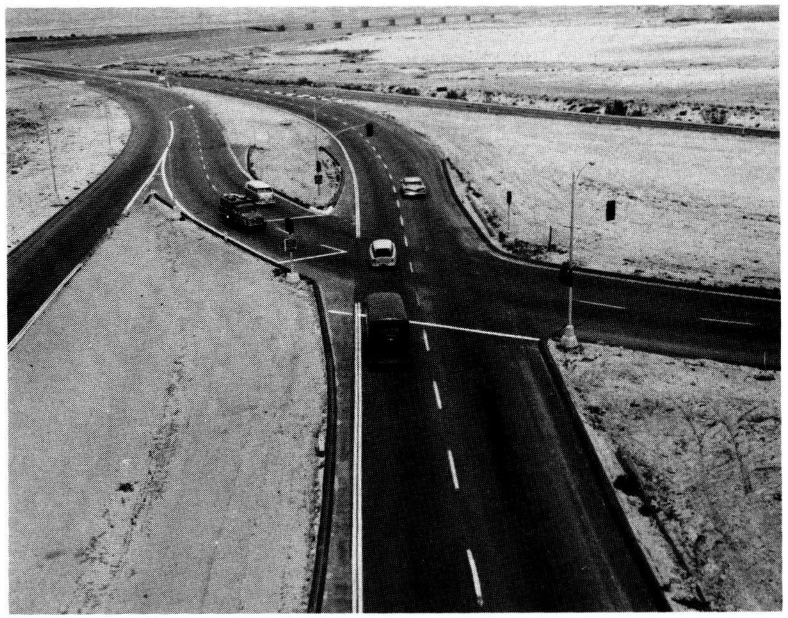


Figure 1: Looking North along Sunset Cliffs Boulevard

Figure 2: Looking South along Sunset Cliffs Boulevard

Figure 3: Looking South from a position farther North

Comments by Committee Members -

1. GEORGE J. FISHER - Standard treatment well applied. What happens to northbound traffic on Nimitz that wants to turn east onto Sunset Cliffs? Also westbound traffic on Sunset Cliffs that wants to go south on Nimitz?

   Was accident experience improved?

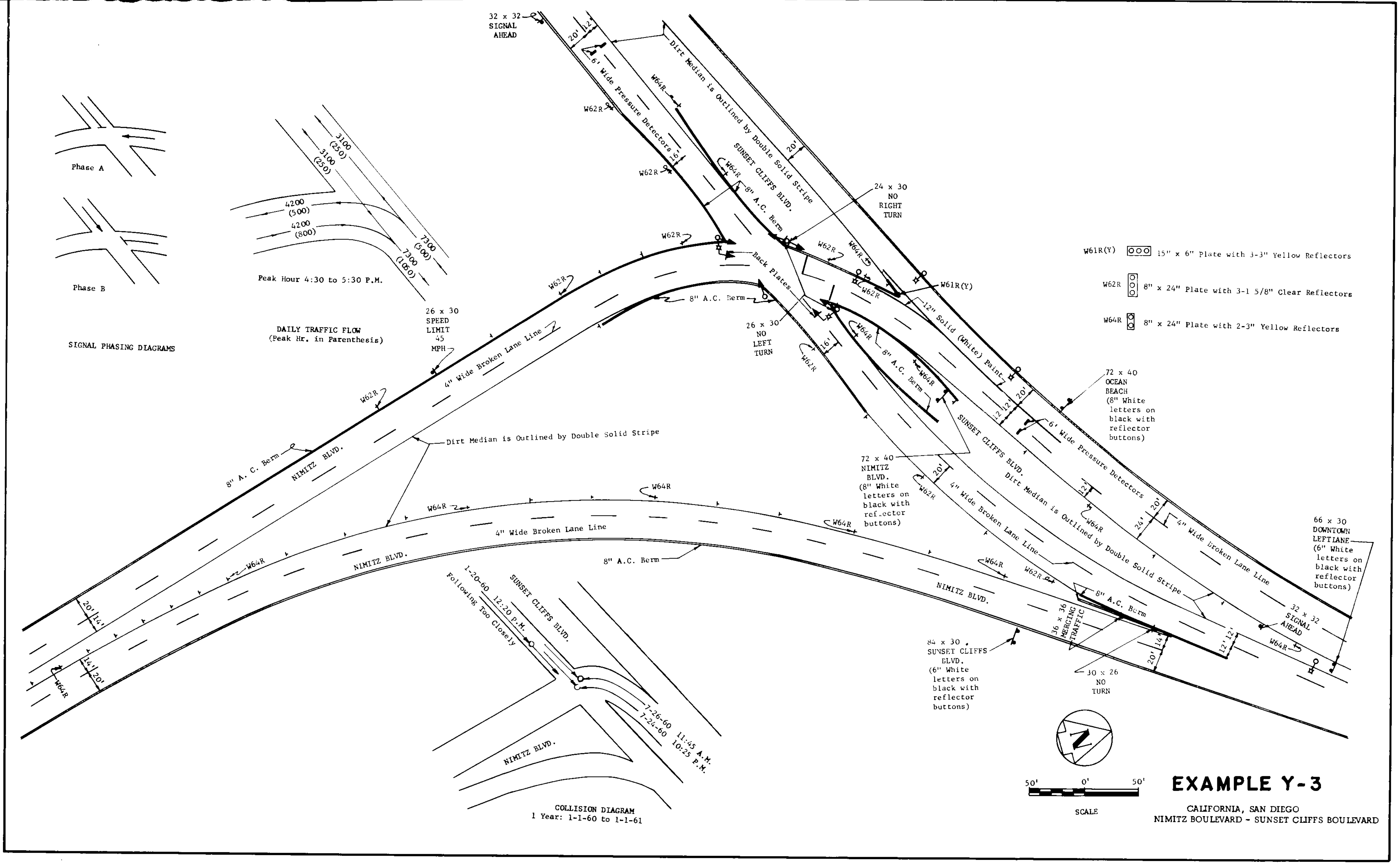
2. CHARLES J. KEESE - The alignment of the left turn from Sunset to Nimitz makes it difficult to place signals for adequate visibility and clear meaning. The accident experience indicates that signal visibility might have been a contributing factor.

   From the pavement width shown, it appears that the 8-inch asphaltic concrete curb or berm is placed at the edge of an 8-foot shoulder. The photographs show no delineation of the shoulder area and indicate use of the full width by traffic. If two-lane use is desired, a wider pavement would be appropriate. The narrowing effect at the end of the curve for northbound traffic on Sunset Cliffs causes the 8-inch asphaltic concrete berm to be placed in such a manner as to be a hazard.

Additional Comments by MARTIN J. BOUMAN - In response to Mr. Fisher's comments, this was new construction for Nimitz Boulevard; therefore there is no "before" accident data available. He also was concerned with turning movements at the intersection; namely, northbound on Nimitz turning east to Sunset Cliffs and westbound traffic on Sunset Cliffs turning to south on Nimitz. Since the first movement is a free right turn and the second movement is the one that passes through the control of the traffic signals, I assume that there is an error in cardinal directions. I would like to point out that there is extremely low demand for the northbound to westbound and for the eastbound to southbound moves. This improvement prohibits the northbound to westbound turn and discourages the eastbound to southbound turn.

In response to Mr. Keese's comments, we certainly agree that the alignment of the intersection made it difficult to place signals for greatest visibility and clearest meaning. Additional analysis of the accidents indicates that an electrical failure might have been involved in one occurence. Mr. Keese offered additional comments concerning the advisability of delineating the shoulder area from the roadway area. At the present time in San Diego we are not experiencing any difficulty with this type of design. Traffic shows no indications of attempting to form a third lane in an obvious shoulder area such as this, even though there is no delineation or line of demarcation between the through lane and the shoulder area.

At the present time we have no reported accident experience involving the 8-inch asphaltic concrete berm that creates a narrowing effect at the end of the curve for northbound traffic on Sunset Cliffs Boulevard.



EXAMPLE Y-3

CALIFORNIA, SAN DIEGO
NIMITZ BOULEVARD - SUNSET CLIFFS BOULEVARD

Location

NEW JERSEY, North Bergen
Hudson County

Submitted by

Wesley R. Bellis
Chief of Traffic and Design
New Jersey State Highway Department

Type of Intersection

3-Way Wye

Date Opened to Traffic

1958

Physical Data

Grades through the Intersection:	Maximum	Approximate Average
Northbound on US 1	3.36%	2.5%
Southbound on US 1	3.96%	2.5%
Northbound on Route 3	3.24%	2.0%
Southbound on Route 3	2.88%	1.5%

Surface Type
Shoulders: 10' normal shoulders with 4" topsoil
Island Height and Type: 8" above pavement;grassed except where narrowing to nose or divider.
Abutting Property: Service station and vacant land on west side of the intersection; truck freight terminal on north side; motels, trailer courts and diner on east side.

Traffic Data

Volumes: Total truck volume: 25%; heavy truck volume: 12%
Speeds: Posted speeds: 40 MPH
Accidents: Annual summaries only were provided, as shown on the plan sheet.

Operational Characteristics

Comment on over-all operation of channelized intersection:
"It is our opinion that the oever-all operation of this channelized intersection is good and there is a minimum of congestion and delay as compared to the traffic circle that was formerly at this location."

Comment on elements of the design which contribute to unsatisfactory operation: "(a) The using of the left-turn slot for Route 3 eastbound traffic desiring to go north on Routes US 1 and 9 did not justify the installation of traffic signals at the time of channelization. The traffic is controlled at present only by a "YIELD" sign. The high volume of traffic northbound on Routes US 1 and 9 makes it difficult for this traffic to merge. However, if this left-turn volume increases, the traffic signals can easily be installed as the wiring is completed. (b) The opening provided for motorists using the motels, now under construction on the easterly side of Routes US 1 and 9 may create a problem. Should any difficulty develop here, it will only be necessary to move the stop line for Routes US 1 and 9 southbound traffic to a point north of this location."

Figure 1: Aerial view

Comments by Committee Members

1. R. T. SHOAF - While fundamentally the channelization looks quite reasonable and certainly must be vastly better than the former traffic circle in regard to delays, the reported traffic accident experience would indicate that there is additional need for improvement.

   Lacking accident diagrams, I suspect the current problem stems from two factors:
   1. Long fixed-time signals
   2. Lack of depreciating the LT for Rts. 1 and 9 into Rt. 3 to a position of secondary importance.

   To overcome the first factor, I would consider traffic actuated signals instead of fixed-time, making Route 1 & 9 the main artery. This is without knowing conditions at or distance from Secaucus Road and the need for southbound coordination.

   To overcome the second factor, I would consider making a left turn storage slot for northbound Rt. 1 & 9 to Rt. 3 rather than using a Y treatment type of storage, at the same time relocating the storage area for a crossing more nearly at right angles to southbound Rt. 1 & 9. This would also permit the weaving left turn from Rt. 3 to north on Rt. 1 and 9 to be lengthened by close to 100 feet.

   This relocation of the crossing would allow removal of signal heads 1 & 2. The right turn from Rt. 3 to Jersey City would be free running, possibly with Yield control.

   A possible alternate treatment would be to completely redesign as a Tee intersection. In this case, because of the very low left turns from Rt. 3 to Rt. 1 & 9 northbound, a third phase signal would only occasionally be used. (However, I prefer to avoid 3 phases).

   In both cases of redesign, all 3-lane roadway could be cut to 2 lanes because of the low lane usage (50/hr) and thus shorten the amber intervals at least for all phases except possibly southbound on Rt. 1 & 9.

2. EUGENE MAIER - This is a typical "suspender" type design which can be used effectively at a Y-type intersection. Non-conflicting movements are carried through the intersection without delay and the major conflict is isolated and controlled with traffic signals.

   Development adjacent to intersections of this type present difficult problems of access, particularly in an area such as this where the street network in the vicinity is limited. Control of access should be acquired, but this is not always possible. Although the number of accidents after channelization remains about the same as before, the number of injury accidents is less. In the absence of a collision diagram, it is difficult to relate the accident experience with the design.

Additonal Comments by WESLEY R. BELLIS - There are frequent synchronized signals along Route US 1 & 9. At the subject intersection the signal for Route US 1 & 9 southbound is in perfect progression with the next signal to the north, thereby minimizing the number of southbound vehicles stopping. Also, the signal for the left turn into Route 3 is in perfect progression with the next signal to the south to reduce stopping.

We do not consider the left turn into Route 3 a secondary movement. We consider it a major movement as evidenced by the left turn volume of 1200 per peak hour and therefore, have not used a left turn slot.

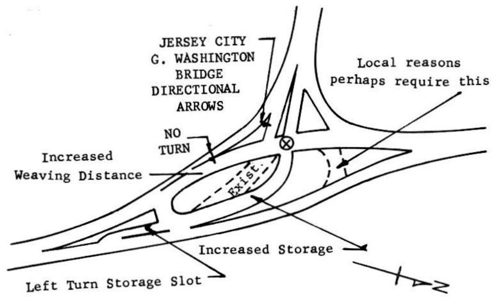
We have used a long cycle length because of the high volume. A 120 second cycle will give a greater capacity than a 60 second cycle (or a cycle less than 120). If traffic actuated signals were used, the signal would produce the equivalent timing to fixed time most of the 24 hours of the day. The additional cost for traffic actuated signals is not justified.

The left turn from Route 3 is not a weaving movement. It is made with the aid of traffic signals which alternate the movements. The left turn from Route 3 is made while southbound Route US 1 & 9 is stopped.

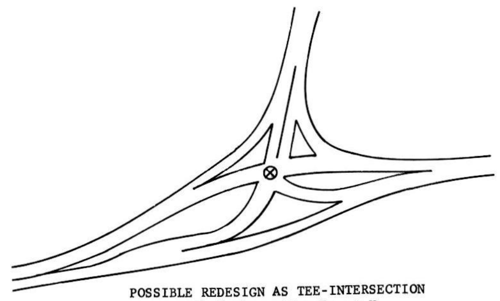
I do not believe the right turn from Route 3 should be free flowing. With traffic volumes less than the capacity of the facility free flowing merges are advisable, but when the volume is in excess of the capacity, alternation of traffic is better. If free flow was used with a yield sign then theoretically the right turn from Route 3 should move only when southbound Route US 1 & 9 had a red signal. With a signal instead of the yield sign the desired traffic behavior is clearly defined resulting in less confusion.

The length of the amber phase is not a function of the width of roadway being crossed. It is a function of the normal speed of the ap roach road. We use roughly 3 seconds for 30 miles per hour, 4 seconds for 40 miles per hour and 5 seconds for 50 miles per hour.

Accident experience and traffic congestion is still far from desirable, but this can only be overcome by a major wholesale improvement, such as a parallel route to divert most of this traffic. It is impractical to widen and improve on this alignment to meet traffic demands. A parallel facility was built 20 years ago but traffic has again reached the overloaded condition.



POSSIBLE REDESIGN AS WYE-INTERSECTION
with 2-Phase Signals at ⊗
by R. T. Shoaf



POSSIBLE REDESIGN AS TEE-INTERSECTION
with 3-Phase Signals at X
by R. T. Shoaf

Figure 1: Aerial view

Location

CONNECTICUT, Columbia
US 6 - US 64

Type of Intersection

3-Way Wye

Physical Data

Grades: None in excess of 3%
Surface Type: Shoulders are constructed of 2" hot asphalt concrete on 6" rolled gravel base. The islands are equipped with reflecting concrete curbing 4" in height while the remaining curbing is bituminous lip type 6" in height. Both types of curbing are mountable.
Cross Section: Standard treatment
Traffic Control Devices
Lighting: Highway illumination consisting of mercury vapor units, 400 watt, 20,000 lumen mounted on wood poles at a height of 25' and providing an average 0.8 foot candles maintained, adequately identify the channelized area during the night-time hours.
Transit Operations: No transit stops are made here.

Submitted by

David S. Johnson, Jr.
Director of Planning and Design
Connecticut State Highway Department
P. O. Box 2188
Hartford, Connecticut

Date Opened to Traffic

November, 1956

Traffic Data

Volume: 1960 Average Daily Traffic: Route 6 west leg 4100; Route 6 east leg 6800; Route 6A 3100. The one-way approach ADT is one-half of these volumes.
Design Vehicle: C50
Speeds: Posted speed limit on all routes is 40MPH
Accident experience at this location was not significant either before or after to develop a worthwhile collision diagram.
No pedestrians in this area.

Operational Characteristics

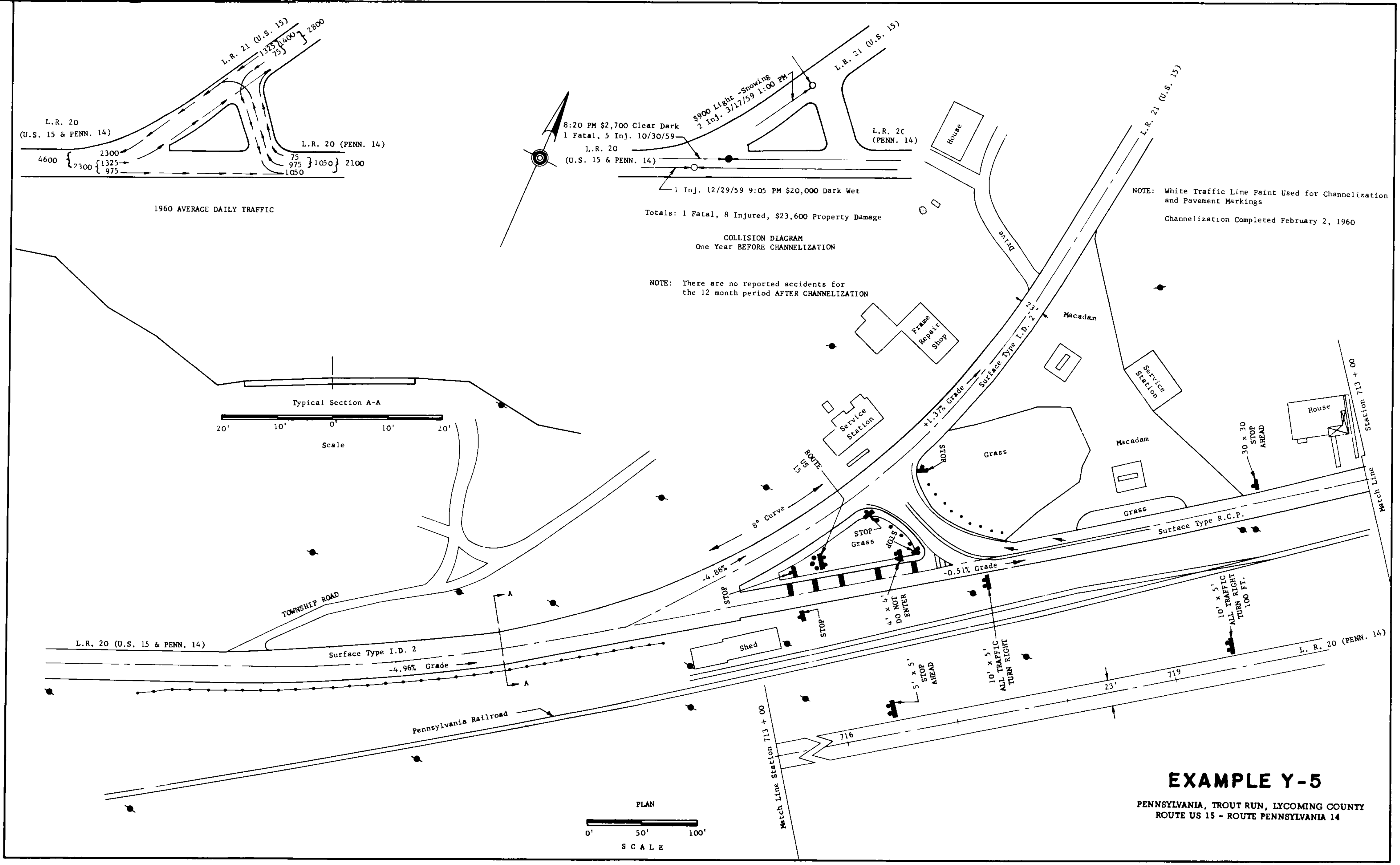
As indicated in the average daily traffic, considerable left-turn movement occurs from the east leg of Route 6 into Route 6A. The original installation consisted of a non-channelized "Y" intersection and the left-turn movement from the east on Route 6 into Route 6A had to be stored in the through lane of Route 6. Congestion during peak periods and rear-end accidents resulted. With the construction of the deceleration lane for westbound traffic on Route 6 and with adequate storage facilities for vehicles stopped for the left-turn movement into Route 6 under the control of the semi-actuated signal installation, the difficulty existing at this location was eliminated.

Due to economies in construction, an unsatisfactory condition of minor importance resulted where the right turn from the west leg of Route 6 connected with existing Route 6A. Route 6A at this location is on a banked section with the end result that the connection of the right turn from Route 6 occurs with an adverse cross slope at the point where vehicles enter Route 6A. Accident experience does not indicate this to be of any importance and to date no changes have been deemed necessary in the particulars of design.

Comments by Committee Members

1. R. T. SHOAF - It appears from the ADT that this is a satisfactory channelization.
   I do question the need for traffic signals rather than STOP signs to control the minor cross movements. It would appear that the storage space provided more relief than the signals. Unless signals are actually needed, they should be avoided, because they cause delay and tend to increase accidents, if few occur without signals.
   In any event, if signals must be used, there should be a double indication. Also, if signals are needed only for a short peak period, they should flash at other times.

2. IRV. WEINBERG - This design should work well if well marked by signs and paint markings. I have two comments:
   (a) Since this type if design is not as common as other "Tees" and "Wyes" it is conceivable that a driver (a stranger) proceeding northerly on route 6A wanting to turn west on Route 6 would want to use the most "logical positioned" channel (which appears as if it should be the channel connecting Route 6 to Route 6A for traffic west on Route 6 to south on Route 6A). To prevent this wrong maneuver, I would recommend a curb from the vicinity of the town road to the "bull nose" instead of painted lines.
   (b) It appears that there is an abrupt termination of pavement for the channel taking eastbound on Route 6 to south on Route 6A at the point where it meets and merges with the channel taking westbound on Route 6 to south on Route 6A. I would recommend additional pavement so that a stop condition will not result. A driver stopped and required to look back for approaching vehicles would result in a more dangerous situation than a right stop.
   The way the diagram appears, there is not enough merge - gap selection pavement. More is recommended.



EXAMPLE Y-5

PENNSYLVANIA, TROUT RUN, LYCOMING COUNTY
ROUTE US 15 - ROUTE PENNSYLVANIA 14

Location

PENNSYLVANIA, Trout Run
Lycoming County, Route US 15 -
Route Pennsylvania 14

Submitted by

Edmund R. Ricker, Director
Traffic Engineering Bureau
Pennsylvania Department of Highways
Harrisburg, Pennsylvania

Type of Intersection

3-Way Wye

Date Opened to Traffic

February, 1960

Physical Data

Type of Curbs and Islands: The islands are grass and there are no curbs.
Traffic Control Devices
Lighting: The intersection is not illuminated; therefore there are no poles or any other types of luminaires.
Transit Operations: Since this is a rural location there is no mass transit present.
Right-of-Way: Since sufficient right-of-way had been previously purchased by the Department, the design of the intersection was not in any way influenced by right-of-way limitations.

Traffic Data

Design Vehicle: C50; the design was very directly influenced by the presence of many large trucks on both Routes 15 and 14.
Speeds: The 85 percentile speed is not available, nor is there a restricted speed zone. However, there are 35 MPH SAFE SPEED signs used in conjunction with warning signs on Route US 15.

Operational Characteristics

Since the installation of the channelization, the intersection has been operating very safely and efficiently.
The major physical characteristic which tends to contribute to the operational problem is the alignment of the roadway on the southern leg of the intersection, which is a vertical curve in conjunction with a horizontal curve.

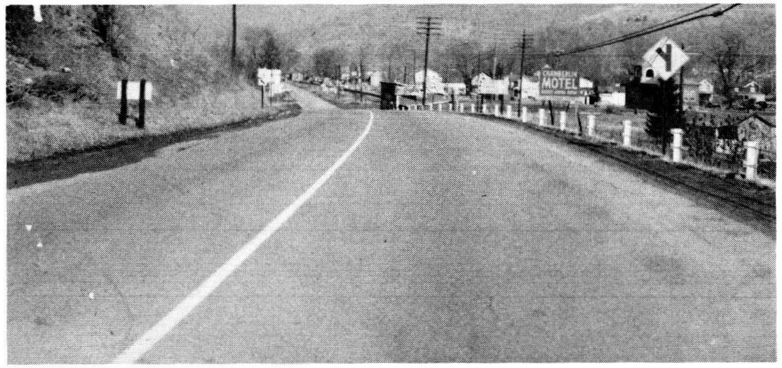


Figure 1: Before Channelization. Northbound approach to the intersection approximately 300' away. Note that intersection is hidden by alignment of highway.

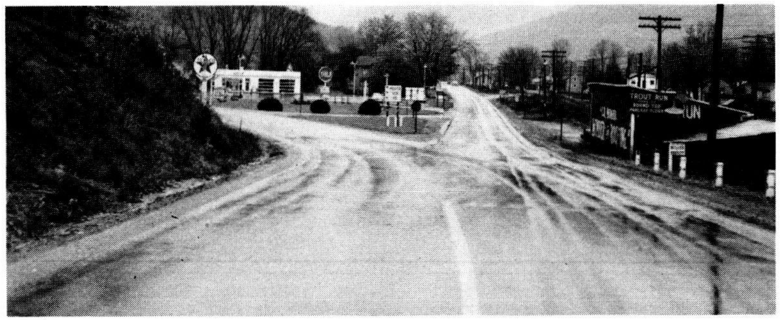


Figure 2: Before Channelization. Northbound approach approximately 100' South of intersection.

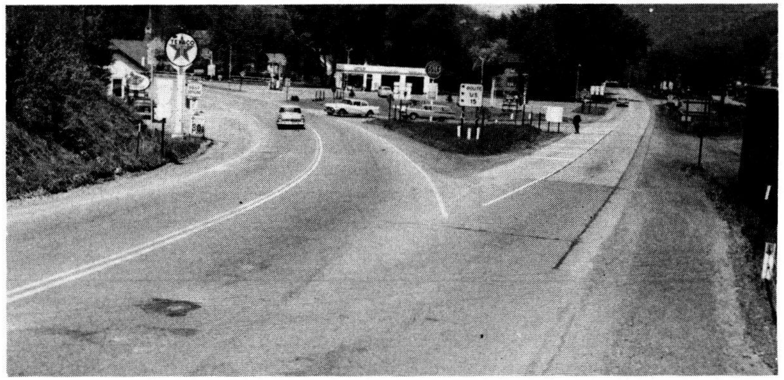


Figure 3: After Channelization. Looking Northeast into traffic island; Route 15 on left, Route 14 on right.

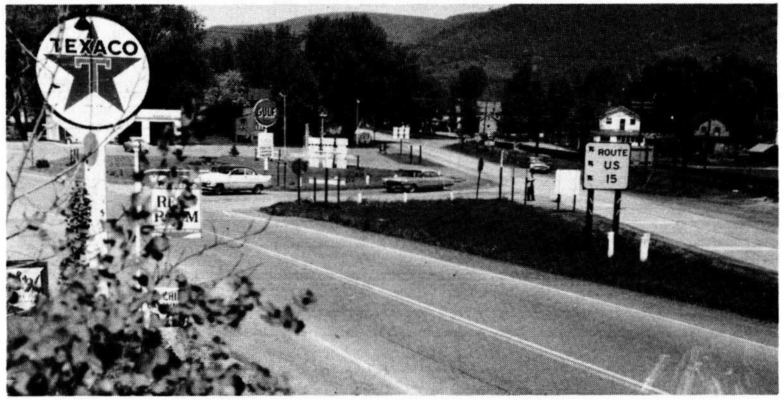


Figure 4: After Channelization. Northbound approach to intersection; Route 14 right, Route 15 left. Note Southbound traffic from Route 14 using channelization.

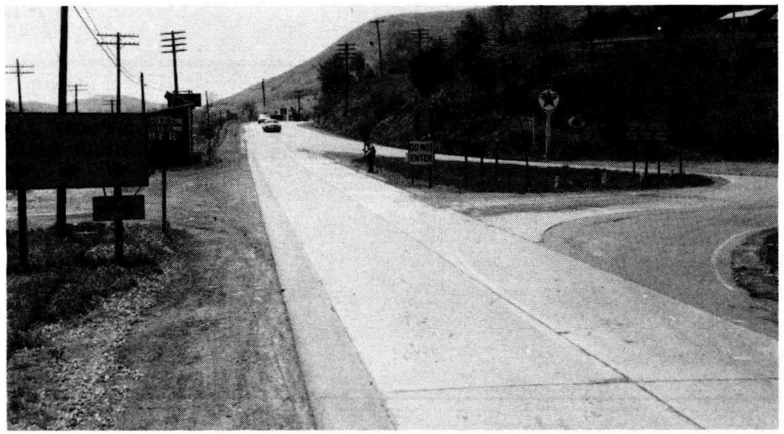


Figure 5: After Channelization. Southbound approach to intersection along Route 14. Photo shows signs and markings used to channelize Southbound traffic approaching Route 15.

Figure 6: After Channelization. Southbound approach along Route 15.

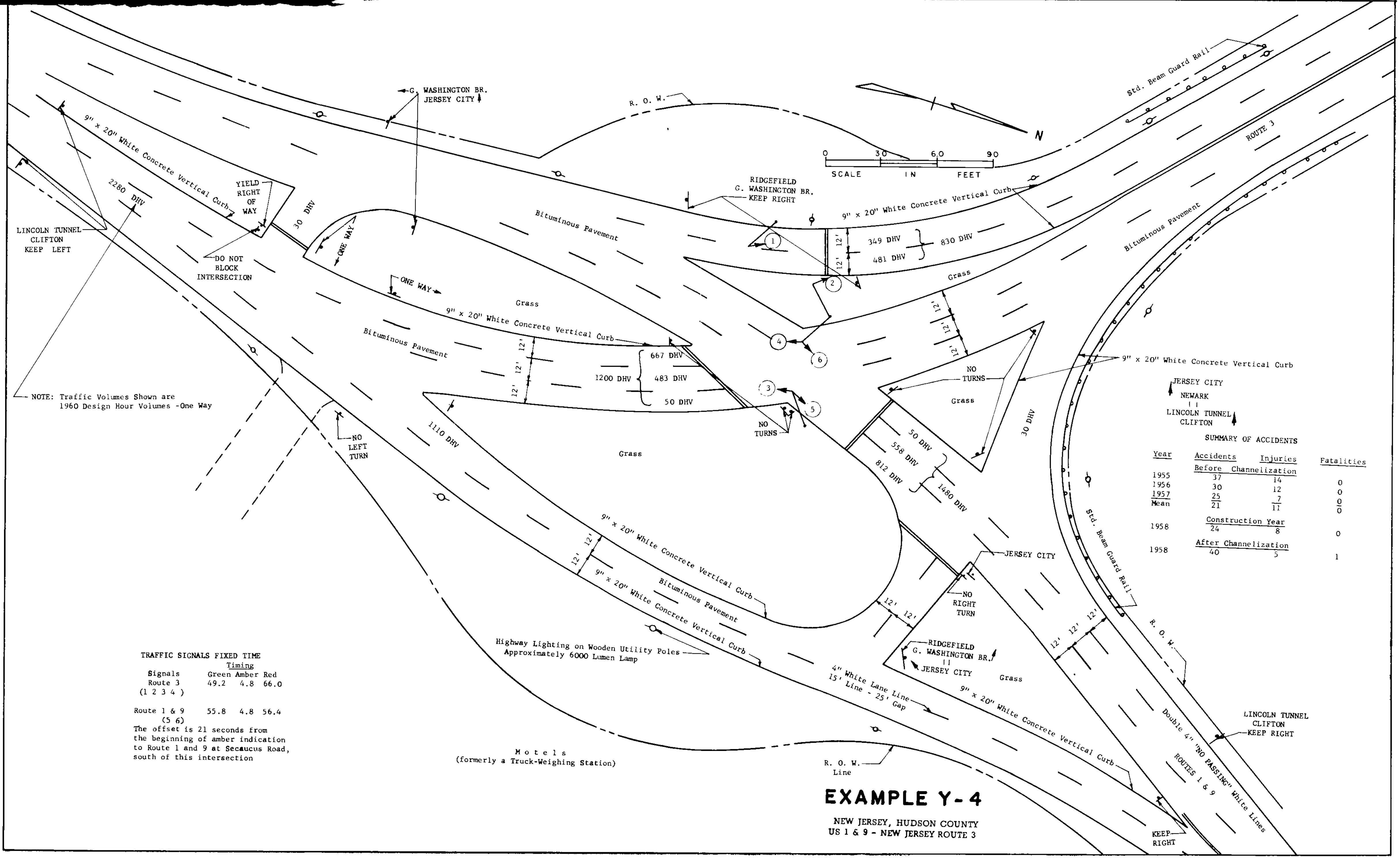
Comments by Committee Members

1. GEORGE J. FISHER - This standard treatment has obviously proven to be satisfactory since the number of accidents has been greatly reduced.
   Better operations could be obtained if the island were curbed and extended into Pennsylvania 14 forming a funnel for eastbound traffic. This would allow little or no chance for westbound traffic to go against traffic west of the cut-across.

2. ROBERT E. DUNN - This example is an inexpensive and effective treatment of the "Y" type intersection problem. Its effectiveness is achieved through the use of traffic signs, paint lines and guide posts. However, the esthetic values of design should not be overlooked. Raised curb, planted or surfaced islands, illumination and flashing beacons add considerably to the visibility and attractiveness of a channelized area. This in turn makes the device more readily recognized for its function and materially adds to the safety of operation that channelization is intended to provide.

Additional Comments by EDMUND R. RICKER - Both George Fisher's and Robert Dunn's comments are well taken regarding the use of curbing, landscaping, and so forth to increase the effectiveness of this type of treatment. Also, extending the island, as Fisher suggested, would be desirable. These things were not done, however, because the channelization is regarded as a temporary measure until the intersection is reconstructed. Route 15 will probably be relocated and for that reason we do not feel justified in a large expenditure for a temporary physical change.

As can be seen from the photographs, a cross connection between Routes 15 and 14 did exist prior to the channelization to handle the turning movements. The physical changes made here constituted widening this crossing, erecting signs and painting necessary markings to require all southbound traffic along Route 14 to use the connection with Route 15. Before this was done Route 14 traffic southbound had less than 250' of sight distance southbound from its normal stopping place and in addition was faced with a long path to cross northbound 15 traffic to get in the right lane before going southbound. By channelizing this movement so that the approach to US 15 is approximately 90 degrees, the sight distance was increased to approximately 450' and the time needed to clear the intersection was reduced approximately 50%.



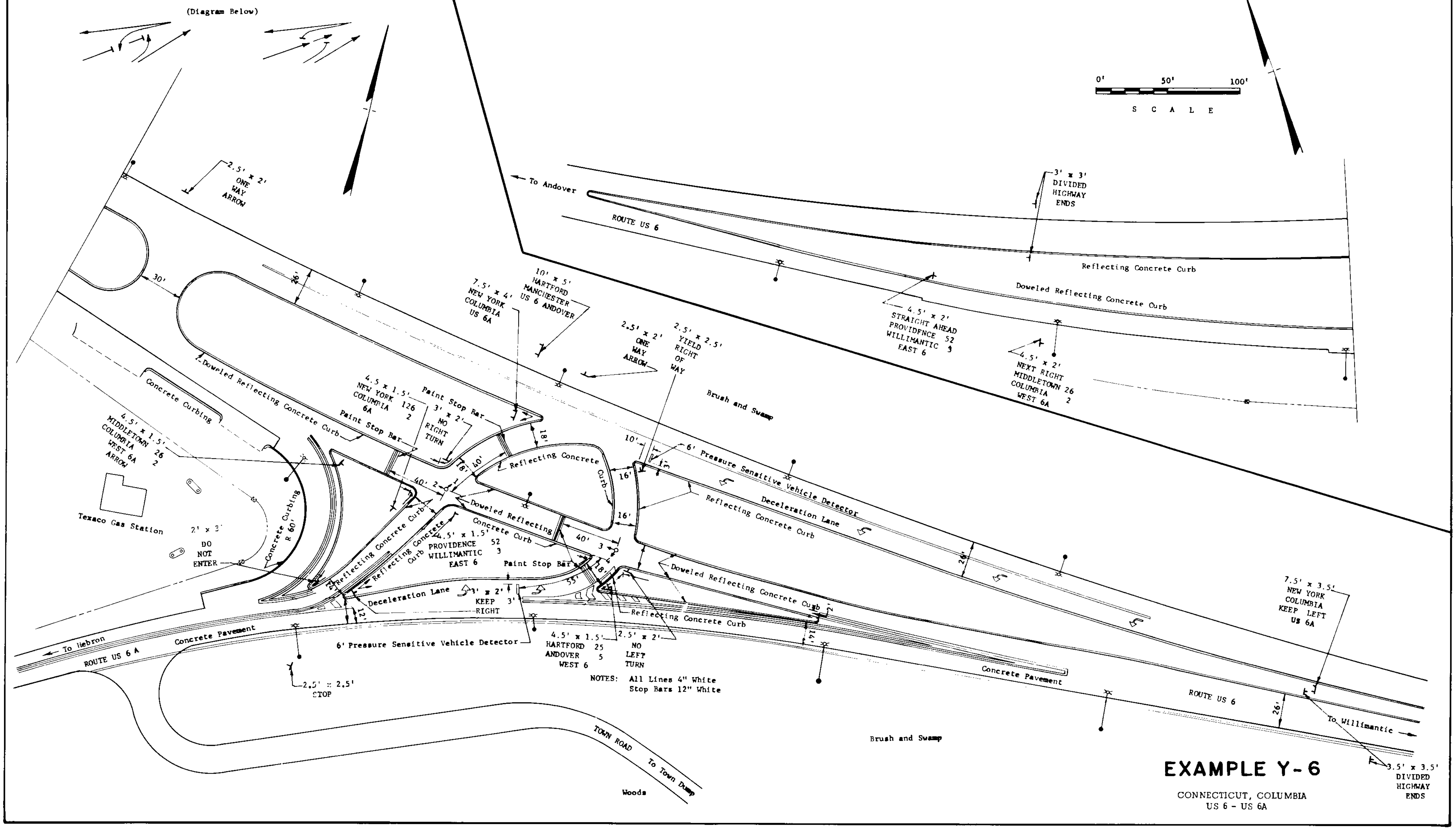
EXAMPLE Y-4

NEW JERSEY, HUDSON COUNTY
US 1 & 9 - NEW JERSEY ROUTE 3

TRAFFIC CONTROL SIGNAL LAYOUT
SEQUENCE AND TIMING

Face No.	Initial Interval	Vehicle Interval	Side St. Max.	Side St. Clear	Artery Min.	Artery Clear	Emerg Flash
1 & 4	G	G	G	A	R	R	Fl. R
2 & 3	R	R	R	R	G	A	Fl. A
Timing	11"	5"	40"	4"	30"	5"	

(Diagram Below)



EXAMPLE Y-6

CONNECTICUT, COLUMBIA
US 6 - US 6A

Location

CONNECTICUT, East Litchfield
Route 8 - Route 116

Type of Intersection

3-Way Wye

Submitted by

David S. Johnson, Jr., Director
Bureau of Planning and Design
Connecticut State Highway Department
P. O. Box 2188, Hartford 15,
Connecticut

Date Opened to Traffic

December, 1959

Physical Data

Grades: None in excess of 3%
Surface Type
Roadway: 1½" hot asphalt concrete on 1½" bituminous concrete binder course on 3" bituminous macadam base on 3" broken stone base.
Shoulders: 2½" bituminous macadam on 6" rolled gravel base.
Islands: loamed and seeded.
Curbings: all mountable type 4" in height; bituminous concrete lip curbing for roadways where shown on plan; concrete park curbing for islands.
Other Details are standard design.
Cross Section: standard treatment.
Traffic Control Devices
Signals: The intersection is not signalized.
Lighting: The intersection is not illuminated.
Abutting Property: The abutting land is undeveloped with no commercial value due to the differential between the roadway and existing ground elevation (15-20 feet). It is further protected from abutting land interference inasmuch as access rights were purchased.
Transit Operations: No transit stops are made here.

Traffic Data

Volumes: 1960 Average Daily Traffic: Route 116, 1150; Route 8 North, 4500; Route 8 South, 4700. The one-way approach ADT is one-half of these volumes.
Design Vehicle: C50
Speeds: The posted speed limit on Route 8 through the intersection area is 40 MPH and that on Route 116 is 45 MPH.
Accidents: This is a completely re-located section of highway and no previous experience is available.
Pedestrian: None

Operational Characteristics

Observations of the over-all operation of the intersection appear to be entirely satisfactory.

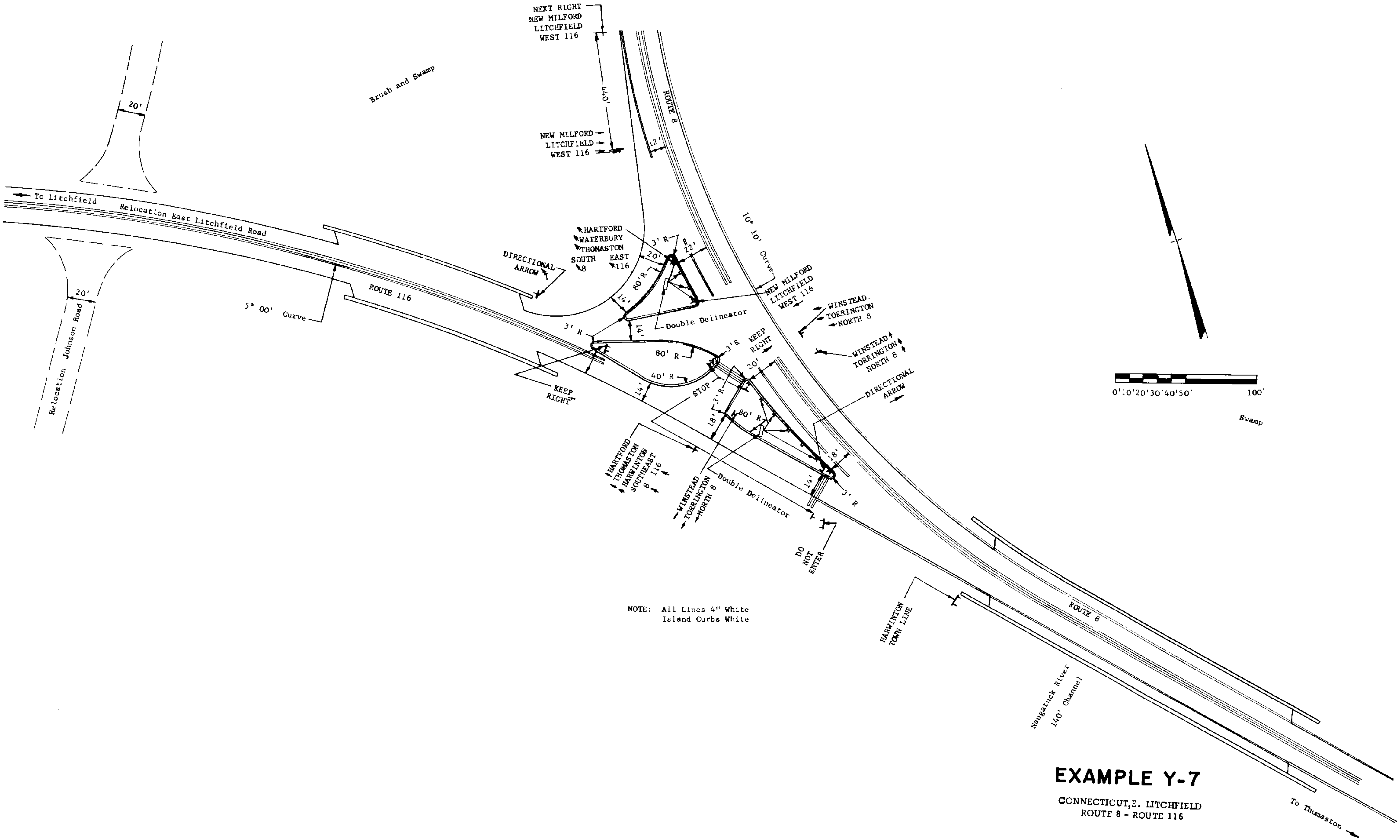
Figure 1: Aerial view looking Northwest

Comments by Committee Members

1. ROBERT E. DUNN - This illustration is a near classic example of "Y" type intersection channelization. It satisfies the warrant condition by an almost perfect application of the listed principles*.
 The location of the two bridge structures however, confined the area of design. The application of this example to other locations having higher traffic volumes could well utilize a larger land area. This would be for the purpose of separating the directional lanes on the west approach of Route 8 to construct a divisional island with a left-turn storage lane for traffic destined to the east on Route 116. The removal of slow moving or standing left-turning traffic from the heavier traveled northbound lane on Route 8 would provide safer and freer movement for through traffic, as well as a refuge area for turning vehicles.
 The presence of adequate intersection illumination would also measurably increase the safety of operation during the hours of darkness.

2. KARL MOSKOWITZ - This is a good solution for the volume of existing traffic.
 Accident data are not included in the comments, but a condition does exist which could be improved. A left turn median lane for traffic north-westbound on Route 8 destined for west on Route 116 would reduce the hazard to the standing vehicles. A minimum painted left turn lane to keep the through lane open can be provided at a nominal cost by cutting back the islands and reducing the shoulders to possibly 5 feet.
 The edge striping for southbound traffic on Route 8 has a gap of approximately 60 feet for vehicles turning right onto Route 116. The construction plan indicates the stripe to cross the path of the turning vehicles and the gap located alongside the triangular neutral area between the edges of the main roadway and exit ramp. It would be more appropriate to locate the gap in the edge stripe in the path of the turning vehicles. A gore stripe along both sides of the neutral area would reduce conflicts with the curb nose and direct the turning vehicles.

*Principles Involved:
1. Reduction of relative speed and impact energy
2. Confining the area of conflict
3. Crossing of vehicle paths at near right angles
4. Merging traffic streams at small angles
5. Providing refuge for turning and crossing vehicles
6. Locations for traffic control devices



EXAMPLE Y-7

CONNECTICUT, E. LITCHFIELD
ROUTE 8 - ROUTE 116

Location

DELAWARE, Keidel's Corners
Newport Gap Pike (Delaware 41) -
Lancaster Pike

Submitted by

Ernest A. Davidson
Chief Engineer
Delaware State Highway Department
P. O. Box 151
Dover, Delaware

Type of Intersection

3-Way Wye

Date Opened to Traffic

May 20, 1955

Physical Data

Grades: None over 3%
Surface Type and Height of Curbs and Islands: Cement concrete; 6".
Traffic Control Devices
Signs: Where records of equipment signs or markings were not available, they were not secured, as no time was available for field trips.
Signal Timing: Fully actuated
Markings: Normal
Other Control Devices: Guard posts and rumble strip.
Abutting Property: Rural; hilly terrain; little development.
Transit Operations: There is little commuter traffic through here in spite of its nearness to Wilmington.

Traffic Data

Design Vehicle: C50
Accidents: Very good over-all record.
Pedestrian: Negligible volume

Operational Characteristics

Although the signal shown is three-phase, it normally operates two-phase as there is little call for Phase C. Because of the rural nature of the area and the hilly terrain, there is little development at the intersection proper. This aids the freeflowing nature of the intersection. Traffic volumes are not critical here except possibly on summer week-ends.

There is no particular improvement which suggests itself to this intersection in the immediate future, except possible doubling the northwestern approach as the southbound traffic begins building up under the ever expanding influence of the city.

Figure 1: Looking into intersection from South approach, Delaware 41; showing details of approach through cross-over.

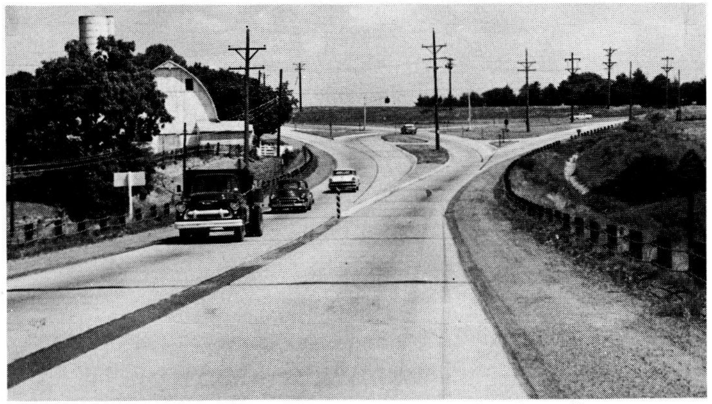


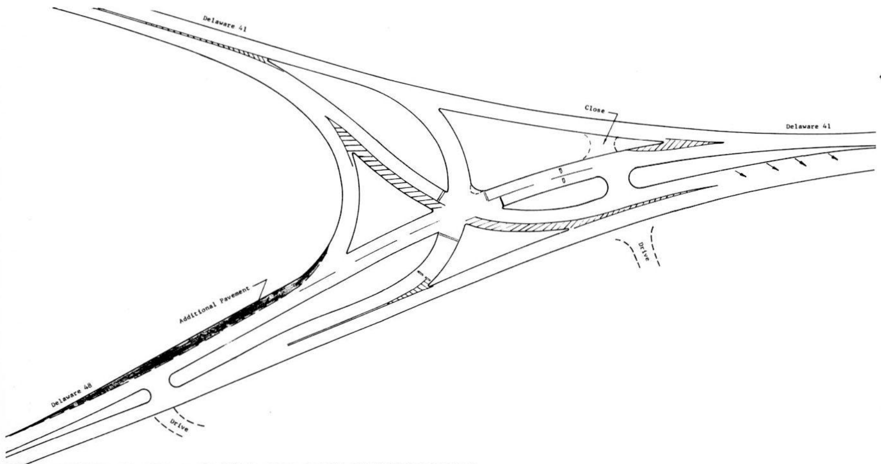
Figure 2: Looking into intersection from North approach, Delaware 41; showing details of approach for Southbound traffic and channelization. The dark stripe between the lanes is a rumble strip several hundred feet long in front of the dividing island.

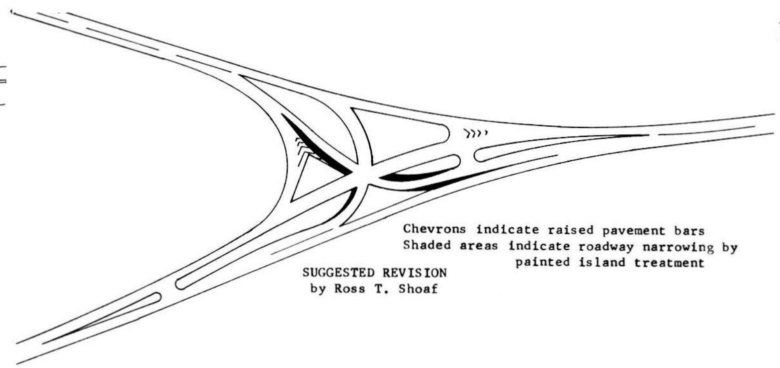
Comments by Committee Members

1. WARREN TRAVERS - Three-way traffic activated signalized intersection of two state highways. Relatively low volumes--no immediate plans for improvement of approach roadways.
   It appears from the above, and in consideration of the relative traffic flows, that a few minor revisions would result in a safer and perhaps more efficient operation.
   The attached sketch emphasizes driver guidance through the use of pavement markings. In particular, the merge between Route 41 northbound and Route 48 northbound is delineated to provide merging of two lanes to one lane rather than three to one as indicated by the original plan. Until such time as Route 41 is widened to four lanes north of this intersection (volume counts suggest that this roadway will be widened first), it appears that the revised layout is more compatible with the approach roadways.
   It is suggested that additional pavement be added to Route 48, south of the intersection, as shown. This will insure adequate merging area to accomodate the two-lane storage as it leaves the intersection control point, a more appropriate entrance for the right-turn movement from Route 41 and increased maneuverability with respect to interference to through traffic caused by turn around or local vehicles entering the mall opening.
   It is suggested that the opening between Route 41 southbound and Route 48 southbound be closed and that local traffic be routed via the westbound roadway located between these two routes. This movement can be facilitated by cutting back the acute corner, as shown.

2. R. T. SHOAF - The fundamentals of channelization appear to be generally good. The changes suggested by Mr. Travers, however, are significant improvements in design.
   From the traffic volumes involved, I believe the greatest efficiency would be gained by placing the traffic signals on a flashing operation, in which case Mr. Travers' left turn revisions would be of more immediate value.
   The photographs indicate a relatively new installation but, even so, the accident experience is such that I doubt that any major change is warranted except to turn the signals off. Since sight distance is good, there is probably more chance that someone will run a red signal light and cause an accident than if the two left turns are controlled by STOP signs (flashing red) only.
   In connection with a signal change, I would reduce both left turns to one lane roads by means of paint (see small sketch).
   If I were designing this intersection initially, I believe the only major change I would have included would be to taper the islands introduced in the middle of moving traffic and install advance raised bars (see small sketch).

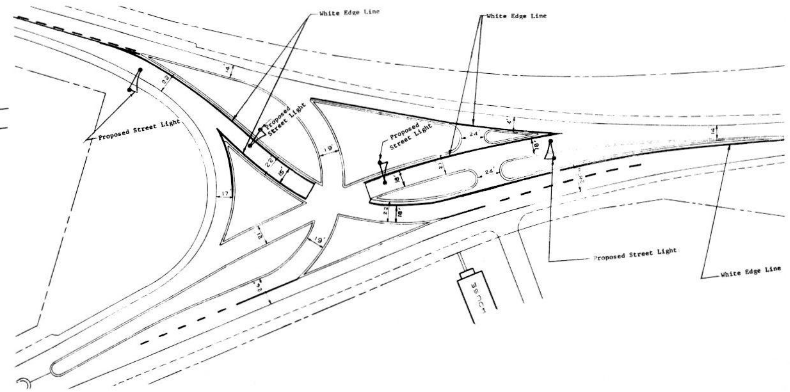
Additional Comments by WILLIAM R. CARROW, Traffic Engineer, Delaware State Highway Department - We would agree with the reviewers on most items if the intersection were being newly designed and constructed. Furthermore, if we were experiencing any real difficulty with the width of the left turn roadways, we would reduce the width as suggested. We agree that the widths should be reduced, but it will be done quite simply with edge lines in accordance with the desired travel paths, as shown on the accompanying revision. This method has proved successful at other locations.
The suggested revision also indicates possible use of future highway lighting for the area.
The opening between Route 41 southbound and Route 48 southbound exists by right-of-way agreement, since it is opposite the access to a private estate from which necessary land for construction of the intersection was obtained.
Many traffic signals in rural areas are placed on flashing operations during light traffic periods. Consideration is being given to the intersection in question at this time.

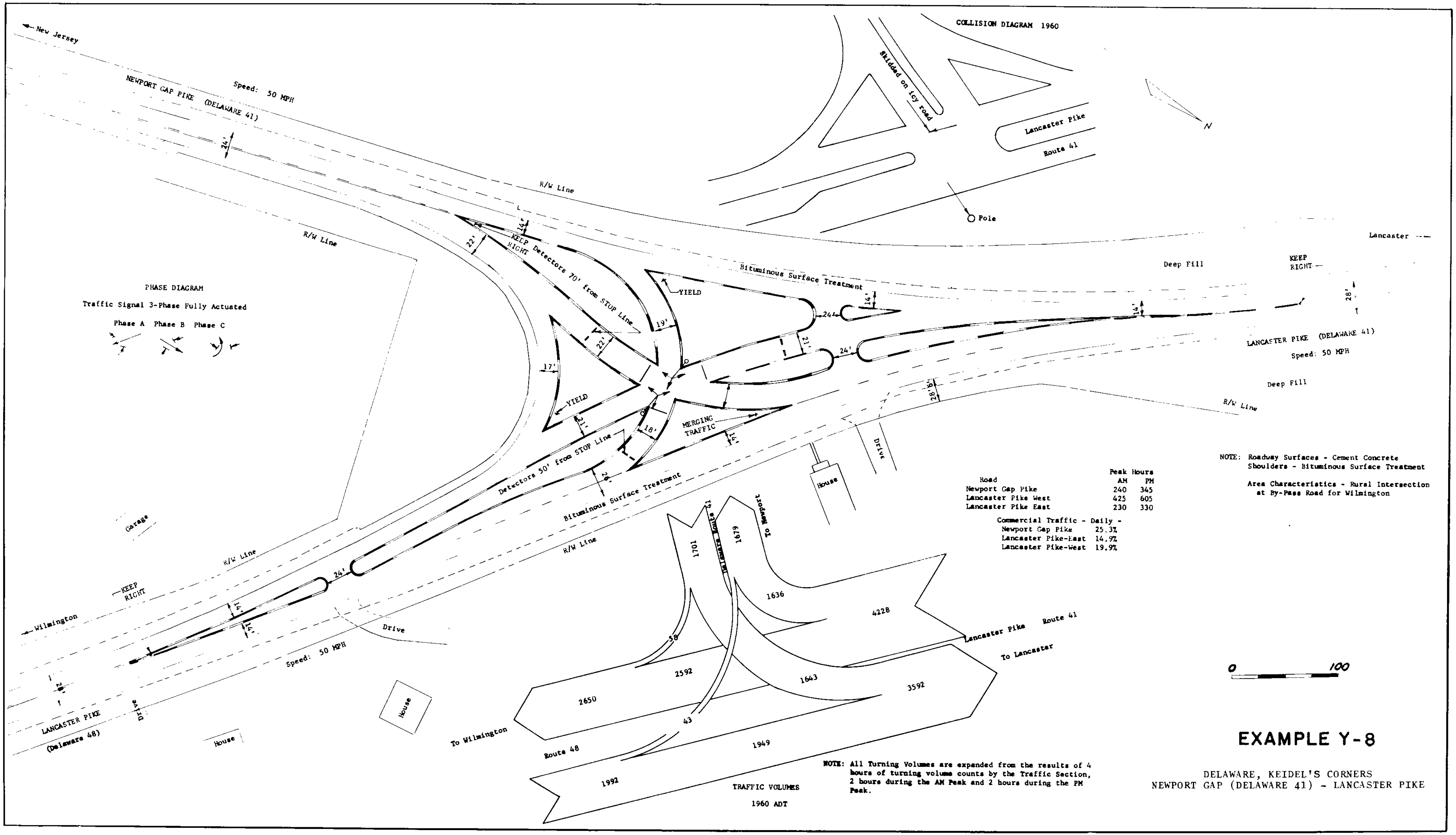




Chevrons indicate raised pavement bars
Shaded areas indicate roadway narrowing by painted island treatment

SUGGESTED REVISION
by Ross T. Shoaf





EXAMPLE Y-8

DELAWARE, KEIDEL'S CORNERS
NEWPORT GAP (DELAWARE 41) - LANCASTER PIKE

Location

DELAWARE, Little Heaven
US Route 113 - US Route 113A

Submitted by

Ernest A. Davidson, Chief Engineer
Delaware State Highway Department
P. O. Box 151
Dover, Delaware

Type of Intersection

3-Way Wye

Date Opened to Traffic

1956

Physical Data

Grades: None over 3%
Surface Type
Roadways: Cement concrete
Islands: Grass, same elevation as roadway (slight slope for drainage). No curb.
Shoulders: Bituminous surface treatment
Cross Section: Normal
Signals: Semi-actuated. 30 seconds main street minimum; 4½ seconds amber; 5 seconds initial; 5 seconds vehicle; 30 seconds maximum; 4½ seconds amber.
Markings: The highway painting has recently been changed to the design as shown on the drawing.
Abutting Property: Rural, with a local accumulation of scattered service stations and houses.

Traffic Data

Design Vehicle: C50
Speeds: US Route 113 - 50 MPH
US Route 113A - 50 MPH
Pedestrian: No pedestrian provisions; small volume.

Operational Characteristics

This intersection was rebuilt five years ago because of the very heavy summer week-end traffic to and from the down-state shore resorts. It was lighted by 250 watt mercury vapor lamps soon after it was built, because of the heavy northbound summer Sunday night traffic. Note that the highway painting has recently been changed to the design shown on the drawing rather than that shown on the photographs which were made in 1956.

There has been no particular history of accidents or malfunctioning of this intersection.

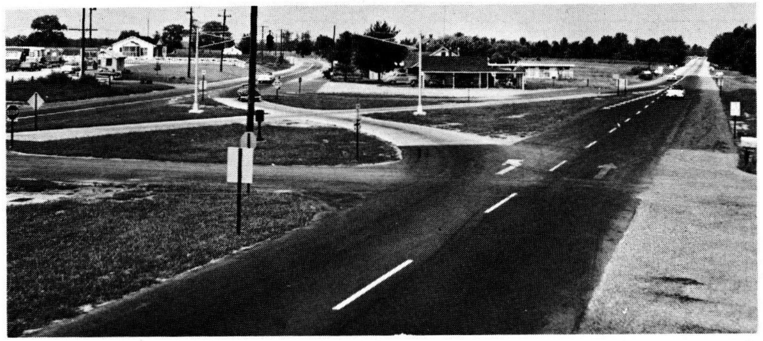


Figure 1: US Route 113 looking North from the intersection, showing details of crossover and intersecting road. Note that the markings in the picture have been later revised as shown on the drawing.

Figure 2: US Route 113 looking North into the intersection, showing details of approach from the South. The drawing shows a later revision of the markings than those indicated in the picture.

Comments by Committee Members

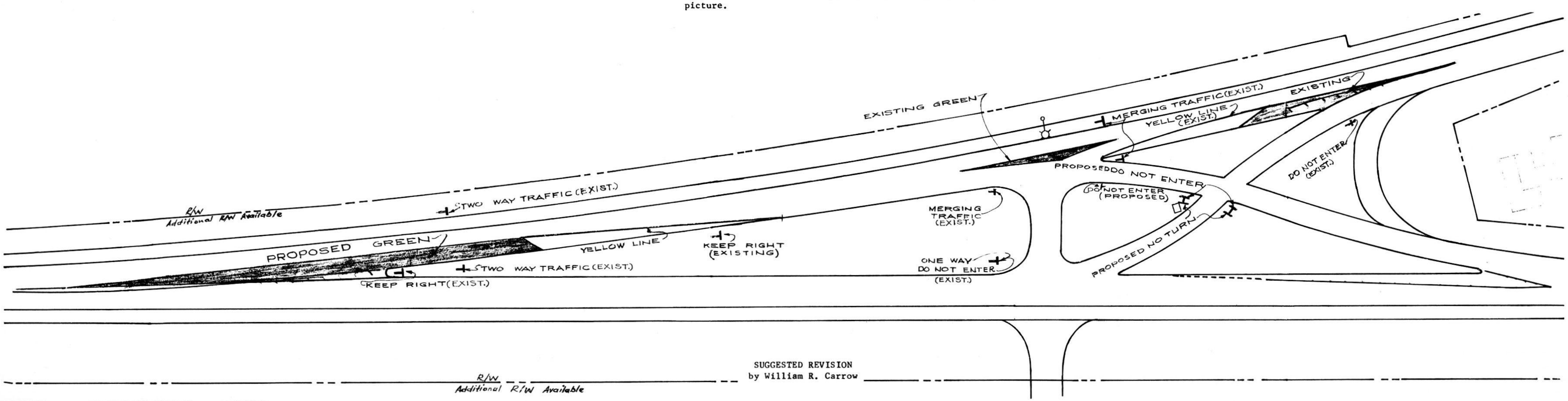
1. KARL MOSKOWITZ - This is a good basic channelized "Y" design, modified to bring in County Road 372. The moderate traffic volumes at the signal and lack of accident history indicate that the plan is adequate.
   Suggest that the transition at the south end of the channelization be revised so that the two southbound lanes are merged to one lane, while two northbound lanes are still available. This design would provide an extra lane for maneuvering in case of an emergency in lieu of the single northbound lane on existing plan, and would avoid "trapping" a northbound driver into the southbound side of the island in case he happened to be passing someone before he noticed the island.
2. DONALD H. SIDES - The indicated channelization is typical for such flat angle layouts. The accident record indicates that motorists readily understand the design. There is indication that U-turns are made under the signalized crossing in lieu of the County Road crossover. Note the worn grass. Signs do not seem to be placed to warn of wrong-way operation. Also, the pavement markings provided for the major movements might cause some erratic operation on the part of traffic to and from the County Road.

Additional Comments by WILLIAM R. CARROW, Traffic Engineer, Delaware State Highway Department - The intersection was re-studied by our Traffic Section and Mr. Moskowitz's idea was given consideration. Highway painting was used to merge lanes heading south. The revised sketch indicates the changes made here.

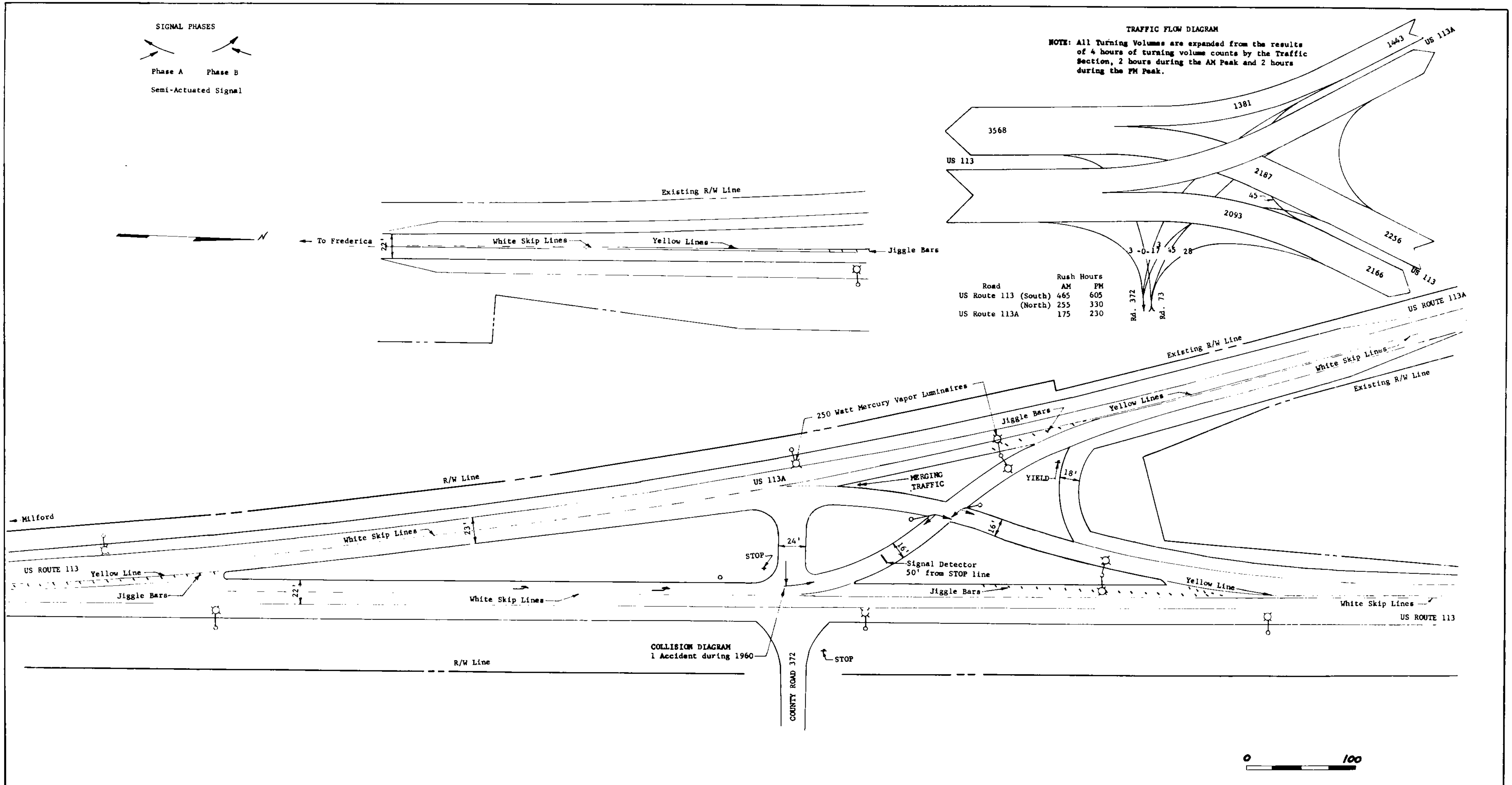
Two "No Turns" signs were added on the northbound lane, and on the reverse side of the signs will be two "Do Not Enter" signs.

Additional right-of-way is available on either side of the road for reconstruction at some future date.

The bare spot at the intersection is a concrete pad around a catch basin.



SUGGESTED REVISION
by William R. Carrow



EXAMPLE Y-9

DELAWARE, LITTLE HEAVEN
US 113 - US 113A

Location

OREGON, near Salem
Oregon 22 - Oregon 223

Type of Intersection

3-Way Wye

Physical Data

Surface Type
Island Curbs: Non-mountable, 7" high
Shoulders: 4' oiled plus 4' gravel - total 8'
Typical Cross Section of Raised Asphalt Jiggle Bar: 8" wide, 1" high on each side and 2" high in the middle.
Traffic Control Devices
Markings: Jiggle Bar areas are outlined with yellow stripe.
Abutting Property: Rural; see photograph.

Traffic Data

Design Vehicle: C50
Pedestrian: None

Operational Characteristics

This intersection evolved by reason of a virgin realignment project wherein the channelization layout was part of the original construction. Based on general experience with this type of intersection I do believe that the one reported accident within a year's period indicates that it has done a good job. The intersection is pretty much rural in nature, being approximately ten miles due west from our capital city, Salem, which is the only near metropolitan area. Again, Oregon 22 is a coast feeder for people in the Salem area and experiences high seasonal peaks with a maximum Sunday running almost three times the ADT.

I might mention that we had to make a minor adjustment in the originally constructed layout. The initial construction did not provide an adequate run of acceleration for the merging movements between movements "A" and "B". We subsequently did some pavement widening and extended this merging area with a projection run of jiggle bars on the trailing nose of the originally constructed curbed island. The plan submitted includes this revision of the initial installation.

Submitted by

F. B. Crandall, Traffic Engineer
Oregon State Highway Department
Salem, Oregon

Date Opened to Traffic

July 30, 1957

Figure 1: Aerial view looking West

Figure 2: Aerial view looking East

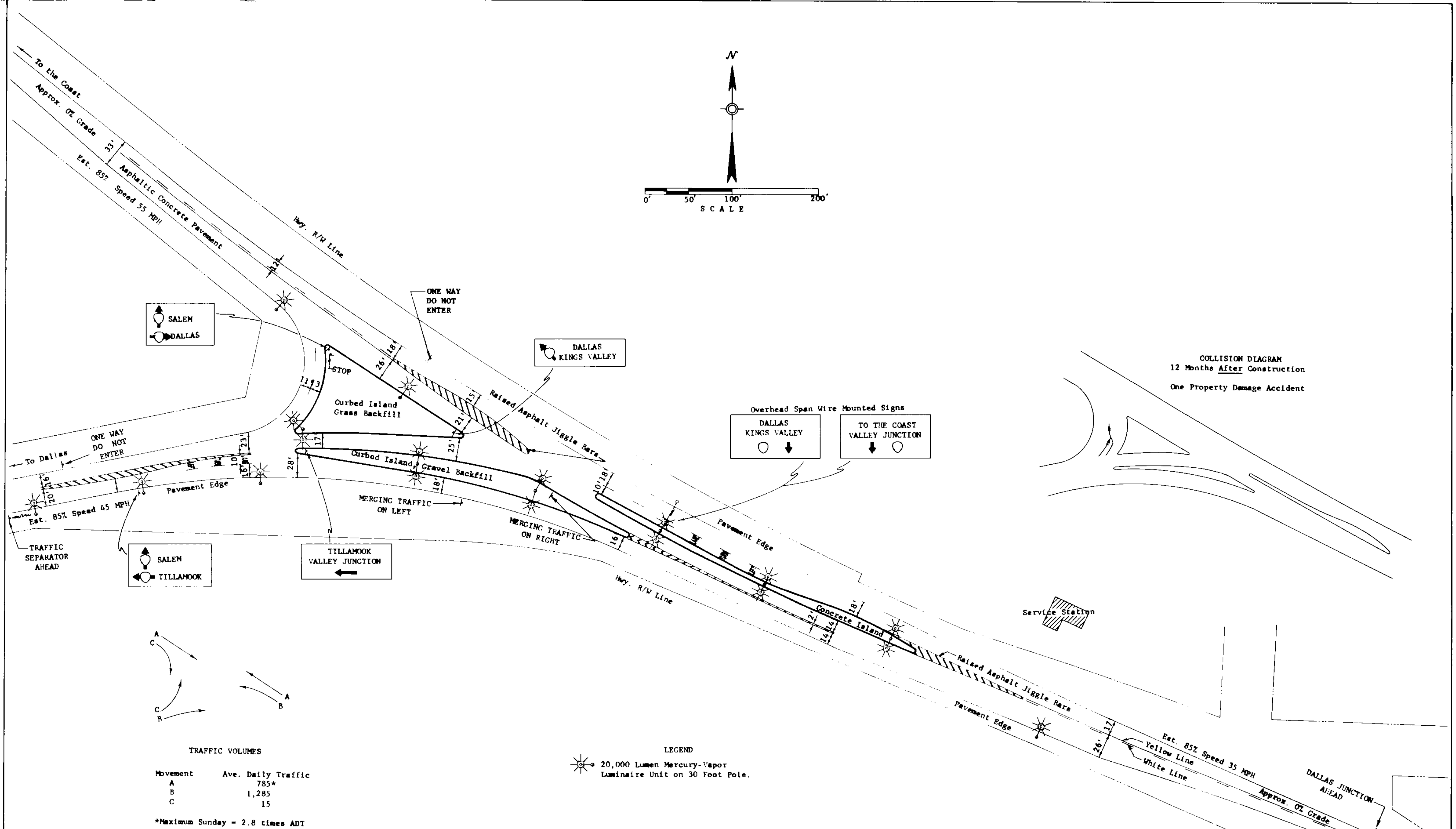
Comments by Committee Members

1. WESLEY R. BELLIS - This is a good design type for a "Y" intersection. The installation of traffic signals would allow the intersection to accommodate more than twice the volume experienced on peak Sundays.

2. WARREN TRAVERS - The following modifications are suggested:
   a. "Paint out" recovery areas beyond turnouts to better delineate vehicle paths for both through and turning traffic.
   b. Stripe "C" ramp with solid striping to better separate opposing traffic flows.
   c. "Break" centerline of Route 22 at point where "C" movement enters.
   d. Install a stop line to augment stop signs for "C" movement.

Additional Comments by F. B. CRANDALL - One of the reviewers suggests that the recovery areas beyond the turnouts be "painted out" to better delineate vehicle paths. Probably the prime reason we have not incorporated such treatment is the maintenance aspect. There is also the possibility that such paint markings might be mistaken for raised islands at night, resulting in sudden maneuvers and thereby nullify the basic purpose of providing recovery areas.

It has been suggested that a solid instead of a dashed stripe be painted on the "C" ramp which is the cut-back movement from north to west and reverse. This comment is well taken and there is no reason why there should not be a solid stripe.



EXAMPLE Y-10

OREGON, near SALEM

OREGON 22 - OREGON 223

Location

TEXAS, Dallas
Gaston Avenue - East Grand Avenue - Garland Road

Submitted by

James S. Saylor, Assistant Director
Department of Traffic Control
Dallas, Texas

Type of Intersection

3-Way Wye

Date Opened to Traffic

April 6, 1959

Physical Data

Grades: None in excess of 3%; not critical to the design.
Surface Type
Roadways: Concrete
Islands: Grass
Height of Curbs and Islands: 6"
Traffic Control Devices
Markings: Dashed 4" White Lane Lines; 24" White Stop Lines:
Curbs on all Islands Spotted with Reflectorized Yellow; All Buttons Painted with Reflectorized Yellow.

Traffic Data

Design vehicle: Considering speeds through the channelization the design vehicle could be C50
Pedestrian: The pedestrian volume is insignificant and no provision for crosswalks has been made to date.

Operational Characteristics

The original intersection was restricted due to insufficient right-of-way. The left-turn movement from Gaston Avenue to Garland Road was extremely sharp, making it difficult for the movement to be made in two lanes and seriously reducing capacity. The physical arrangement made it necessary to stop Movement E (East Grand Avenue) to allow Movement B to proceed without conflict. With this operation the capacity of the entire intersection was restricted due to the fact that the peak period for both Movements E and B ocurred at the same time during the afternoon. Both of these movements resulted from heavy vehicular loads from the downtown area. Even with full actuated volume density control it was impossible to handle these loads without considerable congestion and delay.

In designing the improved intersection it was determined that any appreciable increase in the capacity of the intersection must be obtained by allowing Movement E to proceed uncontrolled by signals. Thus, Movements E and B merge rather than conflict. You will note that the two lanes provided for each of these movements become almost parallel at the point of mergence and that four full lanes are provided after they merge for quite some distance before the transition is made into the normal three-lane section.

A considerable amount of additional right-of-way was obtained so that all curvatures could be flattened out and proper merging areas could be designed.

Figure 1: Existing Channelization Before Revision

Figure 2: Revised Channelization

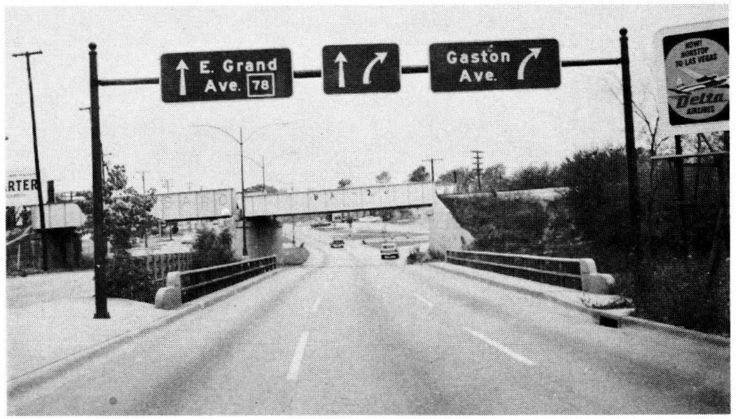


Figure 3: Overhead Lane Usage Signs
Approaching intersection from Northeast

Comments by Committee Members

1. IRV. WEINBERG - With movement C as high as it is, I would recommend that only 2 lanes be provided by movement D. This would produce 2 favorable situations:
   (a) Reduced conflict area crossing of movements F, D, and B.
   (b) Would provide added pavement for merge and gap selection for movement A.

   Reducing flow D pavement to two lanes by moving the north islands' south curb southerly would not be too expensive and would produce (a) and (b).

   Also, the bus stop on the north side at the garage could be moved easterly and the island in the N.W. quadrant could be so shaped to reduce the lanes for flow D to 2 lanes and make a bus bay out of existing lane #3. This would still provide for extended pavement for merge maneuver of flow A, as the "bull nose" would be extended and the additional exiting pavement in excess of 2 lanes would be for flow A.

2. DONALD H. SIDES - That this is an efficient intersection is evidenced by the volume and accident record. The space utilized is not large; the channelization has been evolved by introducing a short section of median along East Grand Avenue--Garland Road, approximately 1,000 feet long, whose maximum width is about 50 feet.

   Objection is sometimes made to crossing three movements at a single point as shown for movements F, D, and B. Separation of these movements, however, would have added materially to the right-of-way required.

   The pavement markings in the northeast quadrant seem to permit a hazardous movement. Movement C requires two turning lanes for capacity. The second lane could well conflict with the portion of movement D occupying the right lane on the approach to the turn. The overhead lane usage signs may, however, preclude movement D from the right lane.

   The need for the numerous driveway entrances upon the plan is not made apparent by the plan descriptions or photographs.

Additional Comments by JAMES S. SAYLOR - The intersection in question was originally a "Y" intersection with no curb and gutter, channelization or other improvements. Both roads were two-lane asphalt rural-type roads. In 1954, the need for channelization became apparent but due to the presence of the service station on the corner, right-of-way costs prohibited the provision of an adequate design. The service station was finally abandoned and sufficient money became available to revise the intersection to its present form.

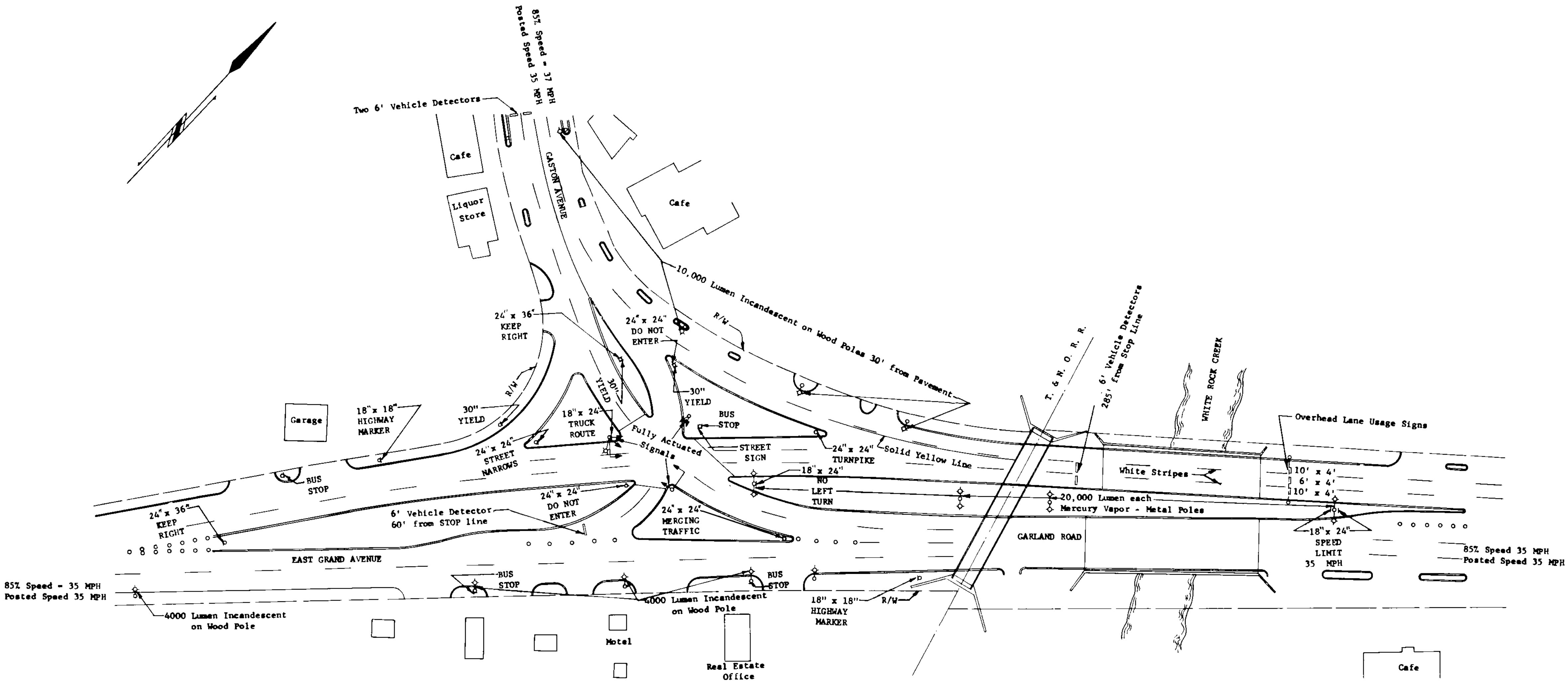
From a pure design standpoint we agree that the roadway should be reduced to two lanes for Flow D. However, due to the presence of the railroad overpass structure it was impossible to provide the desirable storage capacity for Movement D when stopped at the signal. Rather than reduce the area here to two lanes, it was thought the additional third lane might prevent traffic from backing up sufficiently from the stop line to interfere with the free right-turn in the optional lane for movement C.

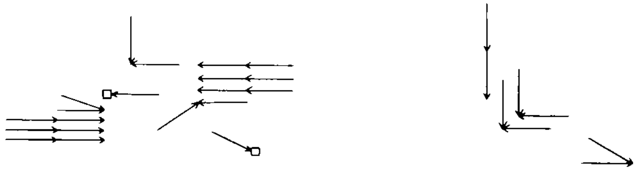
The comments concerning the location of bus stops are well taken. The location of these particular stops, however, were determined by certain pressures from the public.

Concerning the number of driveways in place, the frontages involved consist of small tracts of land of separate ownership. In negotiating for right-of-way with these owners it was necessary to provide individual drives for each of the several separate parcels. We agree that there are far more driveways than are actually necessary, but apparently right-of-way negotiation required this.

We feel that the present intersection is doing an excellent job and that the only major design fault is the lack of sufficient space between the railroad overpass and the intersection proper to completely separate movements C and D.

As a matter of interest, plans are under way to improve East Grand Avenue southwest of the intersection with the standard major thoroughfare section consisting of two 30' roadways and a 14' median. Flow E now has only two lanes and such is necessary in order to achieve the merging of Flow E with Flow B. Some difficulties will arise when it becomes necessary to pinch the proposed three lanes to the existing two lanes at the intersection, even though it is a free flowing movement.

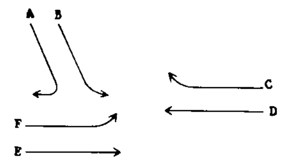




12 Months Prior to Construction

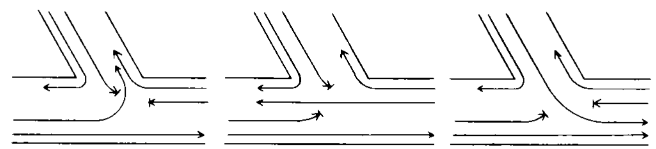
12 Months After Construction

COLLISION DIAGRAM



TRAFFIC FLOW DIAGRAM

Movement	Ave. Daily Vol.	P.M. Peak Hr.	A.M. Peak Hr.
A	409	36	33
B	9389	1654	377
C	11035	419	1884
D	9400	629	1472
E	8659	1254	494
F	259	192	20



Full Actuated Volume Density Control Signals

PHASING DIAGRAM

0' 20' 40' 60' 80' 100'

SCALE

EXAMPLE Y-II

TEXAS, DALLAS
EAST GRAND AVENUE
GASTON AVENUE – GARLAND ROAD

Location

MICHIGAN, Dearborn
US 24 (Telegraph Road) - Ford Road

Submitted by

Harold G. Bauerle
Director of Traffic Division
Michigan State Highway Dept.
Lansing, Michigan

Type of Intersection

4-Way Right Angle

Date Opened to Traffic

December, 1959

Physical Data

Grades: Not of any consequence
Surface Type
Roadways: Telegraph Road northbound, bituminous cap; Ford Road eastbound, bituminous cap; other roadways, concrete.
Islands: White concrete curb (backfilled and seeded); 8-foot divider strip island on east leg has 4-inch concrete cap inside curb.
Traffic Control Divices
Signs: NO LEFT TURN case signs at the principle intersection
Signals: Two-phase signalization with dual indications; 8-inch green arrow for right turn from the west.
Abutting Property
Character of land use: Commercial in the southeast and northeast quadrants; commercial in the northwest and residential in the southwest quadrants.

Traffic Data

Design Vehicle: C50
Speeds: Posted speed limits for area 40 MPH
Accidents: Accident experience not available at this time

Operational Characteristics

The original proposal for improving this location was to construct a diamond interchange. However, a detailed analysis indicated that this type of interchange does not provide adequate turning capacity; and in addition, the high cost of construction and right-of-way was neither justified nor commensurate with adjacent highway facilities. The design combines special left-turn treatments of three varieties into one intersection as follows:

1. Left turns from the south to the west have a directional channelization path.
2. Left turns from the north to the east use a right quadrant left turn facility.
3. Left turns from the east to the south and from the west to the north use a right turn and median-U-turn maneuver.

Signal progression is provided for all left-turning movements. This location is currently the subject of a special study for operational efficiency, which should be completed by July 1961. All observations to date indicate that this design operates beautifully.

This intersection has been opened to traffic a little over a year, and no conclusive before-and-after accident comparison is available.

Figure 1: Looking southeasterly from the west leg of Ford Road.

Figure 2: Looking southwesterly from the north leg of Telegraph Road.

Figure 3: Looking northwest from the south leg of Telegraph Road.

Comments by Committee Members

1. ROBERT E. DUNN - This is an intersection of two high-volume roadways, each carrying approximately 30,000 vehicles per day. In many cases, there would be little question as to warrants for an interchange separation. The designers in this instance, have preserved the fluidity of the intersection-at-grade, by the separation of the major conflicting movements.

   The design involves an elongated traffic circle element that provides for some left turn movements that are prohibited at the intersection proper. This causes circuity of travel with double entry into the intersection complex and weaving across through traffic lanes. The "turn-right to go left" directional lane in the northwest quadrant, and the oblique angle left-turn directional lane in the southwest quadrant are probably operational through an ingenious traffic signal phasing arrangement that creates gaps in the through traffic stream for the crossing and storage of turning traffic. This is a delicately balanced arrangement that might not be suitable for general application in many other locations.

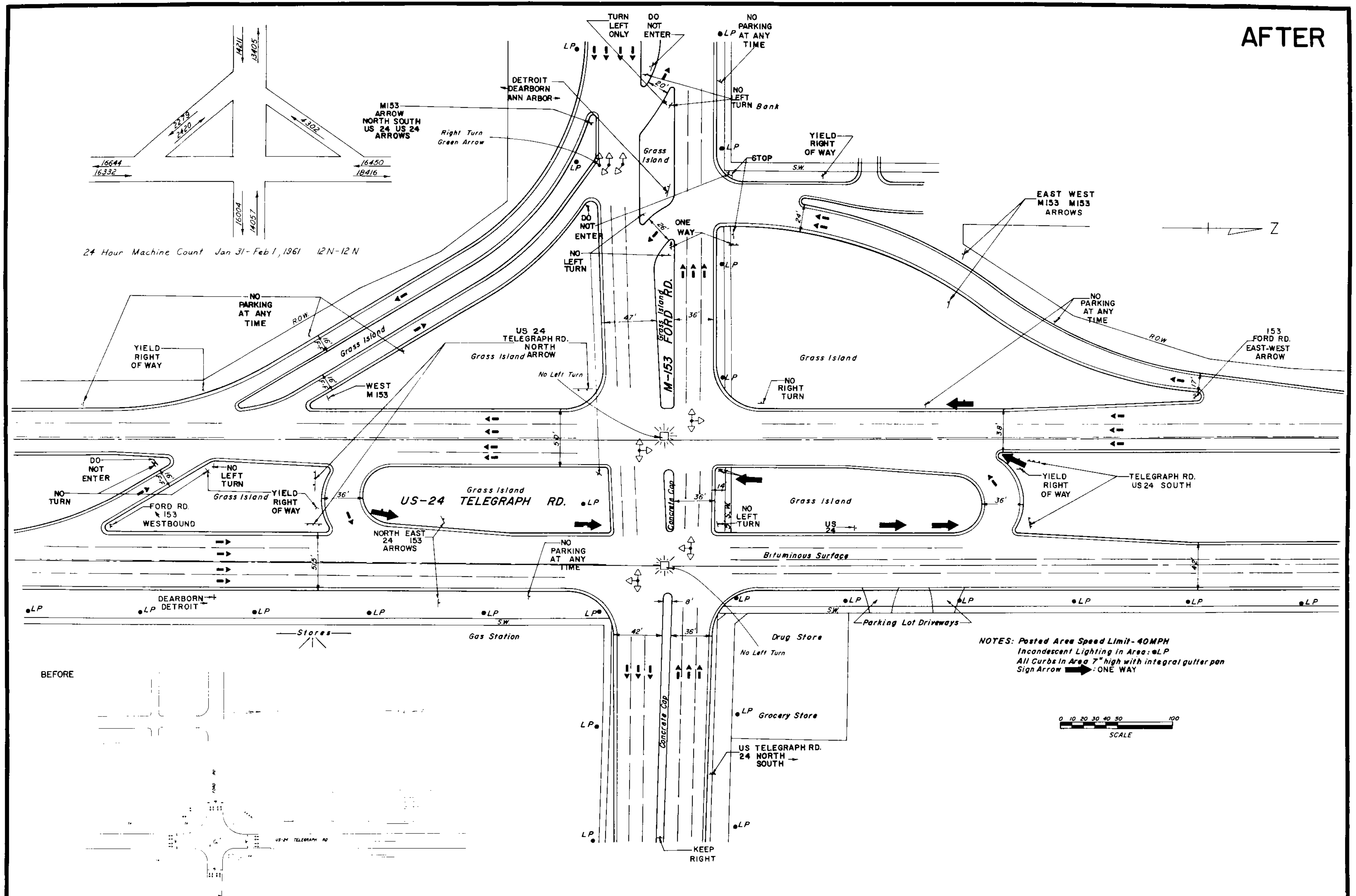
   The submitted design apparently corrects the condition warranting the channelization by basically satisfying the five major principles involved: providing refuge areas for turning and crossing traffic, separating conflict points, blocking prohibited turns, providing locations for traffic control devices, and allowing effective signal control for complex turning movements. The reported statement that, "...this design operates beautifully", and the indicated high volumes of traffic that it handles, make the reviewer wish he had the opportunity to see it - so that he could believe it.

2. WESLEY R. BELLIS - An ingenious and exciting design worthy of competing with grade separation design. The volumes are very heavy, with heavy turning volumes. The percent of trucks should be noted. There are no areas with cross weave. I would think that left turn off of Telegraph Road northbound would be better if signalized. I also feel that the left turn on to Ford Road eastbound would be better if signalized. But, I also know that these types of crossings produce less time delays than if signalized. The signal cycle length and timing should be noted.

Additional Comments by H. H. COOPER, Director of Traffic Division, December, 1961 - Mr. Wesley R. Bellis commented that the left turn off Telegraph Road northbound would work better if signalized. Actually, this turning movement operates in the shadow of the signal from Ford Road. The right-turning traffic from the west on Ford Road turns outside the northbound to westbound left-turning traffic. This practically eliminates any chance of conflicting traffic when the Ford Road signal indication is on "green."

The southbound to eastbound left-turn movement onto Ford Road can also be completed in the shadow of the signal, but must turn onto a separate lane on the median side of traffic stopping for the signal on Ford Road at Telegraph Road. As Mr. Bellis stated, "This type of crossing produces less delay than if signalized." Our accident experience, on our existing channelizations of this kind, indicates a very low accident rate.

Mr. Robert E. Dunn commented that there is weaving across through-traffic lanes. Actually, Mr. Bellis made the correct statement, "There is no area with cross weave." Mr. Dunn further commented that the design is a delicately balanced arrangement. Our experience, in the locations where we have utilized similar designs, indicates that these desins are very rugged and flexible in handling peak hour flows. We termed the design in the southwest quadrant as a one-quadrant at-grade directional. We feel that this is the highest type of at-grade treatment to effectively handle a heavy left-turning movement and that its application is suitable where there is sufficient right-of-way available. The Michigan State Highway Department has locations where two such designs are used in adjacent quadrants and these would be termed two-quadrant at-grade directionals. Because of its cost and operational advantages, the Michigan State Highway Department is planning the use of the at-grade directional in various other locations.



EXAMPLE FR-1

MICHIGAN, DEARBORN
US 24 (TELEGRAPH ROAD) - FORD ROAD

Location

ILLINOIS, Bureau County, near Normandy
Illinois Route 92 - Illinois Route 88

Type of Inte

Submitted by

M. K. Lingle, Engineer of Traffic
Illinois Division of Highways
Springfield, Illinois

Location

ILLINOIS, Bureau County, near Normandy
Illinois Route 92 - Illinois Route 88

Type of Intersection

4-Way Right Angle

Physical Data

Transit Operations: No bus stops

Traffic Data

Design Vehicle: SU

Submitted by

M. K. Lingle, Engineer of Traffic
Illinois Division of Highways
Springfield, Illinois

Date Opened to Traffic

October, 1958

Operational Characteristics

Elements controlling design: Route 92 is the preference route. Present traffic control is a 4-way stop. Existing pavement widths are sufficient for capacity. The layout eliminates additional points of conflict where turning roadways enter the main highway and brings the geometrics up to present standards. The 3-centered curve is based on SU Design Vehicle.

The photograph is a view, looking southwest, on the intersection of Route 92 with Illinois Route 88 south of Sterling in Bureau County. Prior to its reconstruction, this intersection had the highest accident rate in the District, with an average rate of 6.7 for the four years preceding channelization. This rate was quite high, since an intersection with an accident rate of 3.0 is considered to be "accident prone". Subsequent to the construction of the channelization, there have been no accidents reported at this intersection. If accidents had continued to occur at the average rate prior to channelization, there would have been approximately 20 accidents during the period since October, 1958. The prevention of these 20 accidents has saved several thousands of dollars of property damage and an unknown number of injuries and deaths. No separate turning lanes have been provided at this location to increase capacity. Channelization was provided for the sole purpose of increasing the operational safety of the intersection. From the results of our survey, it appears that the islands are doing their job.

Figure 1: Aerial view of the intersection

Comments by Committee Members

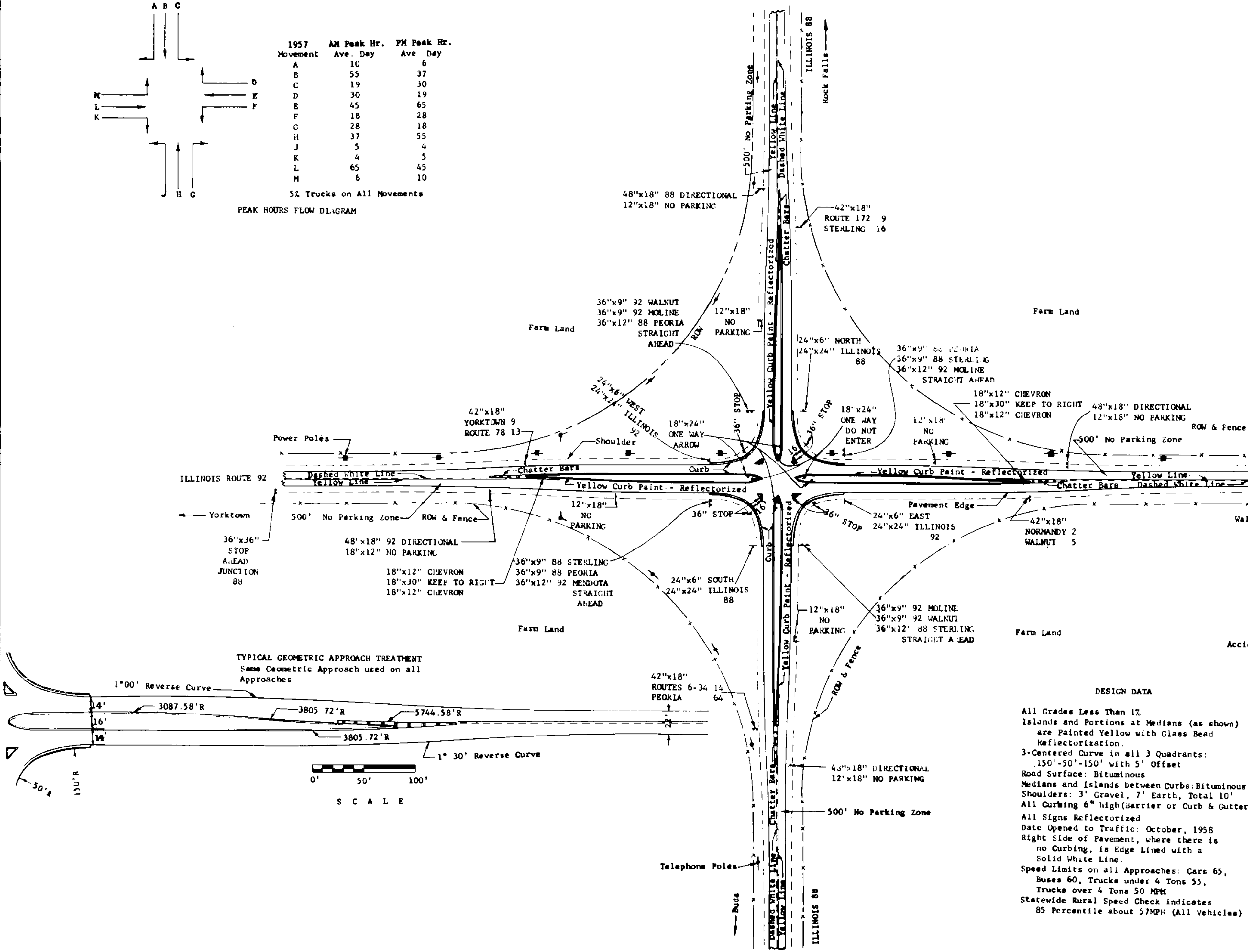
1. C. J. KEESE - This design appears to be an adequate treatment for the purpose of increasing operational safety of the intersection.
   The need for the 4-way stop sign is questionable for the volumes shown.
   Standard "KEEP RIGHT" signs probably would be more easily understood than the "ONE WAY" and "ONE WAY DO NOT ENTER" signs on the divisional islands.

2. R. J. SHOAF - I concur with the comments of C. J. Keese

Additional Comments by M. K. LINGLE - We concur with Mr. C. J. Keese's comment concerning this intersection with regard to the four-way stop control. We might mention that volume-wise the four-way stop barely meets the State of Illinois warrants for a four-way stop control. However, in view of the high number of accidents that could be reduced by a four-way stop control, we felt justified in permitting it at this location. Mr. Keese comments on the usage of certain signs at the intersection. These signs have been erected substantially in conformance with the 1958 edition of the State of Illinois Manual of Uniform Traffic Control Devices. As you are well aware, the signs do not conform to the 1961 edition of the Federal Manual on Uniform Traffic Control Devices. The State of Illinois is presently revising its manual to conform with the new federal manual. When published the signing at this intersection will be completely revised.

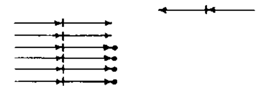
The two intersecting routes extend away from the intersection on a straight horizontal alignment for a distance of at least five miles. We believe by the introduction of channelization at this intersection, we are alerting the motorists to an impending hazard, the intersection. This appears to be true at many of the similar intersections throughout the State where a complete reconstruction and channelization has been accomplished.

We do not believe that the reduction of the accident rate can be attributed entirely to the introduction of channelization which was done as part of the reconstruction of this intersection. There are numerous factors which influence the accident rates here, such as better stop sign placement and concentration of the conflict points at one location. The old intersection had circular two-way turning roadways in all quadrants concentric with the existing right-of-way lines.



1957 Movement	AM Peak Hr. Ave. Day	PM Peak Hr. Ave Day
A	10	6
B	55	37
C	19	30
D	30	19
E	45	65
F	18	28
G	28	18
H	37	55
J	5	4
K	4	5
L	65	45
M	6	10

5% Trucks on All Movements



Accident Record During 1957: 3 PD, 4 PI
No Accidents During 1959

DESIGN DATA

All Grades Less Than 1%
Islands and Portions at Medians (as shown) are Painted Yellow with Glass Bead Reflectorization.
3-Centered Curve in all 3 Quadrants: 150'-50'-150' with 5' Offset
Road Surface: Bituminous
Medians and Islands between Curbs: Bituminous
Shoulders: 3' Gravel, 7' Earth, Total 10'
All Curbing 6" high (Barrier or Curb & Gutter)
All Signs Reflectorized
Date Opened to Traffic: October, 1958
Right Side of Pavement, where there is no Curbing, is Edge Lined with a Solid White Line.
Speed Limits on all Approaches: Cars 65, Buses 60, Trucks under 4 Tons 55, Trucks over 4 Tons 50 MPH
Statewide Rural Speed Check indicates 85 Percentile about 57MPH (All Vehicles)

0' 50' 100'
S C A L E

EXAMPLE FR-2

ILLINOIS, near NORMANDY
ILLINOIS ROUTE 92-ILLINOIS ROUTE 88

Location

TEXAS, Austin
US 183 (Airport Blvd.) -
US 290 (Koenig Lane)

Type of Intersection

4-Way, Right Angle

Physical Data

Grades: Not over 3%. Vertical curve data not critical.
Surface Type
Roadways: Asphaltic concrete
Islands: Consist of 6" vertical barrier curb, topped with grass.
Shoulders: Improved gravel
Cross Section: Not unusual
Abutting Property: No entrances

Submitted by

Walter H. Klapproth, Traffic Engineer
and Don H. Johnson, Traffic Research
Engineer
City of Austin
Austin, Texas

Date Opened to Traffic

June 1, 1958

Operational Characteristics

Comments on over-all operation of the channelized intersection:
It should be noted that this intersection was originally a "T" intersection with island configuration not shown on the accompanying plan. After the addition of Koenig Lane (Farm to Market Road 2222) to the west, it was evident from the severities of the resulting collisions that the "stop" and "yield" controls were not adequate to handle the increasing traffic volumes.
The right turn lanes from US 290 were constructed with the original "T" intersection. With the construction of Koenig Lane, the other right turn lanes were added. At the time of signalization the left turn lanes were constructed in the existing islands. With the revision of the intersection and the traffic signal installation, the present operation is quite satisfactory. Total collisions have been reduced by approximately 30% and the severity of these collisions has been materially lessened.

Comments on elements of the design which contribute to any unsatisfactory operation:
Some features of this intersection, however, are not as could be desired. As can be seen, the intersection exists on a curved section of the major street (Airport Boulevard). The left turn lane for northbound traffic is partially shaded or obscured, due primarily to a flat grade and to the existence of an 8" rolled-face curb. This condition could be improved by increasing the radius of the curve and reconstructing the curb several feet to the left of where it is now located. It would have been desirable to locate the "through vehicle" detectors on all approaches possibly 10' or 15' farther from the stop lines - at a location which would have prevented the detecting of right-turning vehicles, especially since right turns are in heavy volume. Due to the excessive width of the intersection in an east-west direction, it was felt that extending detectors would be desirable for slow-moving vehicles. The use of these detectors is quite satisfactory in that the vehicle interval may be cut to a minimum. This results in no undue extensions from fast-moving vehicles, yet assures the slow-moving vehicle a safe passage before opposing movements are released.

Figure 1: An aerial view looking northeast. A large truck turning left from southbound to eastbound.

Figure 2: Aerial view looking west

Figure 3: Aerial view looking southwest

Comments by Committee Members

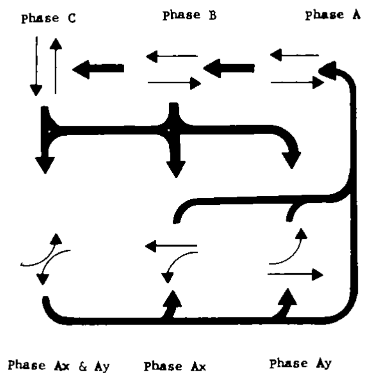
1. KARL MOSKOWITZ - The author's comments appear to cover practically all conditions.
   In regard to his comment that the northbound left-turn lane is partially obscured by the island, it is suggested that the left-turn lane be extended concentric with the through lanes. This will provide an early cue for left turn vehicles and also lengthen the deceleration lane which appears to be short.

2. ROBERT E. DUNN - This is a fairly well executed example of traffic signal and channelization control of a major intersection having 8,000 to 9,000 vehicles per day on each of four approaches. The curvature in the north-south route U.S. 183, however, somewhat complicates the left-turn lane design.
   The principles involved, never-the-less, are adequately applied in this design. The major turning movements between the south and the east are cared for by a free-flowing right-turn lane and a left-turn storage lane. The three-phase actuated traffic signal with its skip features allows for the efficient and orderly movement of vehicles through the focus of the intersection.
   Adaptations of this design can well be applied at the intersection of two major highway routes, and a scaled down modification at the crossings of principal city arterials.

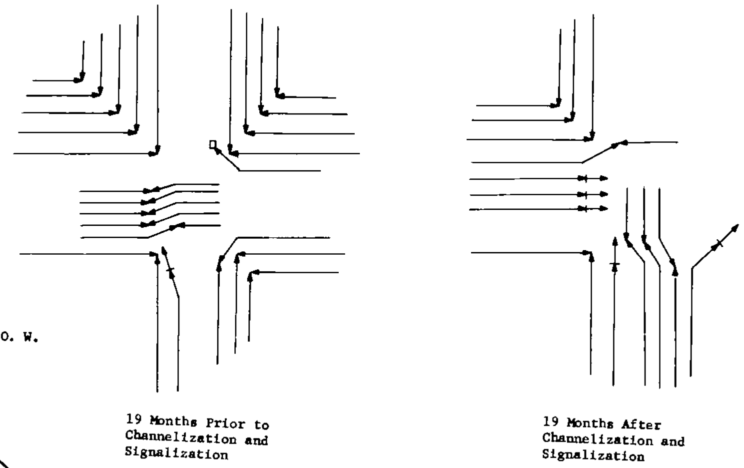
Additional Comments by WALTER H. KLAPPROTH - The "through" vehicle detectors are now located about 70 to 75' from the stop lines and this was primarily due to the length of the islands. I have about come to the conclusion that under certain traffic conditions it would be better to eliminate the right turn lanes and subject all traffic to signal control.

As far as the detectors in the left turn lanes are concerned, they are located about 70' from the stop line and this distance does not require an exceptionally long initial or vehicle extension interval. In fact, these intervals are set at 5 and 4 seconds respectively. From the experience at one or two other intersections, it appears that the detectors for the left turn should be located at about 40 to 60' from the stop line in order to obtain vehicular movement over the detector at an earlier time after the beginning of the initial period.

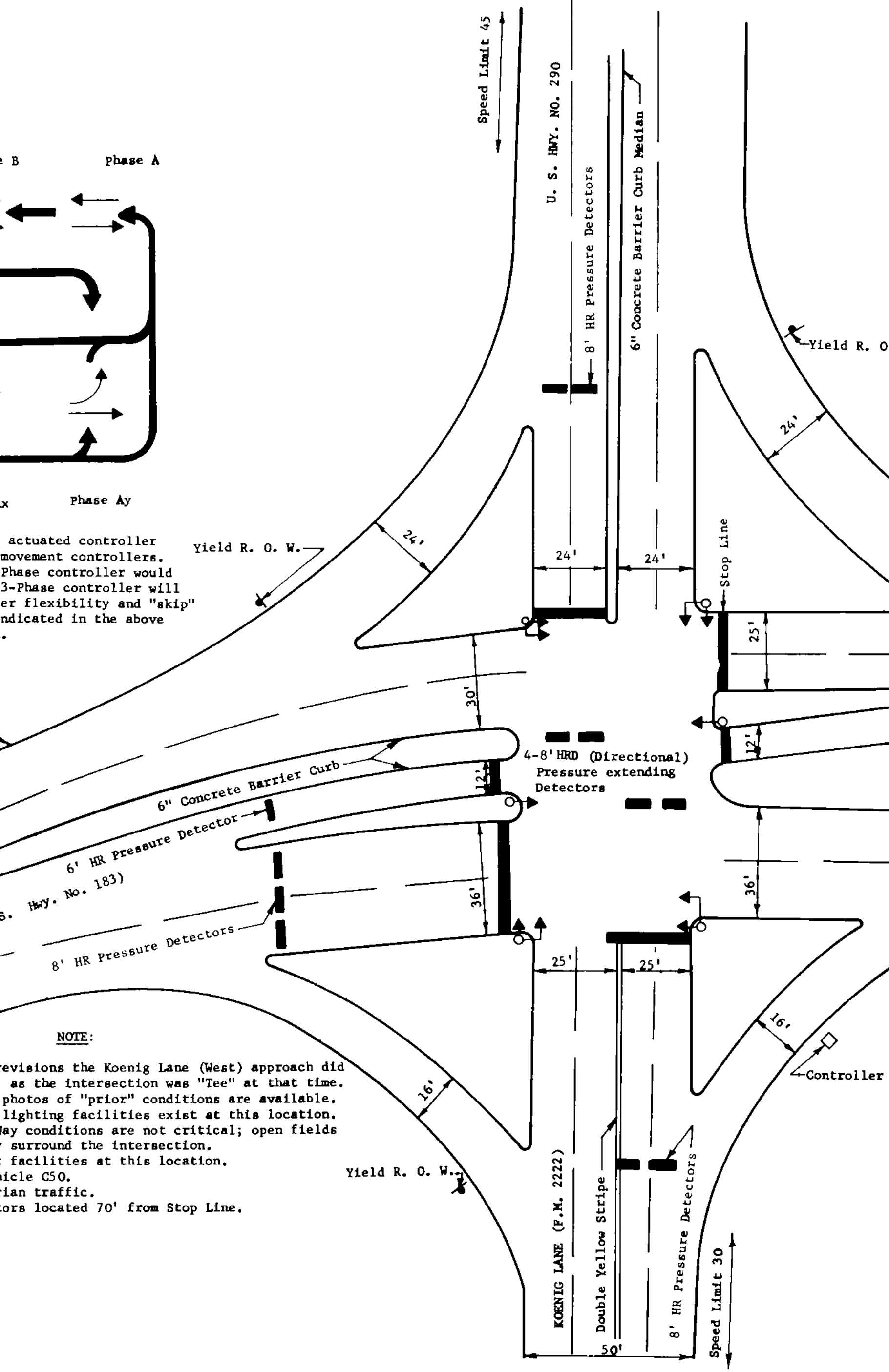
Our experience at this intersection has been most gratifying. There have been only four collisions this year, none of which involved movement from the left turn lanes. This appears to be a considerable improvement over the fourteen collisions which occurred at this intersection in 1958. Only five of the collisions in 1958 occurred after the signals were installed on June 26.



Signal Control: 3-Phase fully actuated controller with 2 minor movement controllers. Although a 2-Phase controller would suffice, the 3-Phase controller will achieve greater flexibility and "skip" features as indicated in the above phase diagram.

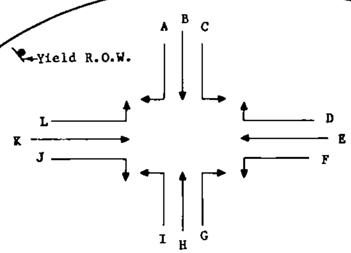


COLLISION DIAGRAM



NOTE:

1. Prior to revisions the Koenig Lane (West) approach did not exist, as the intersection was "Tee" at that time.
2. No aerial photos of "prior" conditions are available.
3. No street lighting facilities exist at this location.
4. Right of Way conditions are not critical; open fields completely surround the intersection.
5. No transit facilities at this location.
6. Design Vehicle C50.
7. No pedestrian traffic.
8. All detectors located 70' from Stop Line.



TRAFFIC VOLUMES

Movement	Avg. Daily	P.M. Peak	A.M. Peak
A	2320	119	52
B	3800	170	142
C	1997	60	71
D	1270	101	23
E	4780	326	243
F	2920	217	124
G	5180	165	265
H	2730	101	107
I	6	0	0
J	124	8	3
K	6860	231	429
L	1320	41	81

5% Commerical

0 50 100
SCALE

EXAMPLE FR-3

TEXAS, AUSTIN
US 183 (AIRPORT BLVD.) - US 290 (KOENIG LANE)

Location

ARKANSAS, Little Rock
Meadowcliff Road - US 67 and 70

Type of Intersection

4-Way Right Angle

Physical Data

Grades: All less than 3%
Surface Type
Curbs: Median - 6" rolled; Access controlled - 6" barrier; Islands - 6" rolled.
Traffic Control Devices
Signals: None
Abutting Property: The Meadowcloff area consists of a subdivision of approximately 700 homes. The intersection is at the south city limits of Little Rock. Meadowcliff Road (east and west) serves local residential land adjacent to the divided highway. The divided highway is the present location of US 67 and 70 and is four lanes divided for approximately two miles on either side of the intersection.

Traffic Data

Design Vehicle: C50
Speeds: Speed data is not available. A speed of 50 MPH is enforced on the divided highway.

Operational Characteristics

Comments on over-all operation of the channelized intersection:
This intersection has been in operation for nearly 36 months. At first, acceleration and deceleration lanes were not properly utilized and some accidents resulted from the improper use. An extensive campaign to instruct and force motorists to use the lanes properly was successful. All in all, this intersection functions properly, especially when the prevailing high speeds and high volumes are considered.

Comments on elements of the design which contribute to any unsatisfactory operation:
Since the divided highway is not a fully-controlled access type, some problems are created by entry and exit to commercial property in the intersection, particularly where commercial access is allowed from the acceleration and deceleration lanes. The nearest median cross-overs are about 0.5 mile north and one mile south of the intersection, and some difficulty has been created by motorists entering and/or leaving commercial areas and driving short distances in the wrong direction on the divided highway. Additional problems have resulted from the differences in the speeds on the divided highway as compared to the intersecting road. But while there have been a few spectacular accidents, the overall rate (property damage and injury) has been low.

Submitted by

J. R. Henderson
Planning and Research Engineer
Arkansas State Highway Department
Highway Building
Little Rock, Arkansas

Dated Opened to Traffic

October, 1958

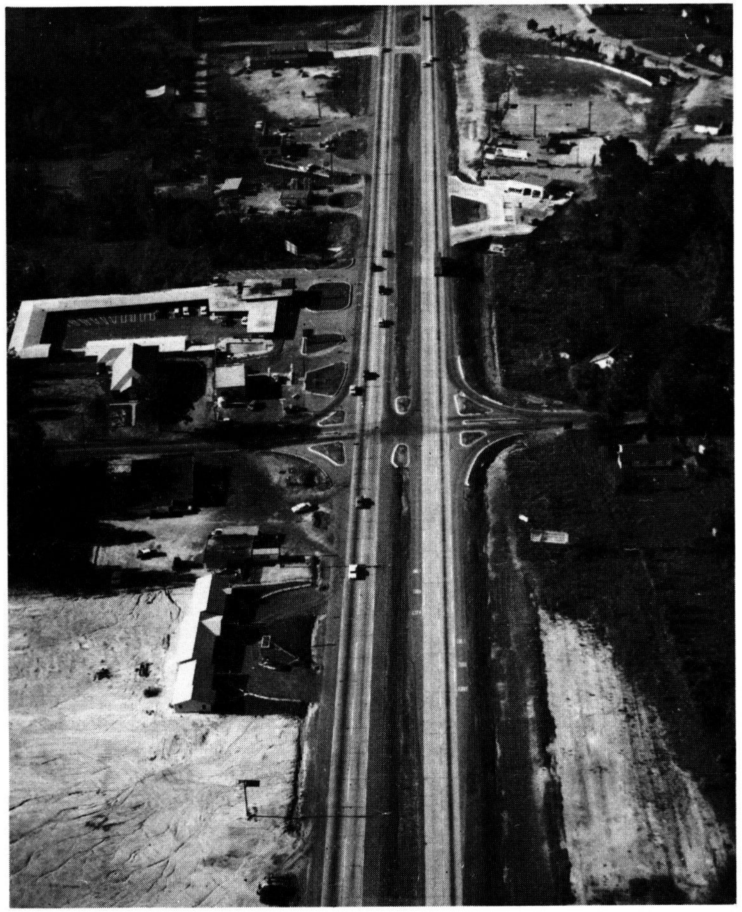
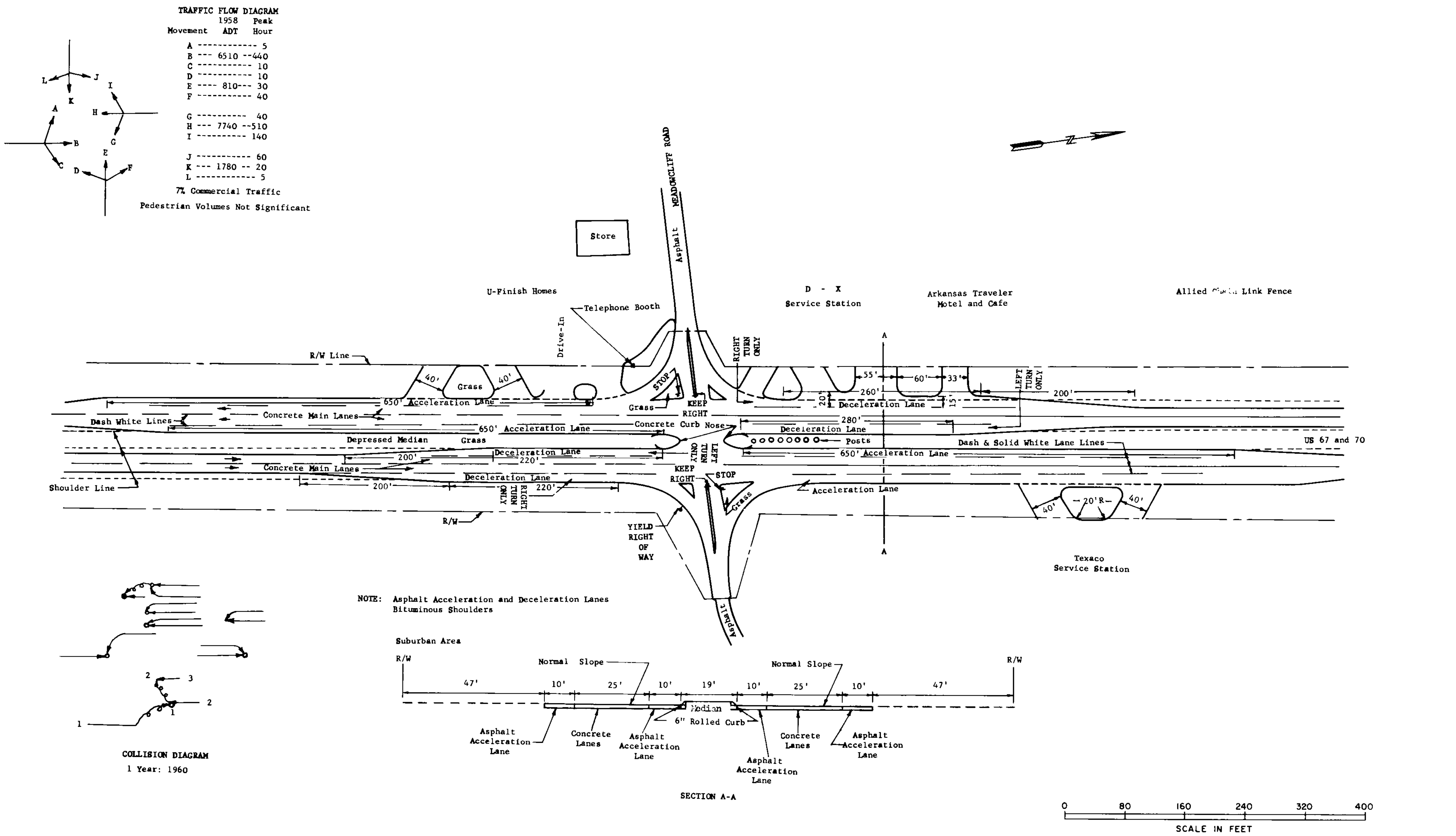


Figure 1: Aerial view of the intersection, looking north.

Comments by Committee Members

1. R. T. SHOAF - The author's comments seem to cover practically all conditions, with the exception that there seems to be little need for the exit from the corner gas station. It would appear better if the exit on the curb return were closed to force traffic to exit onto the minor road.
   Perhaps some medial treatment should be performed opposite those locations where motorists travel a short distance in the wrong direction. However, if not too pressing, perhaps this improper operation should only be watched until a change is required by evidence of hazard.

2. KARL MOSKOWITZ - This appears to be a good standard treatment for typical intersections on divided highways. However, the median acceleration lanes, and the acceleration and deceleration lanes for right turns in all four quadrants, are not believed necessary for the low turning volumes shown. It is felt that this money could better be spent providing left-turn deceleration-storage lanes at other intersections. The separating islands on the cross road should be eliminated since they merely constitute an additional obstacle for traffic. We would prefer to see fewer openings in the right-of-way line in the near vicinity of intersection.



EXAMPLE FR-4

ARKANSAS, LITTLE ROCK
MEADOWCLIFF ROAD - US 67 & 70

Location

IDAHO, Eagle Junction, Ada County
US 60 & 26 - Idaho 69

Submitted by

E. L. MATHES, Assistant State
Highway Engineer,
Idaho Dept. of Highways
P.O. Box 879, Boise, Idaho

Type of Intersection

4-Way Right Angle

Date Opened to Traffic

April, 1957

Physical Data

Grades: 0%
Surface Type
Roadways: 0.2' Plant mix bituminous surface; 0.4' Crushed gravel base, 3/4' mix.; 1.3' Crushed gravel base, 2' max.
Islands have .15' of bituminous surfacing.
Shoulders are paved with bituminous surfacing.
Concrete curb and gutter, curb 6" high; Reflectorized Curb for left-turn bays.
Islands: Left-Turn Bays are 5 3/4" high.
Abutting Property: There is one service station in the northeast corner; the other three quadrants contain farm homes.
Transit Operations: No parking or passenger loading zones in this area.

Traffic Data

Design Vehicle: C50
Speeds: Posted Speed: 60 MPH Day, 55 MPH Night

Operational Characteristics

The over-all operation of the intersection is good, and the raised median and left-turn bays help to move traffic through the intersection. For the traffic that wish to turn left there is a place that they can wait until it is safe for them to turn without interference with through traffic.

Since April, 1957, when the intersection was reconstructed with channelization, there have been 12 accidents reported, most of which were due to failure to yield right of way. There was no good accident record available prior to that time.

Figure 2: Looking west on US 20-26 and Idaho 69

Comments by Committee Members

1. WARREN TRAVERS - This design appears to be adequate.
It is noted, however, that the accident record is not particularly good and, further, that most of the accidents are caused by failure to yield right of way. Inasmuch as there appears to be very adequate warning to drivers on the cross street (Idaho 69), it is possible that sight distance may be somewhat of a problem. Also, the intersection is rather wide, thereby increasing the exposure of crossing vehicles to traffic on the main roadway (U.S. 60). It is suggested that "shoulder lines" be delineated 12 feet beyond the lane lines (8 feet from the curbs), thereby reducing the effective exposure area for cross traffic. This should also increase sight distance substantially since cross traffic, after having started from a complete stop, can be posited farther into the intersection with reasonable safety, thereby giving the driver a "second chance" to evaluate or perhaps, more importantly, a chance to react to a previously misjudged situation.

2. GEORGE J. FISHER - Design principle good. As built, it leaves lanes that are too wide.
I recommend, as does Travers, two 12-foot lanes and an 8-foot lane. However, the 8-foot lane can be used as a right turn lane and designated as such.
It seems to me that this intersection is ready for a semi-actuated signal with right-of-way preference given to U.S. 60 and 26.
Very large "STOP AHEAD" signs may help on both approaches of Idaho 69.

Additional Comments by E. L. MATHES - Shoulder striping is not normally used in Idaho. Our experience has been that shoulder striping does not change the lateral placement of vehicles materially for the relatively short distance as is the case at this particular location. Consequently, no substantial reduction in exposure area would be realized at this junction by a shoulder stripe eight feet from the outside curb.

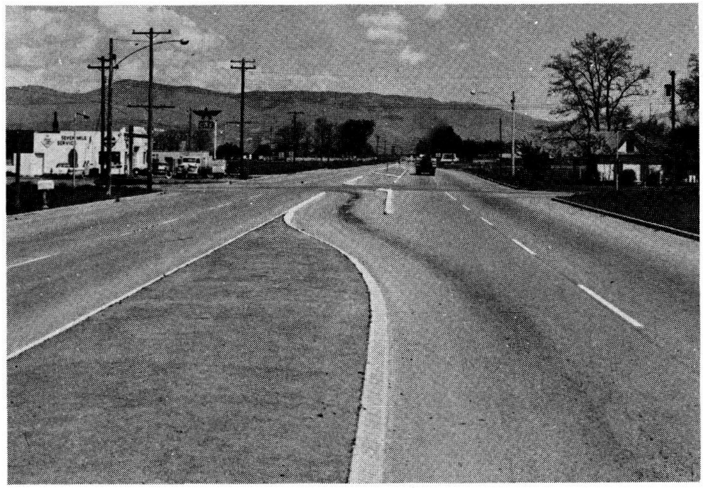


Figure 1: Looking east on US 20

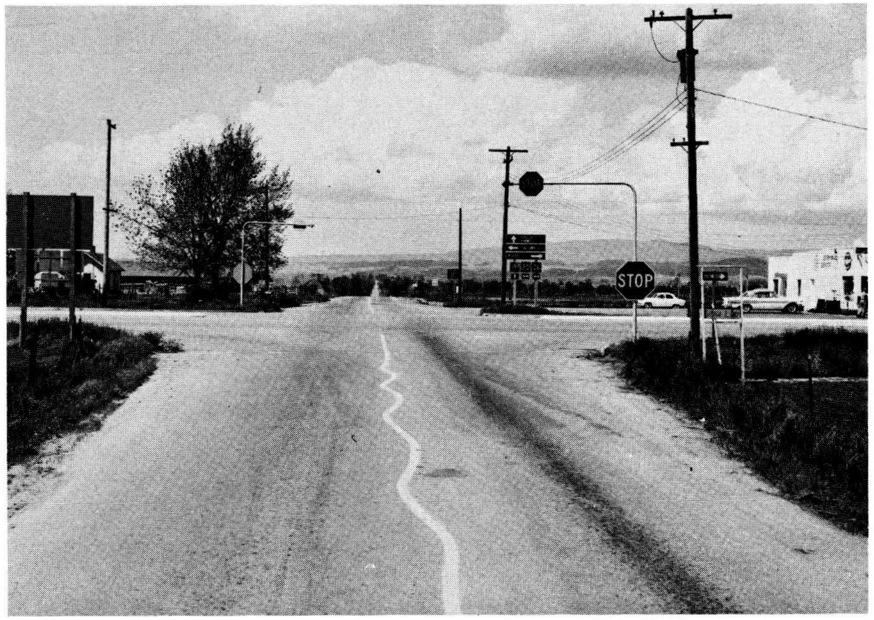
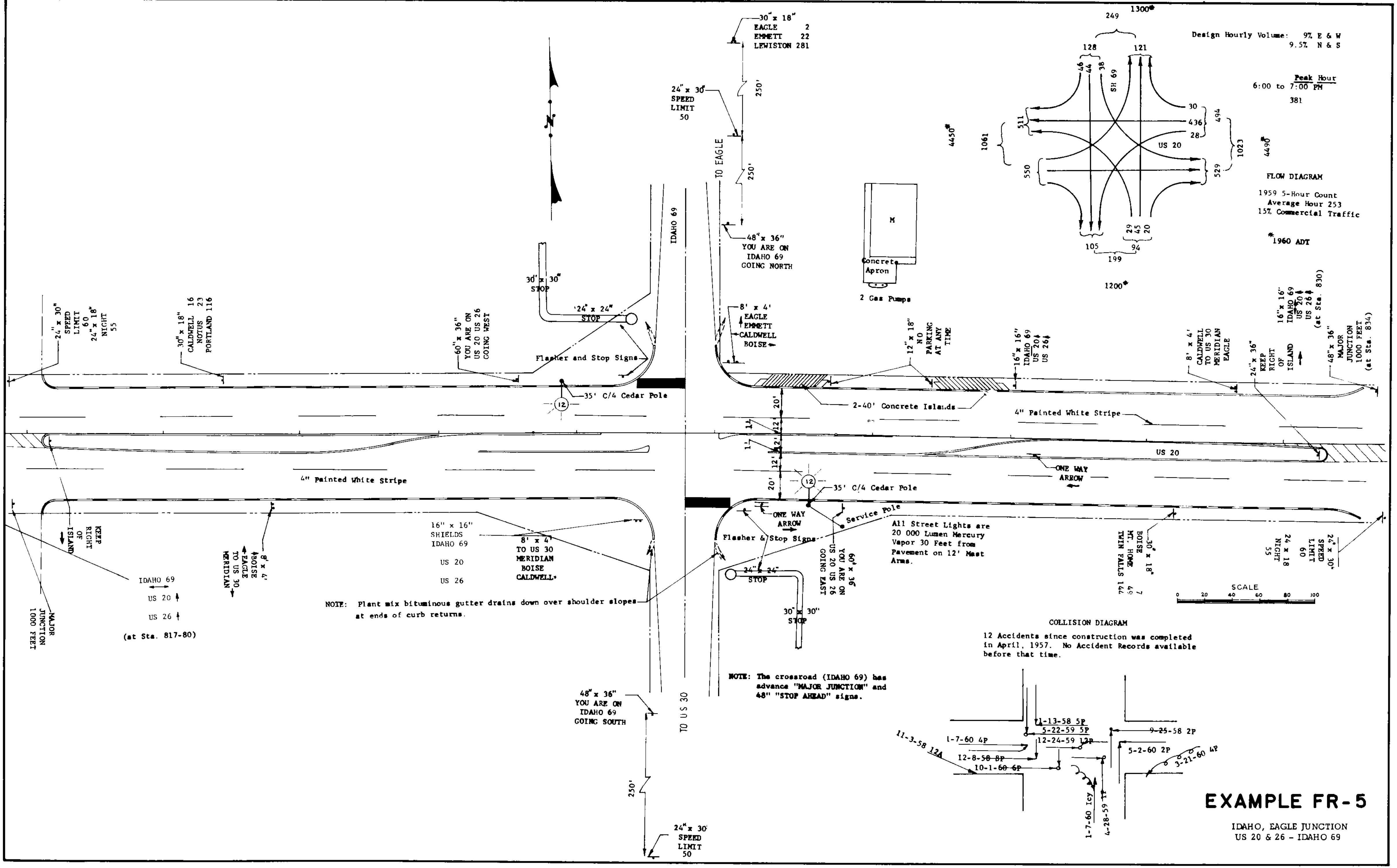


Figure 3: Looking north on Idaho 69



EXAMPLE FR-5

IDAHO, EAGLE JUNCTION
US 20 & 26 - IDAHO 69

Location

NEW MEXICO, Cannon Air Force Base
US 60 & 84 - SR 277 - Base Entrance

Submitted by

New Mexico State Highway Department
Santa Fe, New Mexico

Type of Intersection

4-Way Right Angle (Offset)

Date Opened to Traffic

July, 1960

Physical Data

Grades: None 3% or more. No critical vertical curves
Surface Type
Roadway: Bituminous (3")
Islands: 6" Curbed, with gravel chips on prime coat surfacing
Shoulders: Bituminous (1 ½") with seal and chip cover
Curbs: 6" high and 6" wide at top; sloping face; 12" integral gutter.
Cross Section: Not unusual
Traffic Control Devices
Signals: None - except at Railroad Crossing
Lighting: Double tube (48") fluorescent flood lights at service station.

Traffic Data

Design Vehicle: C50

Operational Characteristics

The over-all operation is generally satisfactory. The intersection was channelized primarily to allow free flow from the Air Base in the P. M. and allow storage for a large left-turn inbound A. M. movement. During short periods in the A. M. when the railroad crossing is occupied by a train, inbound traffic occasionally must store, not only between the highway and the railroad crossing, but in the holding lane provided along US 60-84.

Although the State Route 277 intersection is offset instead of re-aligned to make a direct four-way intersection, this has not created any significant problem. Apparently this is because the traffic volumes between the Air Base and State Route 277 are light. It was found that it would be less expensive to move the highway north than to buy out the existing roadside development on the south side of the highway in the vicinity of the Air Base Entrance. Also, this provided a better distance between the highway and the railroad.

An unsatisfactory feature is the at-grade railroad crossing. Ideally, this could be eliminated by grade separation at both the tracks and the intersection. However, this expense and the uncertainty of continuance of the Air Base does not warrant such treatment. Also, the 26-foot-wide two-way throat of the intersection has proved too narrow.

The principal accident concentration before this entrance was re-constructed was of the rear-end nature caused by westbound vehicles slowing and stopping to make their left turn into the Air Base. All of these accidents happened during the heavy A.M. movement to the Air Base. Since re-construction there have been no such accidents.

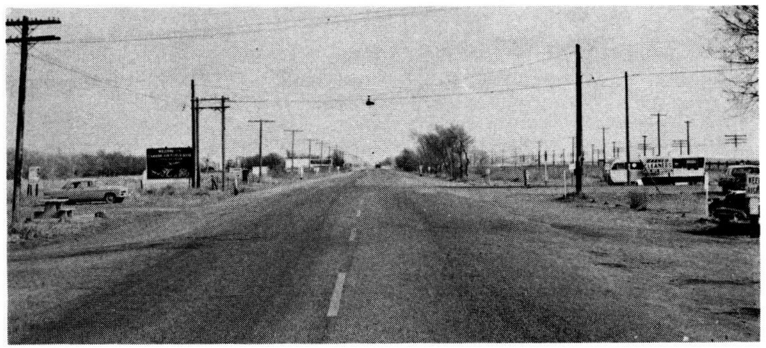


Figure 1: Looking east, before channelization

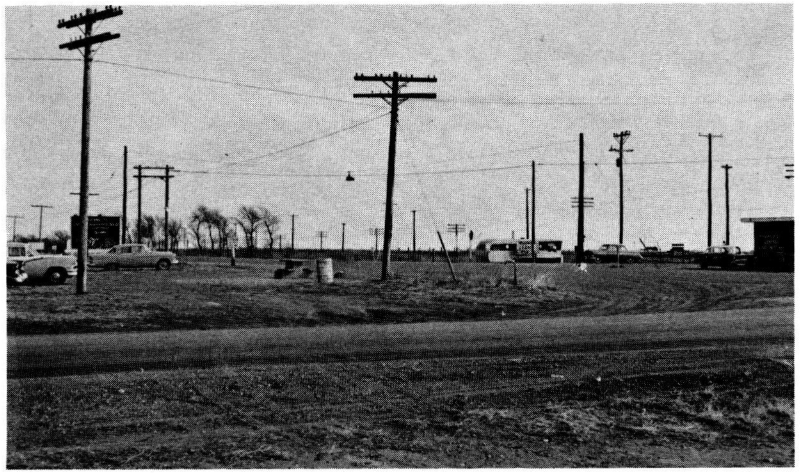


Figure 2: Looking from northwest corner of SR 277, before channelization

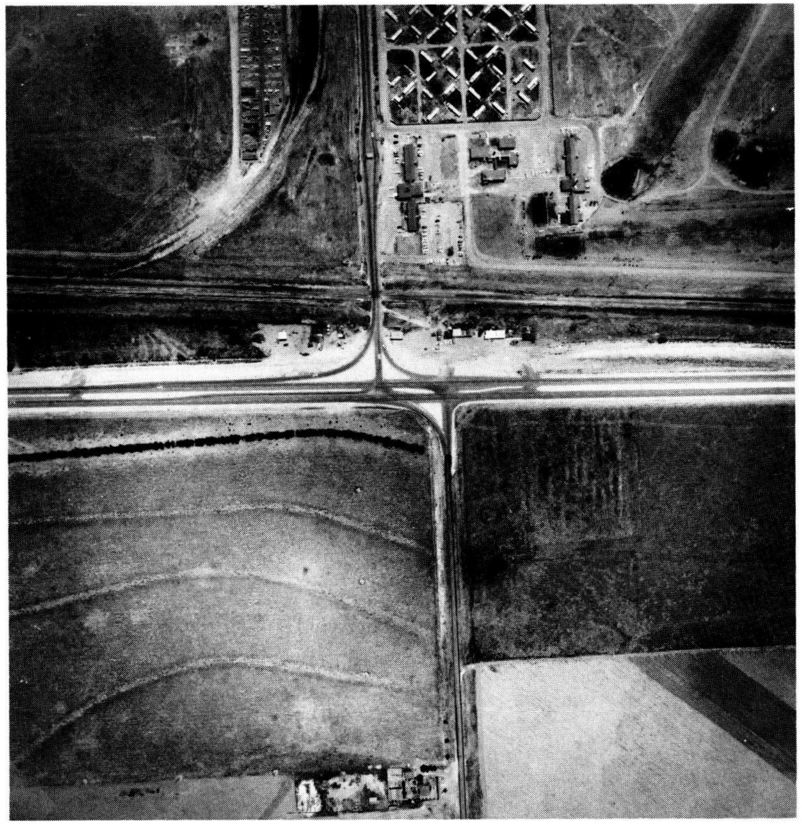


Figure 3: Aerial view, after channelization

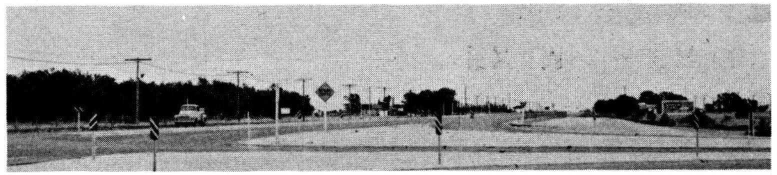


Figure 4: Looking from southwest corner of Air Base Entrance, after channelization

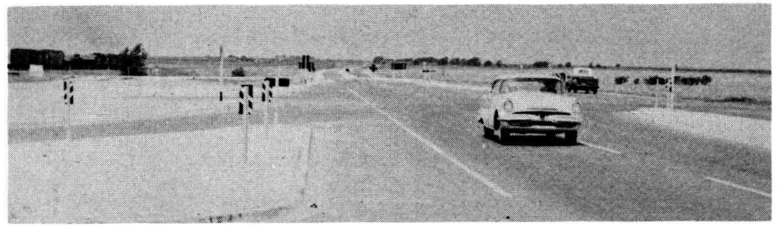
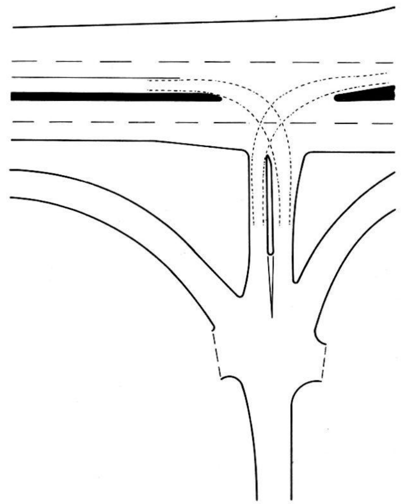


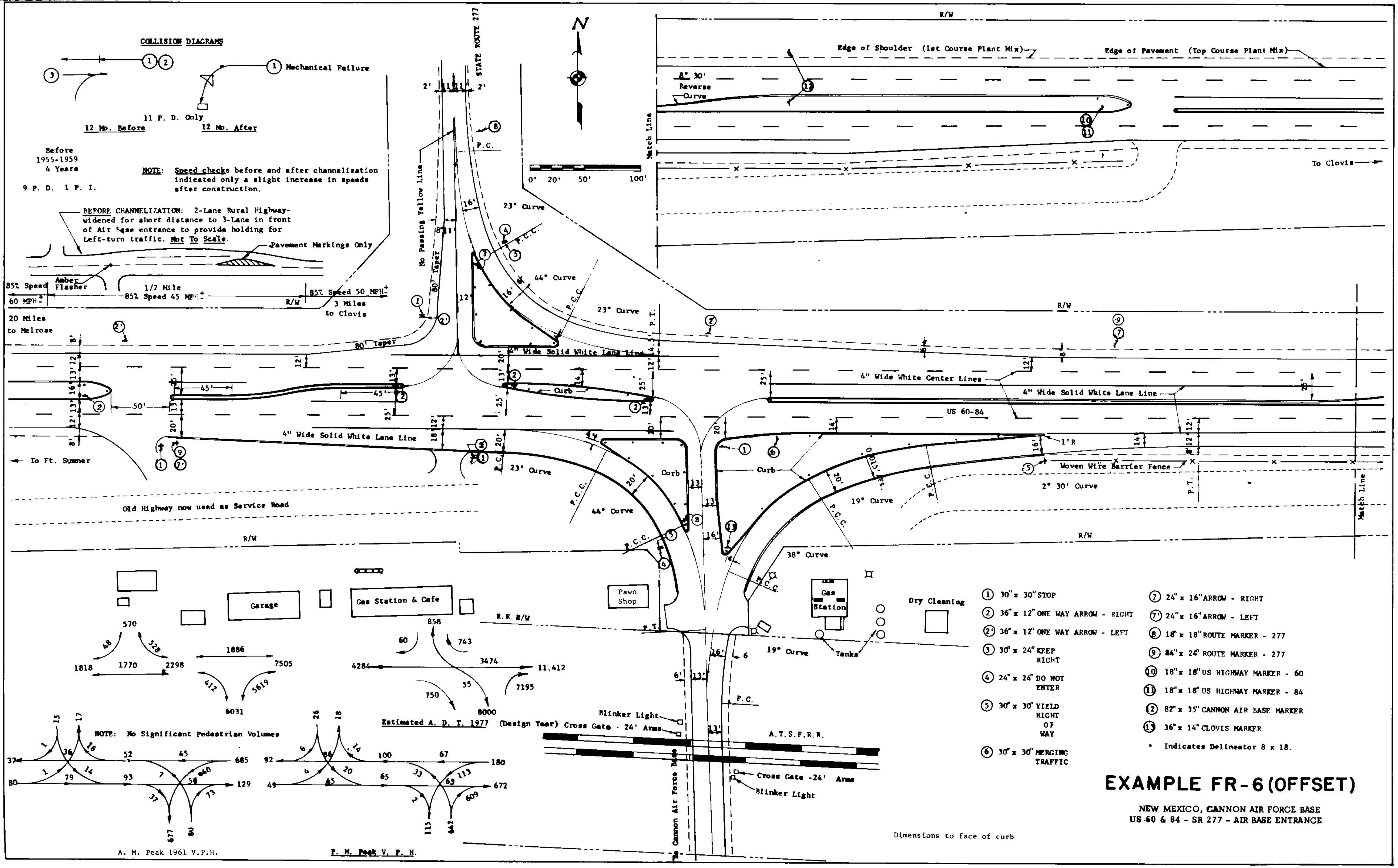
Figure 5: Looking west, after channelization

Comments by Committee Members -

1. EUGENE MAIER - This design is a good example of the use of channelization to minimize the hazards at the intersection of a high-speed rural highway and the entrance to a facility (Air Force Base) which generates heavy entrance and exit movements. The most important feature of intersection channelization is the left-turn lane which provides a refuge for turning vehicles and sorts the approaching traffic for separate signal control. These principles have been used effectively in this example. The geometry of the design conforms to the major traffic movements and, as noted in the "Operational Characteristics", the only dimension which appears to be less than adequate is the narrow roadway between the through highway and the railroad. Both texture and color have been used to obtain good contrast between the roadway and the islands and shoulders. Night visibility of the islands is achieved with well-placed delineators and good signing.

2. CHARLES J. KEESE - Although the movement from the south turning left (to the west) is relatively light, a divisional island could be used on the Cannon Air Force Base entrance for better definition of the entrance for left-turning traffic from the east, as indicated in the sketch revision. If a divisional island is used in a case such as this, care must be exercised to provide a wide open entrance easily identifiable. By location of the ends of the island, a smooth natural path should be provided.





EXAMPLE FR-6 (OFFSET)

NEW MEXICO, CANNON AIR FORCE BASE
US 60 & 84 - SR 277 - AIR BASE ENTRANCE

Location

COLORADO, Denver
Colorado Boulevard - E. 46th Avenue

Submitted by

Richard C. Thomas
Assistant Traffic Engineer
City of Denver
Denver, Colorado

Type of Intersection

4-way Right Angle

Dated Opened to Traffic

December 10, 1959

Physical Data

Grades: Very minor: not pertinent to traffic performance.
Surface Type
Roadways: Asphalt
Islands: The channelizing islands on the northeast and the southwest corners are both paved and outlined by the use of 15" diameter cast iron traffic buttons painted yellow and by delineators on 4' "U" posts. The channelizing islands on the northwest and southeast corners are not paved but have a gravel surface outlined by the use of delineators on 4' "U" posts.
Shoulders: Gravel, sloping to a surface drainage system.
Curbs: No curbs and gutters in this area.
Traffic Control Devices
Signs: All signs except the truck route sign are reflectorized.
Size of signs: "Yield Right of Way" 30" triangle
Delineators 6" x 18 "
Double Arrow Warning Sign 12" x 24"
Markings: All buttons are yellow, outlined with a double yellow line. Double yellow center lines; single white lane lines.
Lighting: 20,000 lumens mercury vapor luminaires.
Abutting Property: The abutting property for a considerable distance in all directions is owned by the Colorado Department of Highways for future inter-change construction, and thus there are no access points of any kind within the limits of three or four hundred feet in any direction.
Right-of-way: Property lines have been extended for future construction of an interchange at this location and are not within the limits of this drawing.

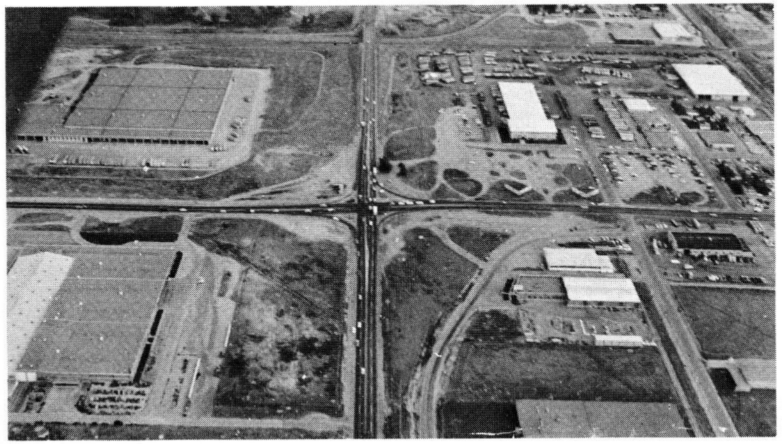
Traffic Data

Design Vehicle: C50

Operational Characteristics

Comment on overall operation of the channelized intersection: Over-all efficiency of this intersection has been improved by storing left-turn movements out of the through traffic lanes. This is proved by the fact that we have had an average increase in traffic volume (both A.D.T. and Peak Hour) of 28.4% on all approaches since the button channelizing was installed. We have also had, however, a corresponding increase in accident experience, with the left-turn vs. straight-through accidents occurring with more frequency than before.

Causes of concentrations of accidents: In addition, this is the intersection of two intra-city truck routes and carries a heavier-than-usual percentage of truck vehicles. It was found that accident-involvement of trucks exceeded the ratio to total volume of traffic by almost 7%. It is felt that passenger car drivers' impatience with the slower moving trucks is a contributing factor to the increase of accident frequency.



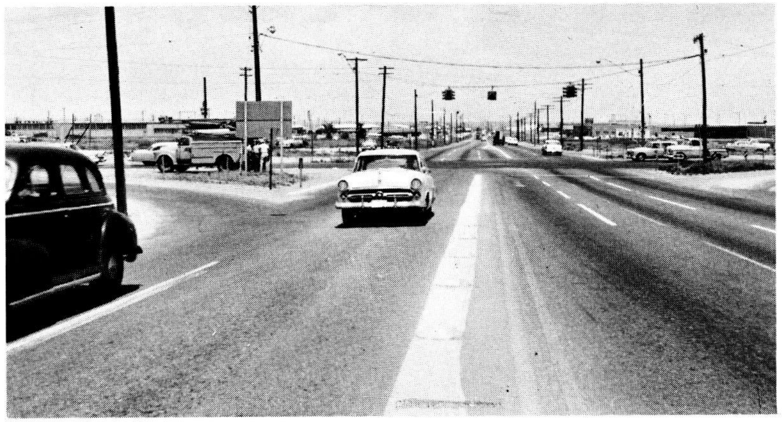


Figure 2: South Leg Left-Turn Pocket; Right-Turn By-Pass

Figure 3: West Leg Right-Turn By-Pass

Figure 4: North Leg Pusher Island

Comments by Committee Members

1. W. R. BELLIS - This is a very good example of design treatment for the typical right angle intersection at grade. The volumes experienced are close to the maximum that can be carried satisfactorily. Severe congestion can be expected with an increase in traffic. The life of this design can be extended by using a longer cycle during rush hours (90 seconds and later 120 seconds.)

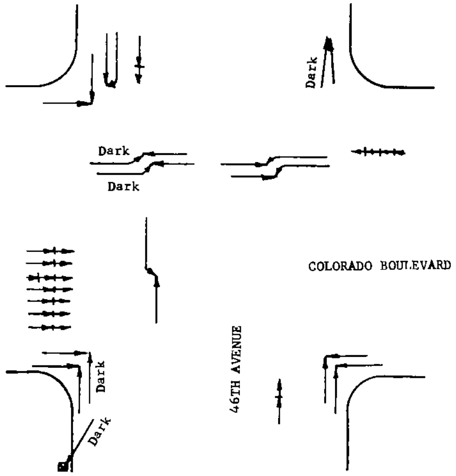
2. KARL MOSKOWITZ - This is a standard treatment for a right-angle intersection. With the volume of traffic indicated on the sketch, it appears that the left-turn lanes are too short.
   In the delineation of the left-turn lanes, it is suggested that an 8" solid stripe be used in contrast to the broken single lane stripe which may be crossed over at any time.
   The author indicates an increase in the left-turn vs. straight-through accidents. In our experience, we have found that a leading green for the left-turn movement is undesirable because the left-turning traffic, seeing the opposing traffic waiting, assumes it has the right-of-way. The first group of left-turners are protected, and the rest are not. The individual drivers never know. For the volume of traffic and the accident experience at this location, a separate phase for the left-turn movement from Colorado Boulevard appears to be in order; ie., the left turn should have a red light while the opposing traffic moves. Another solution, but not so efficient, is to use a lagging green for the left turn. This method causes the left-turners to wait until they actually see the opposing traffic come to a stop. This extra waiting is inefficient but is on the "safe" side.

Additional Comments by RICHARD C. THOMAS - Mr. Moskowitz's first comment concerning the length of left turn lanes is certainly correct. However, the length of the left turn lanes was based on the maximum amount of pavement that the Colorado Department of Highways felt that it could afford on this particular project. It should be kept in mind that East 46th Avenue is on the alignment of Interstate Route 70, and this intersection in the next two or three years will give way to a full interchange. In the meantime, although the left turn lanes are rather short, they do provide adequate storage for the greatest part of the day. The comment concerning delineation of left turn lanes has been taken care of in that the City and County of Denver has this year converted to the 8 inch solid stripe for left turn lane delineation.

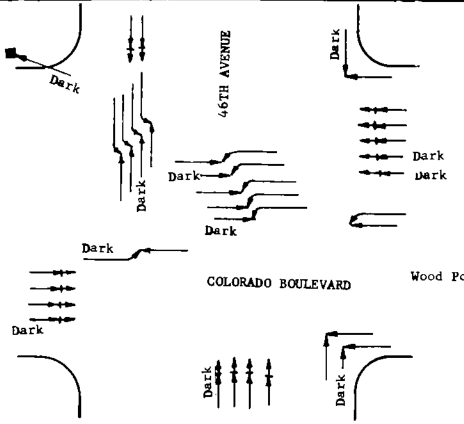
In this office, we have had many discussions concerning the use of left turn arrows to assist heavy left turning movements. The City of Denver has in the past used almost exclusively a leading left turn arrow. The greatest difficulty with this signal indication is that it merely "goes out" to end the phase, with no amber indication. We do use a 2 second clearance interval even though no amber indication is shown. Therefore, the left turning motorist is aware that his phase has ended when the arrow goes out, but our biggest problem has been convincing the motorist who is making the left turn that he must not "cheat" on the clearance interval while the opposing traffic is just getting under way. It has been proposed in this office that many conversions be made to provide a lagging left turn arrow, but no action has been taken as yet because we have not solved the problem of transition from one type of signal operation to the other. It is very difficult to stop using a leading left turn arrow, because the motorist merely assumes the arrow is burned out and charges off on his left turn movement anyway.

We did not go into great detail about the signal system at this intersection, but as a matter of fact the signal timing which we reported to you was merely an interim arrangement. Mr. Bellis comments that the use of a longer cycle during rush hours could reduce traffic congestion. Actually, a few weeks after we submitted this report detectors were placed at all approaches and the intersection signal control was changed to a fully actuated system. We now have a semi-actuated controller in operation during off-peak hours, with East 46th Avenue being the actuated phase. The controller is set with a 60 second background cycle to keep it in step with other nearby traffic signals. During the hours of 7 to 9 AM and 4 to 6 PM detectors on Colorado Boulevard are put into operation and the intersection is fully actuated. The maximum settings are arranged so that the cycle can be as long as 120 seconds if demanded. This controller is a design of our Signal Department, and enables us to have a flexible or "floating" long cycle traffic signal during the peak hours, and yet have an "in step" signal system during the off-peak hours.

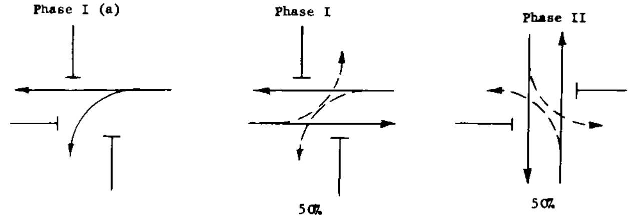
For the northbound and eastbound approaches, we have installed infra-red detectors on the wood poles shown on the drawing in advance of each stop line. For the southbound and westbound approaches, we have installed radar detectors on mast arms from these wood poles.



COLLISION DIAGRAM
Before Channelization
January 1 - December 10, 1959
From Police Department Report
1959 had 29 Accidents, 5 Injuries, 0 Fatalities



COLLISION DIAGRAM
After: Channelization
December 10, 1959 - December 10, 1960
From Police Department Report
1960 had 41 Accidents, 11 Injuries,
0 Fatalities



Split Phase Timer for leading green
15 seconds 7-9 AM and 4-6 PM
5 seconds all other times
(STOP timing on 60 seconds background cycle)

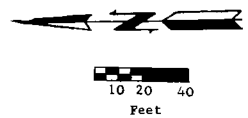
ADDITIONAL NOTE

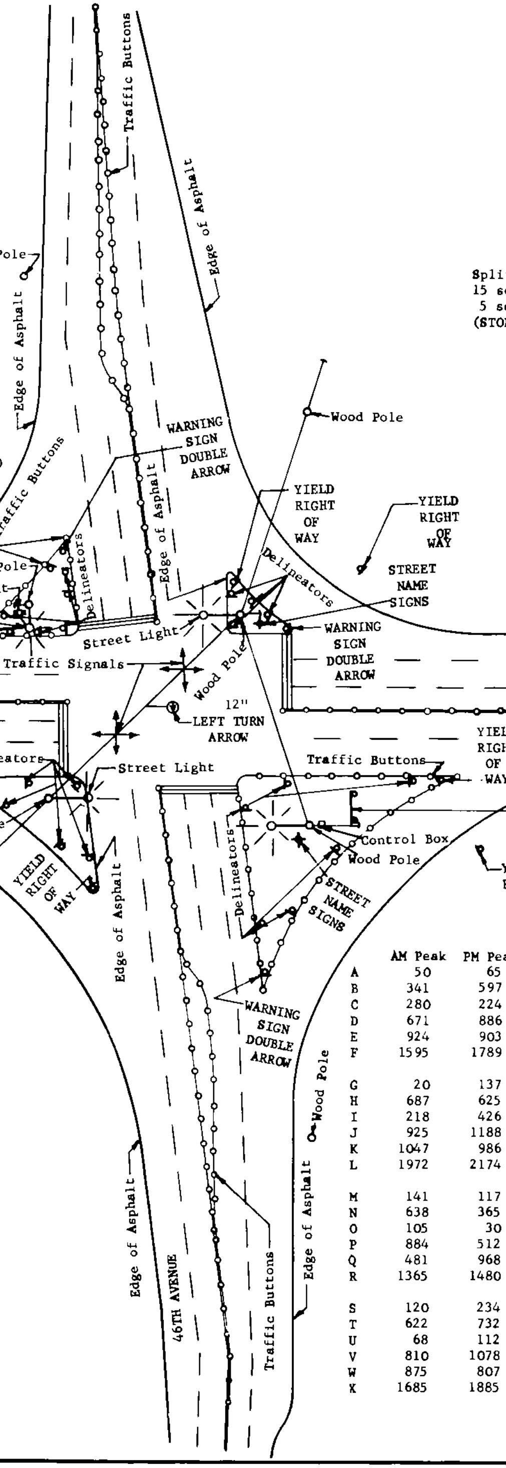
Traffic signals have been changed to actuated type with detectors on all approaches. Signals are operated semi-actuated during off-peak periods and full-actuated during the peak periods (7-9 A.M., 4-6 P.M.).

A 60-second background cycle is used to insure an "in step" signal system during the off-peak hours.

The cycle can be as long as 120 seconds, if demanded, while operating full-actuated during the peak periods.

Detectors are approximately 150 feet in advance of stop lines.

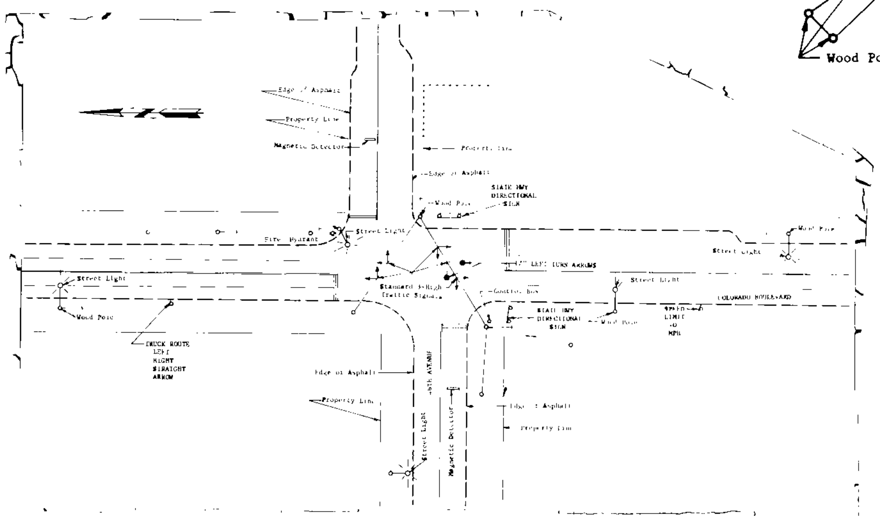




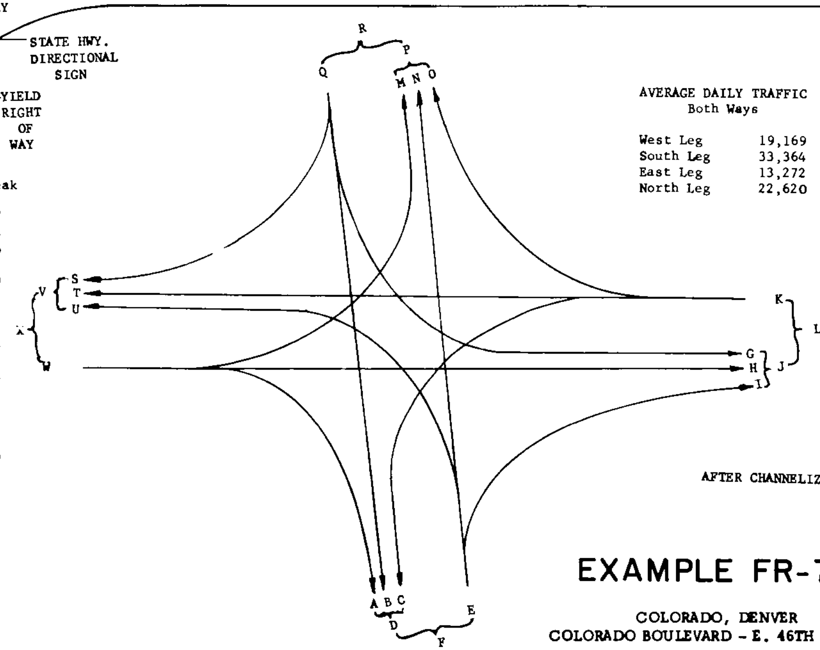
	AM Peak	PM Peak
A	50	65
B	341	597
C	280	224
D	671	886
E	924	903
F	1595	1789
G	20	137
H	687	625
I	218	426
J	925	1188
K	1047	986
L	1972	2174
M	141	117
N	638	365
O	105	30
P	884	512
Q	481	968
R	1365	1480
S	120	234
T	622	732
U	68	112
V	810	1078
W	875	807
X	1685	1885

AVERAGE DAILY TRAFFIC
Both Ways

West Leg	19,169
South Leg	33,364
East Leg	13,272
North Leg	22,620



BEFORE CHANNELIZATION



PEAK HOURS TRAFFIC FLOW DIAGRAM

EXAMPLE FR-7

COLORADO, DENVER
COLORADO BOULEVARD - E. 46TH AVENUE

EXAMPLE FR-8

Location

CALIFORNIA, San Diego
54th Street - University Avenue

Submitted by

Martin J. Bouman, Traffic Engineer
City of San Diego
San Diego, California

Type of Intersection

4-Way Right Angle

Date Opened to Traffic

May, 1957

Physical Data

Grades (on approaches): -6% on L. leg; + 1% on S. leg;
-2% on W. leg; + 3% on E. leg.

Surface Type
Islands are raised, with concrete curb, dirt-filled and covered with 2" A.C.
Shoulders: None; all curb.
Curb: Combination curb and gutter, 8" high.
Traffic Control Devices
Signals: Traffic Signals mounted on Type III Street Light Standards have 15' mast arms attached where shown. Traffic Signal standards in turn pockets are Type F-51. Traffic Signal indications on mast arms have 12" red, with 8" green and amber; all others are 8". Timing: Traffic-actuated control by electromatic 1033 with a dual left turn phase unit.
Markings: Lane lines and cross-walk lines are white.
Lighting: Lights are 400 watt, 20,000 lumen mercury vapor with Type III distribution. Street light mast arms are 6' long.
Abutting Property: Property on southwest corner is residential, and all other is commercially zoned.

Traffic Data

Design Vehicle is C50
Speeds: Speed limit is 35 MPH on all legs except the west leg, which is 25 MPH.
Pedestrian: Volume is insignificant (54 from 4 to 5 PM).

Operational Characteristics

Comments on Over-all Operation: In the three years before this intersection was redesigned there were 22 reported accidents, with an ADT of 21,300. In the three years since this improvement there were 20 reported accidents, with an ADT of 30,900.

Please note that two bus routes cross in this intersection. Originally the stops were farside on the channelizing islands. However, within a year after operation we found that vehicles would become trapped behind buses in the far-side stops and thereby back into the intersection. Since moving the bus stops to their present near-side location this problem has been eliminated.

Figure 1: Looking northeast

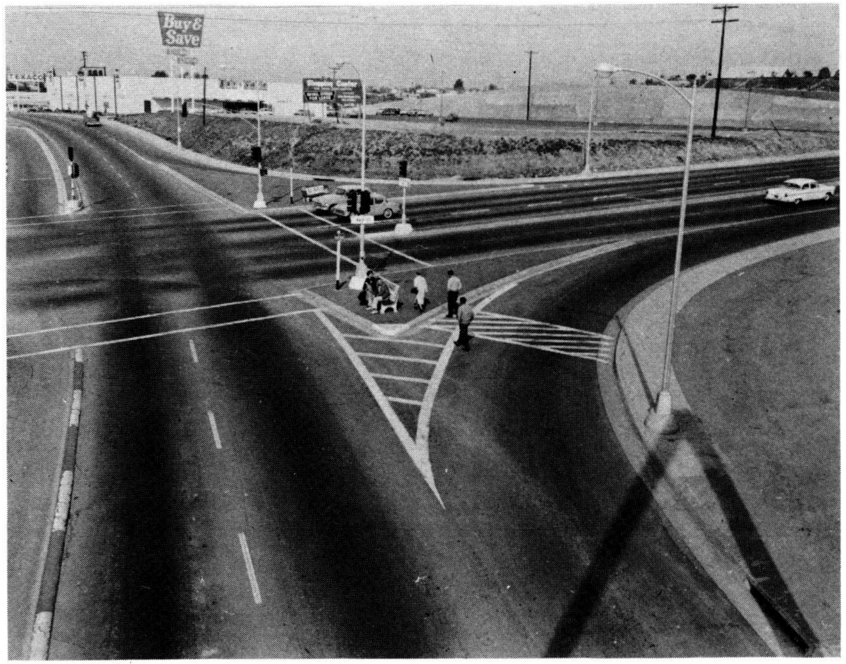


Figure 2: Looking northwest

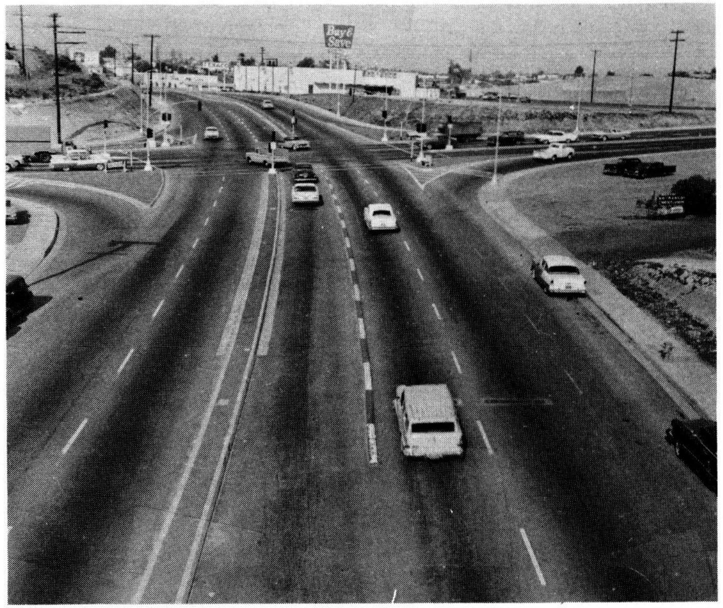


Figure 3: Looking west

Comments by Committee Members

1. DONALD H. SIDES - This is a good basic plan with excellent detailing of islands and markings.

   It is noted that bus stops were provided on the near-side corner islands after a trial period of far-side island use. It would seem to be in the over-all interest of traffic movement to utilize the parking lanes on the approaches to the intersection for bus stops.

   The need for signal phases B-1 and B-2 is not clear. Some inefficiency appears to be introduced by requiring through and left-turning traffic on the east-west road to stop two times in each complete signal cycle.

   The fact that a light standard fell victim to a somewhat less than responsible driver (see Figure 1 and ESS-HBD fixed object accident) is not pertinent to the comment that the standards should not be located in the middle of the somewhat narrow sidewalks.

   Lateral clearance to the signal posts in the 4-foot median is considered deficient.

2. EUGENE MAIER - An outstanding feature of this example is the effectiveness of adequate pavement markings to supplement the channelizing islands. The channelization and signal control combine to develop the full capacity of this high volume urban intersection. The introduction of the added left-turn lanes appears abrupt and the design does not conform to normal vehicle paths. A minimum taper of 1 in 10 is considered desirable. The narrow 4-foot medians at the intersection do not provide the desirable clearance for the post mounted signals for the left-turn movements, but the signals indications are well placed and this is a good compromise where right-of-way limitations do not permit a wider median.

   If the use of the bus stops created any congestion or hazard, the island might have been set back 8 to 10 feet to permit the bus to stop outside of the through traffic lane. With the added bus stop lane, the bus would have to merge with the through traffic within the intersection. The volume and importance of bus operations would determine the value of this design.

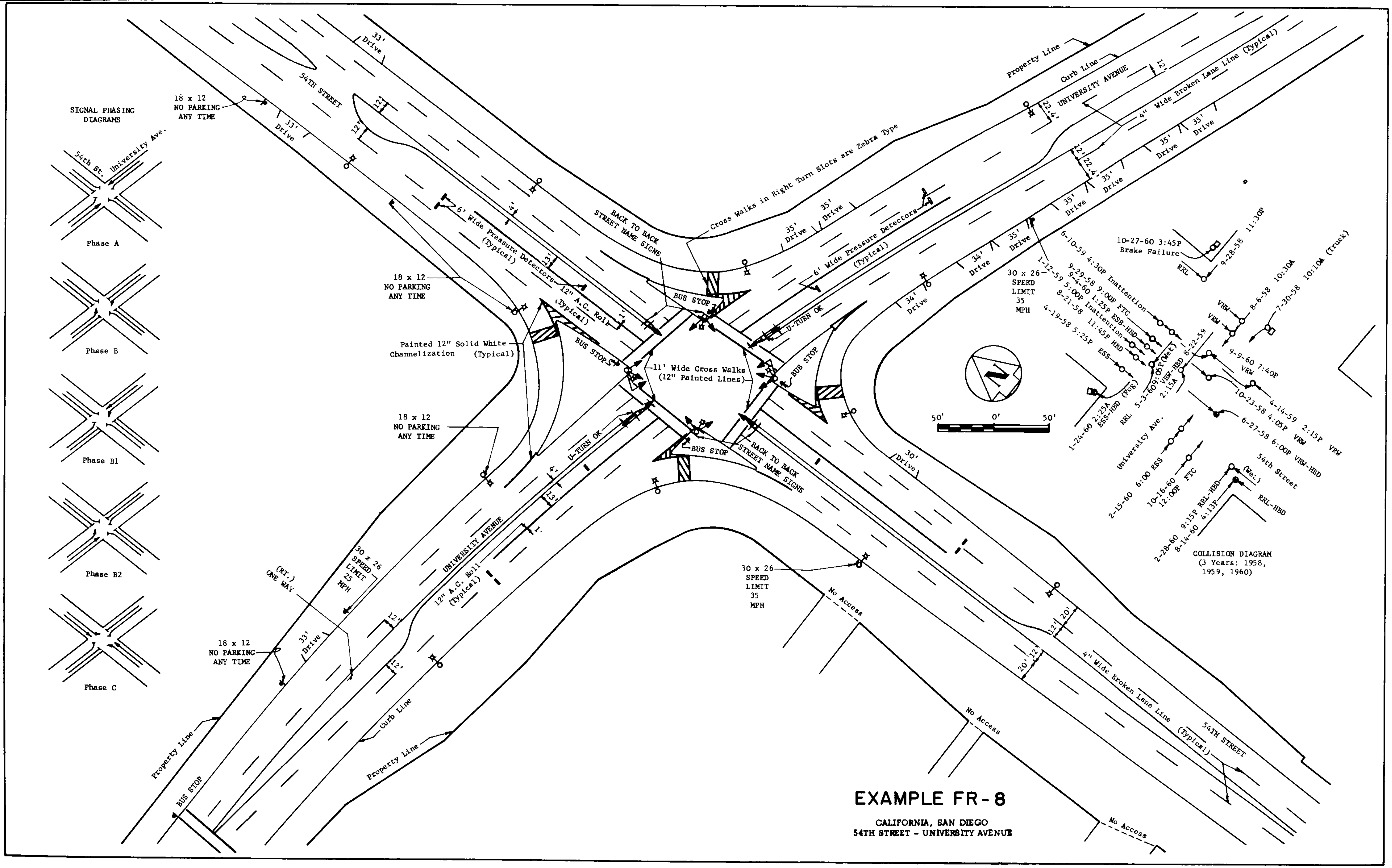
Additional Comments by MARTIN J. BOUMAN - We note that both reviewers commented on the location of bus stops. In future designs of this type we would attempt to establish a far-side bus stop in a widened section. We feel that near-side bus stops create an unfavorable merging condition in the middle of a signalized intersection.

Both reviewers also commented on the substandard four-foot medians or center islands. At the present time we are providing six-foot or wider center islands whenever right-of-way widths permit.

Mr. Maier discussed the abrupt taper at some locations. Since the construction of this project the City has adopted a new standard for island tapers, using the design standards of the California Division of Highways. For example, at a design speed of 35 miles per hour our minimum taper is 1 to 12.5.

Mr. Sides expressed concern regarding the need for Signal Phases B-1 and B-2. As previously discussed, traffic control at this intersection is provided by an Automatic Signal Company 3-Phase volume density traffic signal controller incorporating a dual left-turn phase unit. Turning volumes from University Avenue are heavy enough to warrant a separate turning phase for University Avenue. If a conventional 3-Phase controller were employed, B-Phase would be utilized for all left turns from University Avenue. Once a left turn, or B-Phase, call was received, all straight-through east and west traffic on University would stop for the left turners, even though there were no opposing left turner for one of the straight-through movements. The dual left turn phase in our design does away with this needless stopping of the straight-through east-west traffic. For example, a detector actuation for the westbound left turn during Phase-A or Phase-C results in a B-1 left turn indication and a green for A-Phase traveling in the same direction (westbound); termed an A plus B-1 overlap. Similarly an actuation for the eastbound left turn results in an A plus B-2 overlap for eastbound traffic. If both left turns are actuated during Phase-A or Phase-C, then both left turns move on Phase-B, without utilizing Phases B-1 or B-2.

From the foregoing it can be seen that straight-through movements on University Avenue are not stopped more than once during any cycle. Conversely, there are times when straight-through traffic in one direction on University Avenue is allowed to flow during two consecutive phases without interruption, providing there are no opposing left turners during B-Phase.



EXAMPLE FR-8

CALIFORNIA, SAN DIEGO
54TH STREET - UNIVERSITY AVENUE

EXAMPLE FR-9(OFFSET)

Location

CONNECTICUT, West Hartford
US 44 - Connecticut Route 185 -
North Main Street

Submitted by

David S. Johnson, Jr.
Director of Planning & Design
Connecticut State Highway Dept.
P. O. Box 2188
Hartford 15, Connecticut

Type of Intersection

4-Way Right Angle (Offset)

Date Opened to Traffic

July 31, 1959

Physical Data

Grades: None over 3%. The entire intersection is practically level.
Surface Type
Roadways: Mostly bituminous concrete
Curbs: Bituminous concrete lip curbing at pavement edges; concrete park curbing around islands. Height of curb in the island area is 4" and of mountable design.
Traffic Control Devices
Lighting: Highway illumination providing 1.0 foot candles maintained through the entire area of the intersection and approaches consists of mercury 400 watt lamps, 20,000 lumen, mounted on steel standards at a height of 30'.
Abutting Property: At the present time a large shopping center is located in the southwest corner and another one located in the northeast corner, as may be observed in the aerial photograph. Plans are presently in preparation for the construction of two more shopping centers, one in each of the remaining corners of the intersection.

Traffic Data

Design Vehicle: C50
Speeds: All approach roads are posted at 35 MPH
Accidents: No accident experience has been made available, as the intersection was reconstructed on the basis of traffic operations. Accident experience before and after construction did not indicate any appreciable difference.
Pedestrian: The volume of pedestrian crossing was not significant except for the volume of vehicular traffic on the approach roadways necessary for the pedestrians to cross.

Operational Characteristics

Comment on over-all operation of channelized intersection:

Prior to reconstruction, the intersection and approaches consisted of two-lane roadways on all approaches with a hill located on Route 44 in the vicinity of Flagg Road which created a severe sight restriction for the eastbound vehicles approaching the intersection. Lane capacity to handle the existing volumes plus the numerous turning movements did not exist, and congestion continually occurred, especially during morning and afternoon peak hours.

The design of this entire construction evolved around the traffic signal system. Separate turn lanes were provided at all four approaches to the main intersection, with minor movement controllers provided for each of the separate left turns. The intersection at Flagg Road with its two left-turn slots on Route 44 was also provided with minor movement controllers. The signal at Flagg Road is interconnected with the Model 1022 density controller at the main intersection. Furthermore, three pedestrian interval timers were provided at the main intersection and connected with the 1022 controller.

Since installation of this system it has been necessary to change the timing on several occasions to meet the varying demands of traffic. The movement of traffic through the area, under control of the signal system and with the provisions for all turning movements, has resulted in orderly operation of traffic with no appreciable congestion even during the overloaded peak hours. The signal system is geared for expandable volumes but only time will tell whether the installation is adequate to handle the expected increased volumes generated by the two additional shopping centers plus that normal increase of traffic expected on the approach roads to the intersection.

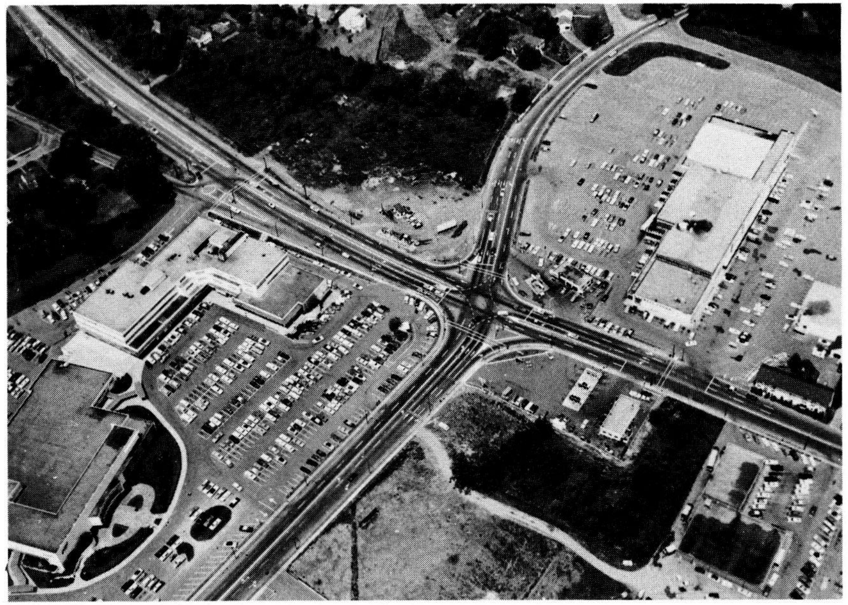


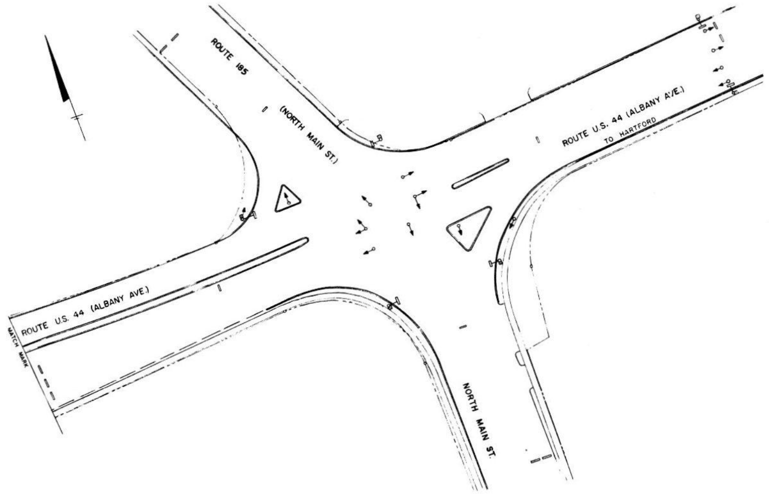
Figure 1: Aerial View

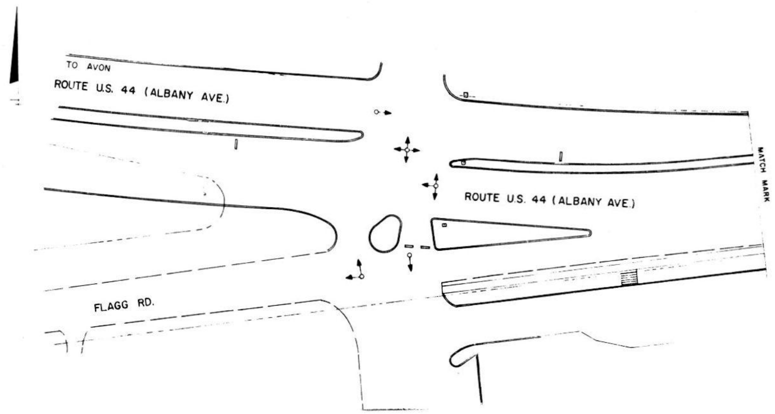
Comments by Committee Members

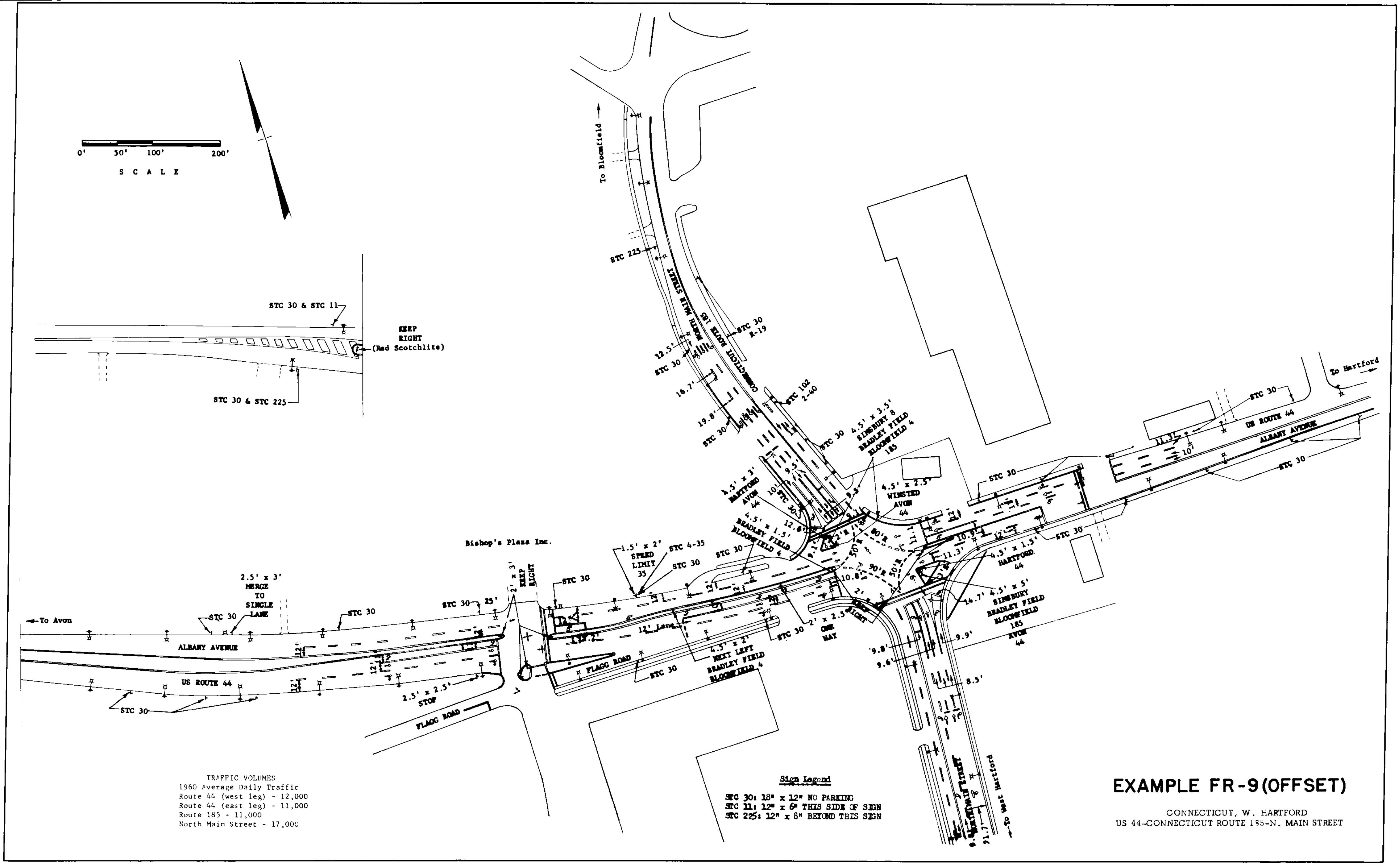
1. IRV. WEINBERG - It would be of interest to designers and planners alike to know how shopping center traffic affects the operation of this intersection with access to the centers to close to the intersection.
   It is possible that the two centers to come will also be allowed access close to the intersection. This, I feel, will affect the capacity and efficiency of this intersection.
   The designer's comments re: the operation of traffic after construction seem justified. (It is unfortunate that access for commercial sites is permitted so close to the intersection.)

2. WARREN TRAVERS - The lack of traffic count data makes it difficult to appraise this design completely. It is assumed, however, because of the proximity of the shopping centers, that approach volumes and turning movements are heavy in peak periods. Typical shopping center traffic patterns and fluctuations, coupled with the non-shopping center demands, further suggest that the inclusion of flexible controls, as indicated, are justified.
   Considering the relatively small intersection area available, this design, in my opinion, is an excellent example of getting the most out of every inch of pavement. It is appropriately channelized, and the extensive use of paint suggests good path delineation.

TOWN OF WEST HARTFORD
TRAFFIC CONTROL SIGNAL SYSTEM
for
Route US 44 at Route 185, North Main Street
and Flagg Road (Bishop's Corner)







TRAFFIC VOLUMES
1960 Average Daily Traffic
Route 44 (west leg) - 12,000
Route 44 (east leg) - 11,000
Route 185 - 11,000
North Main Street - 17,000

Sign Legend

STC 30: 18" x 12" NO PARKING
STC 11: 12" x 6" THIS SIDE OF SIGN
STC 225: 12" x 8" BEYOND THIS SIGN

EXAMPLE FR-9(OFFSET)

CONNECTICUT, W. HARTFORD
US 44-CONNECTICUT ROUTE 185-N. MAIN STREET

Location

MICHIGAN, Lansing
US 16 (Grand River Ave.)
Saginaw Street

Submitted by

H. G. Bauerle
Director of Traffic Division
Michigan State Highway Department
Lansing, Michigan

Type of Intersection

4-Way Oblique

Date Opened to Traffic

May, 1958

Physical Data

Grades: Not of any consequence
Surface Type
Roadways: 9" concrete with bituminous cap
Islands: White concrete curb backfilled and seeded
Shoulders: 10', with 4" gravel
Curbs: 6"
Traffic Control Devices
Signals: Two-phase interconnected with dual indications
Signs: NO LEFT TURN case sign at intersection facing eastbound Saginaw and westbound Grand River. Neon KEEP RIGHT sign facing westbound Saginaw on island nose.
Abutting Property
Character of land use: Large (6000 car) shopping center on the south side of Saginaw Street. Commercial establishments between Saginaw and Grand River Avenue on east and west sides of intersection. Restaurant, motel and golf course on north side of Grand River Avenue.
Transit Operations: No designated bus or taxi unloading zones.

Traffic Data

Volumes: Flow diagram attached
Accidents: Accident experience one year before - 14 accidents, 3 injured; one year after - 8 accidents, 4 injured.
Design Vehicle: C50
Speeds: Area Speed Limit 35 MPH

Operational Characteristics

Comment on overall operation of channelized intersection:
This intersection is the easterly terminus of a one-way street system, which was installed at the time of this reconstruction. This became necessary due to a combination of accident experience and heavy congestion at this intersection, construction of the large shopping center mentioned above, and other planning factors in the City of Lansing. Reconstruction has eliminated the congestion, reduced the accident experience, and has, in general, enhanced traffic operation in the area due to the operation of one-way streets.

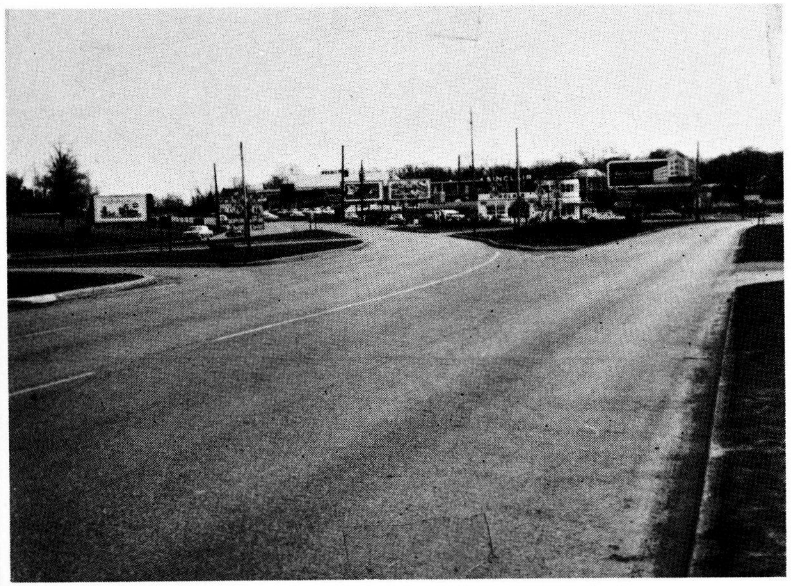


Figure 1: Looking east from the west leg of Saginaw Street

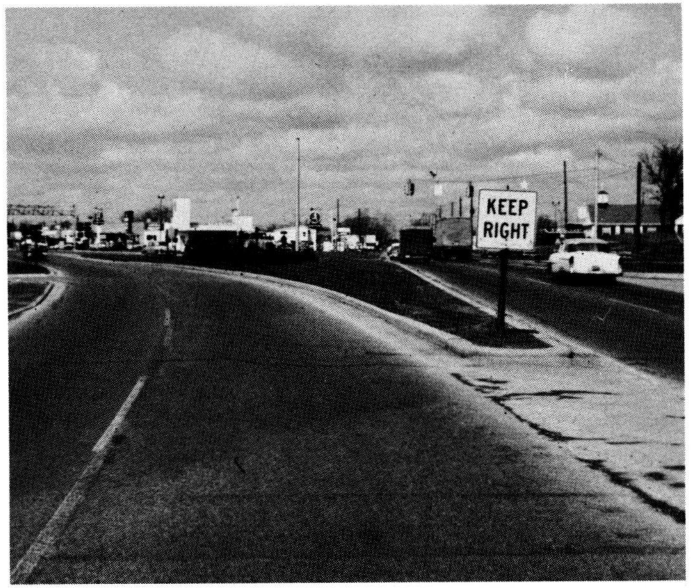


Figure 2: Looking west from the east leg of Grand River Ave.

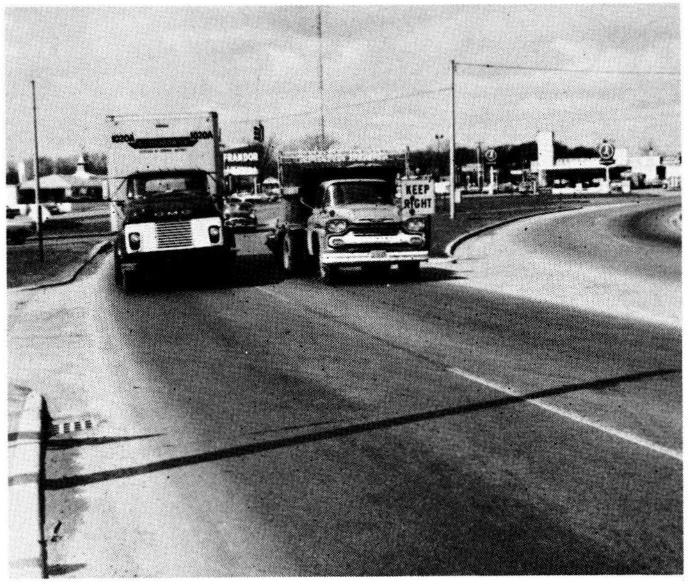
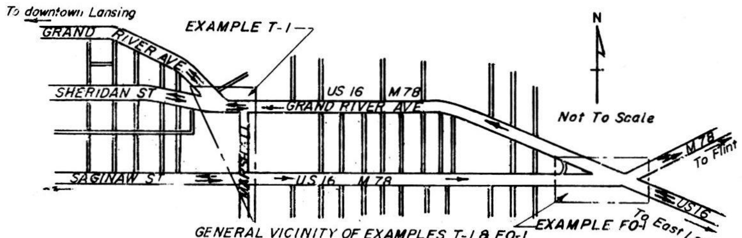


Figure 3: Looking southwest from the northeast leg of Saginaw Street.



GENERAL VICINITY OF EXAMPLES T-1 & FO-1
LANSING, MICHIGAN

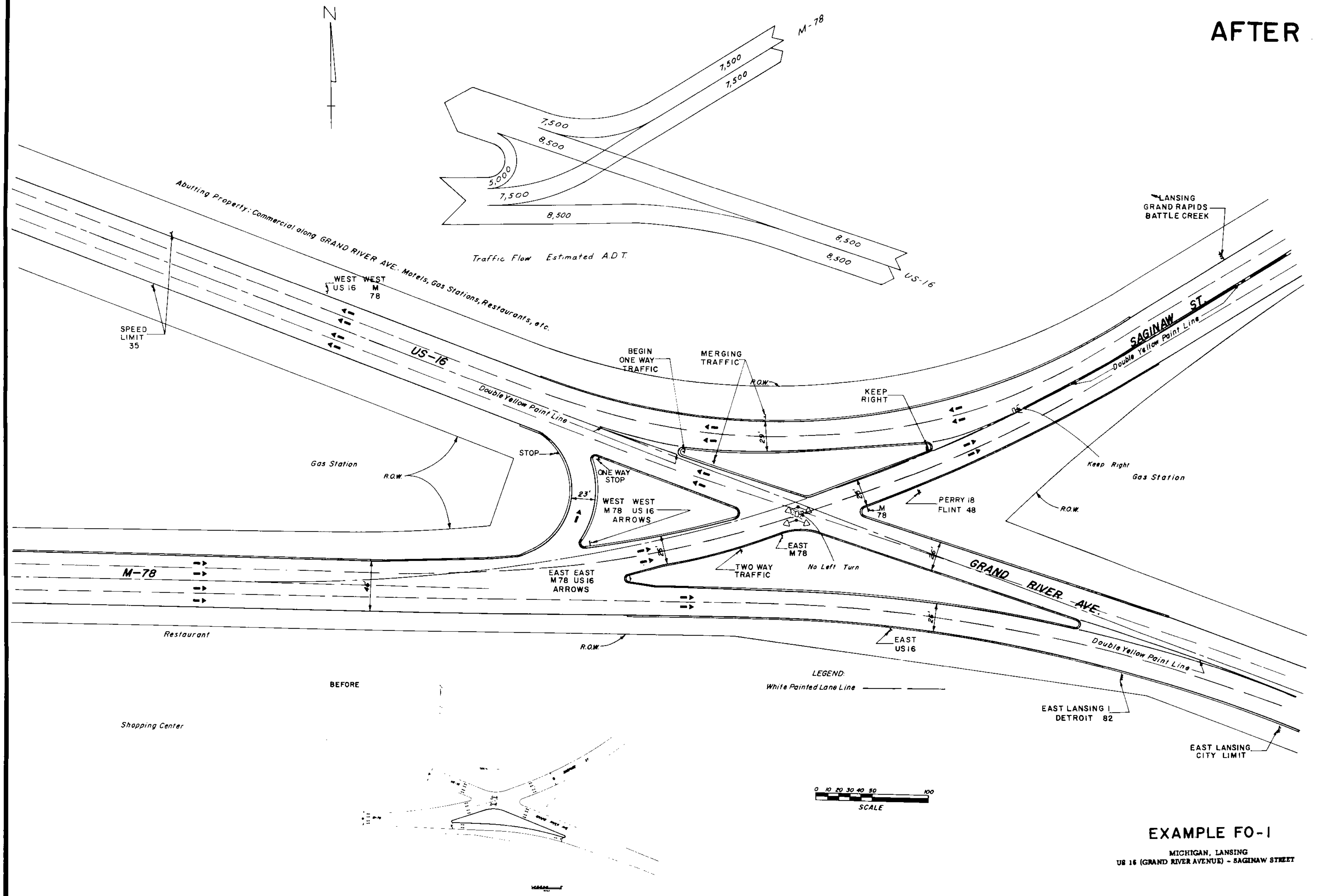
Comments by Committee Members

1. EUGENE MAIER - The channelization of this intersection in connection with the establishment of one-way traffic flow on Grand River Avenue and Saginaw Street to the west has resulted in a substantial increase in intersection capacity and a reduction in accident experience. The pavement area at the point of signal control has been greatly reduced and the volume of traffic through this area of major conflict has been approximately halved.

   The delineation of the islands might be improved by the use of raised bars or jiggle bars on the approach to the ends of the islands. Although the plan indicates no information signs, an over-the-road sign bridge appears in Fig. 2 and Fig. 3. There is an obvious need for adequate lighting at this urban intersection with a relatively high ADT.

2. W. R. BELLIS - An example of simplicity of intersection design in an age where it seems that complexity is the style. This must be considered as part of a 4-way intersection. The other part is absorbed in the one way street system.

AFTER



EXAMPLE FO-1

MICHIGAN, LANSING
US 16 (GRAND RIVER AVENUE) - SAGINAW STREET

Location

WASHINGTON, Seattle
First Avenue Bridge, South-East
Marginal Way, South (US 99)

Submitted by

E. E. Lewarch, Traffic Engineer
105 Public Safety Building
Seattle, Washington

Type of Intersection

4-Way Oblique

Date Opened to Traffic

August, 1955

Physical Data

Transit Operations: No transit or bus zones within the intersection, but transit vehicles do pass through it.

Traffic Data

Design Vehicle: C50
Speeds: Posted Speed Limits 35 MPH
Pedestrian: Only an occasional pedestrian crosses in this vicinity.

Operational Characteristics

Over-all operation:

a. This offset intersection is complicated by separate demand surges in each direction during both morning and evening peak periods which cannot be indicated on a simple flow sketch. The only movement which does not back-log at some period is the northbound free right turn, and the maximum average delay at the worst period of the southeastbound through movement is approximately four cycles. However, the intersection generally handles the peak demands fairly well, and there is no off-peak backlog delay.

b. Signal operation at this intersection is controlled by two three-dial, fixed time, controls. A change of split during the AM peak hour flow is accomplished by a time clock and relay panel.

c. The existing operation eliminates the minor left turns, and the minor right turns are not encouraged and cause no appreciable problem. No pedestrian crossing occurs between signals. So far as feasible the major right turns have been separated from signal control.

d. The tangent through movement (66% of the total entering from E. Marginal Way) plus the offset major left-turn movement (57% of the total entering from 1st Avenue S.) have a capacity limitation which is a function of the storage between signals, because these movements are controlled at both signal locations.

e. The cross-hatched barrier areas adjacent to the direction islands serve multiple purposes:
(1) "Escape hatch" for unfamiliar drivers who unwittingly become trapped in a designated turn lane but wish to go through. The penalty for missing the through lane would be a side trip of approximately two miles for southbound traffic.
(2) Bypass for emergency vehicles.
(3) Bypass space in case of disabled vehicles.
(4) Emergency space for disabled vehicles.

Comment on elements of design, etc.:

a. All through movement lanes on E. Marginal Way are offset to the west by the width of one lane because of right-of-way restrictions along the east side. This requires the four through lanes to traverse two reverse curves, undoubtedly contributing to some confusion and adding to overhead signing difficulties.

b. In order to accomodate better the peak-hour traffic demands, the south leg of 1st Avenue S. should have an additional approach lane, the south-east-bound through traffic should have an additional lane between signals, and the north leg of E. Marginal Way should have an added right-turn lane. No further addition of lanes could be accomodated by the streets receiving traffic from the intersection. The intersection is to be eliminated ultimately, through the construction of a grade separation.

Accidents:

a. Wherever double turning movements take place on surface streets there is accident experience involving vehicles in the turning lanes. In view of the traffic volumes, the accident rate at the intersection is relatively low.

b. The fact that the driver encounters reverse curves through the signalized conflict areas appears to have an effect on signal observance and contributes to the "right angle" accident experience.

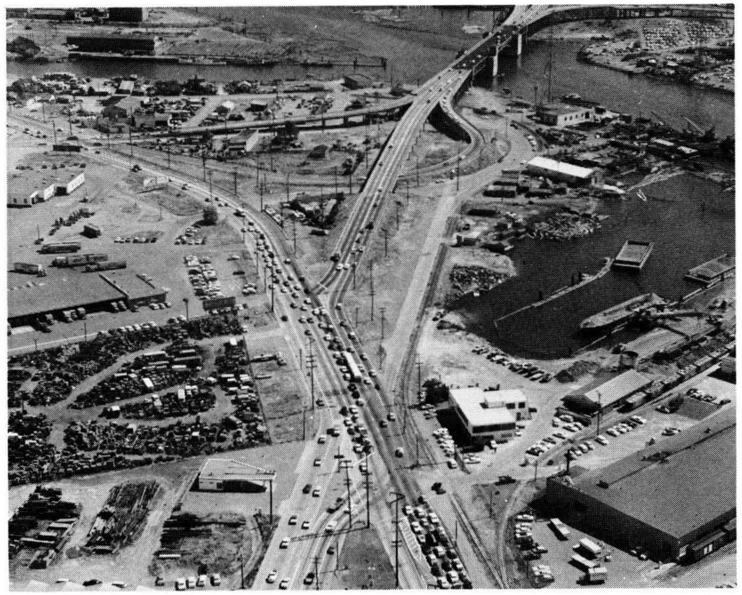


Figure 1: Aerial view, looking south

Figure 2: Looking south on 1st Avenue South at intersection with East Marginal Way South

Figure 3: Looking south on East Marginal Way toward channelization for intersection with 1st Avenue South Bridge

Comments by Committee Members

1. DONALD H. SIDES- This is an example of the offset or braided type of at-grade intersection. The large traffic volumes indicate that operation is at capacity; a marked increase in traffic demand will probably hasten the ultimate plan for grade separation.

The number of accidents, while not large in relation to the traffic volumes, are significant. One could conjecture that a positive median through the area, together with large islands at the intersections, would be helpful in reducing the number of accidents by intersecting movements. The accidents (all noninjury) by movements in the same direction may be in part explained by the evidence of weaving or lane changing. It is to be noted that almost all of such accidents occur in the northbound lanes. If not already provided, signs on the approaches advising of the proper lane would be helpful.

2. WARREN TRAVERS - The principal capacity problem appears to be in the south-bound direction, caused by:

(a) Insufficient storage capacity (pavement width) on East Marginal Way South at the southerly intersection (bridge ramp) for movement from First Avenue South. Apparently this movement is required to stop after having cleared the northerly control point, the progression being given to East Marginal Way South.

(b) The three-phase signal at the northerly intersection permits local access via left turns from northbound East Marginal Way South. Since the signal installation is fixed time, a portion of total green which otherwise could be allotted to the two main approaches, is deviated to the left turn in and flow out of the access roadway during every cycle.

It appears that two things could be considered here to increase capacity without additional widening. (It is assumed from previous comments that this intersection ultimately will be grade separated in some fashion in lieu of extensive widening or other substantial at-grade improvement.)

The present three-phase signal at the northerly intersection could be made two-phase by prohibiting the left turn from the south into the access road; this movement, if minor, could be routed straight through the intersection and be made to turn right, beyond the intersection, right again onto First Avenue and then re-approach the intersection via First Avenue South. It would be "opposed" by left-turning traffic exiting from the access road; however, this would be a normal left-turn conflict typical of any two-phase intersection.

The resulting increased green time per se allotted to the major movements at this intersection apparently would not be of too much benefit to through traffic on East Marginal Way South because of the storage problem at the southerly intersection. It should, however, benefit traffic destined for the bridge.

The storage problem on East Marginal Way South, southbound, at the southerly intersection could be relieved if it were possible during the peak hour to route through traffic on East Marginal Way South southbound via the existing roadway under the bridge approach, thence to rejoin East Marginal Way at the intersection immediately south of the First Avenue South bridge ramp. Although somewhat circuitous, through traffic would probably save time over all. More importantly, however, it would permit a reasonable progression for traffic from the north on First Avenue South which desires to continue on East Marginal Way South southbound and reduce considerably the storage problem at the southerly intersection. It appears, however, that such a routing would be extremely difficult to sign, particularly during the peak hour only.

Additional Comments by E. E. LEWARCH -

1. In reply to Donald H. Sides:

a. A 6-inch high, 12-inch wide precast concrete median curb exists between signalized intersections. Additional width of such median would have an unfavorable effect on lane width unless roadway were also widened. (Paint markings sketch is being submitted to add to original drawing to illustrate lane and street widths.)

b. Larger intersection islands might have favorable effect on accident experience, but unfavorable effect on versatility and/or flexibility of movement, especially as relates to emergency situations.

c. We concur with all other comments.

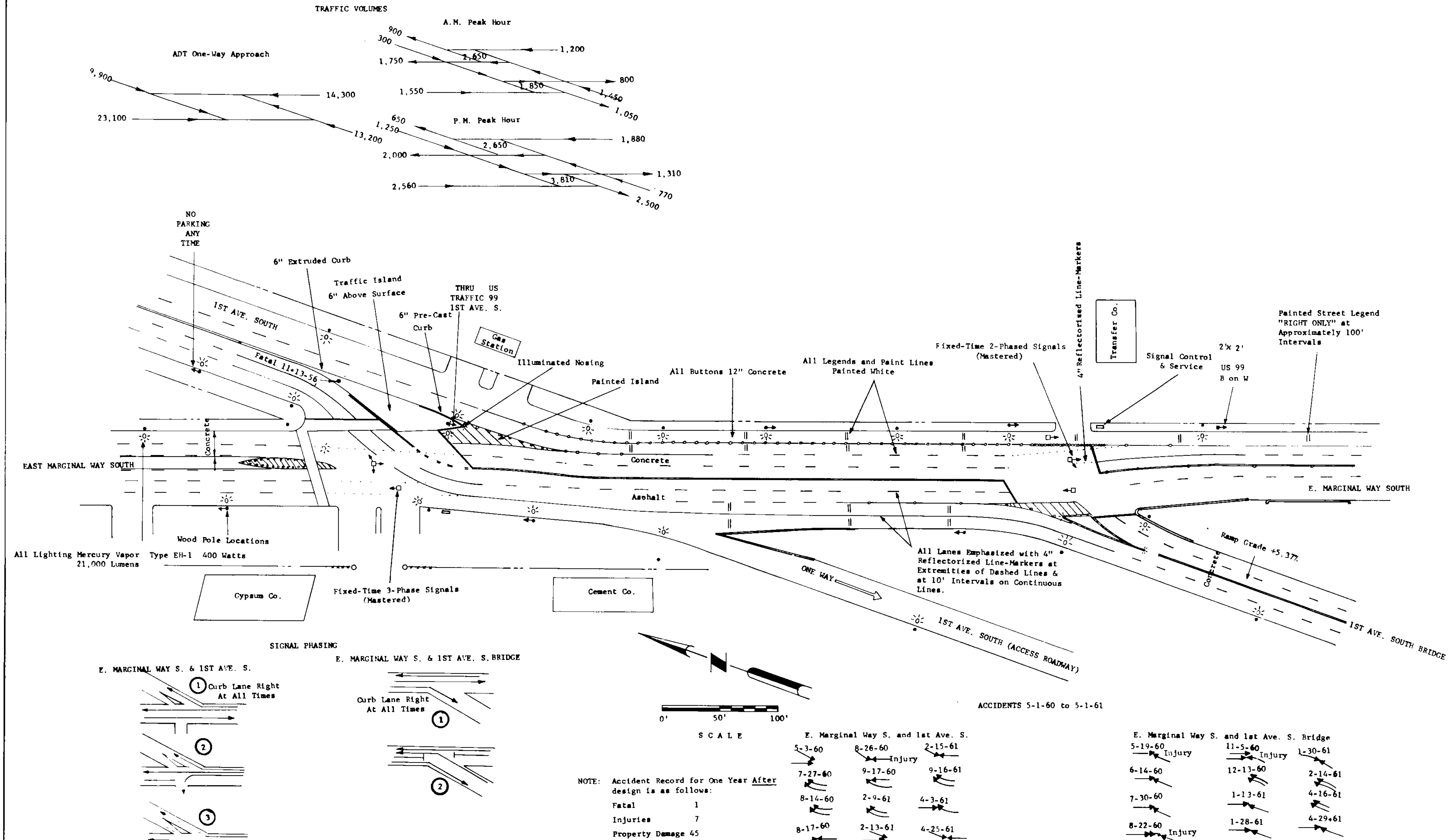
2. In reply to Warren Travers:

a. It is true that the southbound through movement on E. Marginal Way S. is progressed, but this progression depends on a relatively low number of previously stored vehicles between signals. During peak periods, this storage area is repeatedly filled, eliminating smooth progressive movement in this direction, and requires primary attention toward preventing this movement from blocking the north intersection.

b. The third signal phase at the north intersection functions primarily to cut off southbound through traffic on E. Marginal Way S. and only incidentally to allow the non-conflict northbound left turn. This southbound red phase begins almost simultaneously with the onset of red at the south intersection, limiting the number of vehicles stored between control points to a level compatible with the number able to enter this storage area from 1st Avenue S. Thus the third phase functions to allow storage space for the southbound left turn movement from 1st Avenue S., so that this movement will not have to store through the north intersection.

c. Although the left turn movement into the access roadway inhibits the efficiency of the north intersection, it has not been found necessary to divert that movement. Movements out of the access roadway cause very little problem. The benefit mentioned to traffic destined for the bridge is somewhat dubious in view of the existing bridge operation, which is simultaneously at a rather low capacity due to interference of the substandard access ramp. In passing, it may be mentioned that the bridge is one of an ultimate pair, and the substandard ramp on timber bents is temporary.

d. In regard to the southbound peak hour relief route, this roadway is presently available at all times but is seldom, if ever, used as a bypass during peak periods. The chief disadvantage, seemingly, is that there would be little or no time saved once the driver has reached the north intersection, which he cannot bypass to reach the relief route.



EXAMPLE FO-2

WASHINGTON, SEATTLE
1ST AVENUE BRIDGE, SOUTH - EAST MARGINAL WAY, SOUTH (US 99)

EXAMPLE FO-3

Location

DELAWARE, Hockessin
Lancaster Pike - Yorklyn Road (Road 257)

Submitted by

Ernest A. Davidson
Chief Engineer
Delaware State Highway Department
P. O. Box 151
Dover, Delaware

Type of Intersection

4-Way Oblique

Date Opened to Traffic

June 14, 1955

Physical Data

Grades: None over 3%
Surface Type
Roadways: Cement concrete
Islands: 8" depressed, with topsoil and seed center
Shoulders: 10 feet wide, select borrow
Curbs: 8" parkway reflecting curb
Traffic Control Devices
Markings: Standard Delaware State Highway Department markings of yellow and white
Abutting Property: Slowly developing area on a new through highway by-passing the village of Hockessin

Traffic Data

Speeds: Lancaster Pike 50 MPH
Yorklyn Road 50 MPH
Pedestrian: No pedestrian provisions--small volume

Operational Characteristics

Comment on over-all operation of the channelized intersection:

Lancaster Pike is a secondary main intercity highway. Hockessin lies near the limits of the Wilmington commuting area. The highway was built about eight years ago, by-passing the village of Hockessin to the east.

The majority of traffic is through. The secondary flow is that between Wilmington and Yorklyn, followed by Wilmington-Hockessin.

Because of the relatively minor traffic volumes, this intersection has operated freely. Local residents have requested a signal but it has not been found warranted.

If this intersection were being designed today, or if a signal is ever warranted, the through highway should be widened to four lanes in order to give through traffic a chance to pass waiting left-turners.

The accident record is quite good.

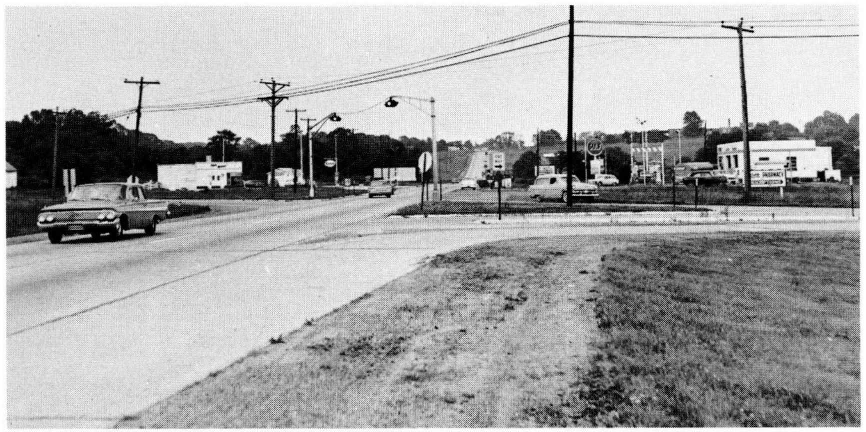


Figure 1: Looking south on Delaware 41, showing channelization of turns into and out of Hockessin (to right) and flasher.

Figure 2: Looking east on Yorklyn Road, showing general details of intersection as seen by driver on western approach.

Comments by Committee Members

1. ROBERT E. DUNN - This intersection with its 135 degree oblique angle crossing of vehicle paths has approximately 1 3/4 times the relative speed and 3 1/2 times the impact energy as would be involved in a collision of vehicles at a 90 degree angle intersection. The basic condition warranting channelization is therefore not corrected in this case, even though certain principles of channelization are applied and some improvement in operation is derived.

   The separate right-turn directional lanes in the east and west quadrants merge turning and through traffic streams at small angles. The separate left-turn directional lanes in the same quadrants separate some of the conflict points on Lancaster Pike. In doing so, however, other oblique angle crossings of vehicle paths are created on Yorklyn Road at the entrances to the left-turn directional lanes; and an intersection area approximately 350 feet in length is created on the free-moving, higher-volume Lancaster Pike.

   Setting aside all the practical local factors that may have influenced this design, the theoretical application of channelization principles would have called for the re-alignment of the minor volume Yorklyn Road to approach and intersect the Lancaster Pike at a right angle. Separate directional lanes could then be provided for the major right-turning volumes to separate some points of conflict. All left-turning and cross movements would be confined and appropriately designed for in the small area of conflict of the intersection proper. This type of 90 degree intersection design would have satisfied the warrant condition and the five basic channelization principles involved in this particular case.

2. CHARLES J. KEESE - The review and comments by Mr. Dunn are quite pertinent. The complexity of the directional turning lanes and the number of conflict points created on both roads are very undesirable features.

   The photographs (Figures 1 and 2) indicate inadequate signing for this complex treatment.

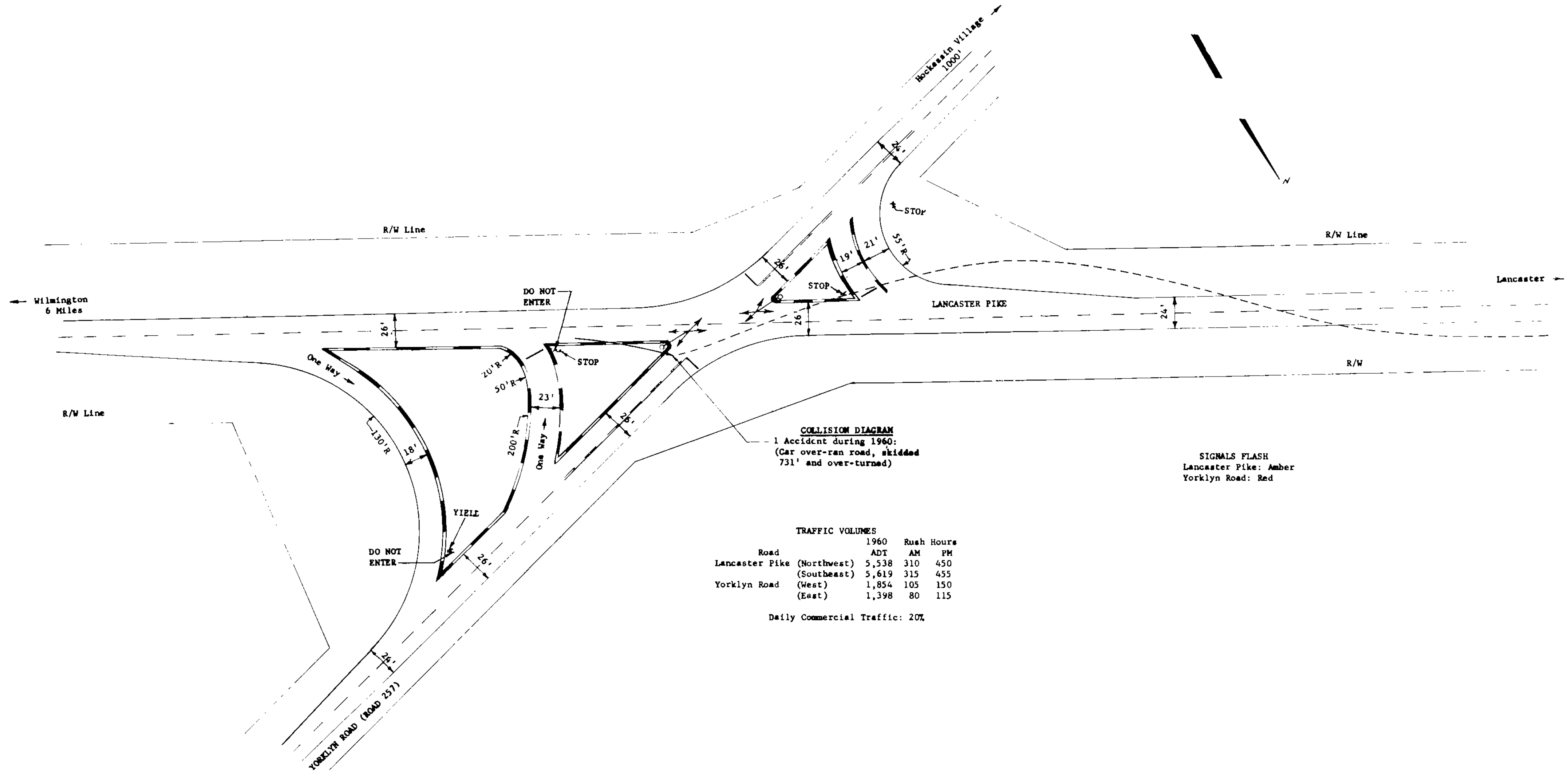
   As suggested by Mr. Dunn, re-alignment of Yorklyn Road to approach and intersect Lancaster Pike at a right angle would have been the appropriate answer. Although volumes are now quite low, the intersection will have to be redesigned if volumes should increase appreciably.

   This design would be difficult, if not impossible, to signalize.

Additional Comments by WILLIAM R. CARROW, Traffic Engineer - We have examined the comments by Mr. C. J. Keese, and appreciate his thoughts as to what the ideal design of this intersection should be if high traffic volumes become a problem here.

It must at first be pointed out that this is a very high type design for such a low volume intersection. The standard conflict points have been spread over a larger area in this case and it is felt that any changes in the design at the present are unwarranted.

We realize that should signalization of this intersection become necessary at some future date, some changes in design may be necessary.



TRAFFIC VOLUMES

Road		1960 ADT	Rush Hours AM	Rush Hours PM
Lancaster Pike	(Northwest)	5,538	310	450
	(Southeast)	5,619	315	455
Yorklyn Road	(West)	1,854	105	150
	(East)	1,398	80	115

Daily Commercial Traffic: 20%

EXAMPLE FO-3

DELAWARE, HOCKESSIN
LANCASTER PIKE - YORKLYN ROAD

Location

MASSACHUSETTS, Seekonk
Fall River Avenue - Highland Ave. - Mink Street

Submitted by

Bernard B. Twombly, Traffic Engineer
Department of Public Works
100 Nashua Street
Boston 14, Massachusetts

Type of Intersection

4-Way Oblique (Offset)

Date Opened to Traffic

On July 26,1932 the intersection contained channelizing islands and semi-actuated signals were operating with actuation on Fall River Avenue (west) and Mink Street. The entire intersection was rebuilt in 1957, and ten channelizing islands were installed. On April 22, 1957, a semi-actuated traffic signal system was put into operation with actuation on Route 114A. However, this intersection was never closed to traffic.

Physical Data

Surface Type
Roadway: 2½" of Class I bituminous concrete. Pavement Type I-1 in two 1½" courses.
Islands: Grass or bituminous concrete.
Shoulders: Gravel treated with ½ gallon of M.C. per square yard-sand covered.
Curbs: Height 6"; Type-granite edging Type SB.
Traffic Control Devices
Signals: Semi-actuated controller inter-connected
Markings: White

Traffic Data

Design Vehicle: C43
Speeds: Posted 35 MPH
Pedestrian: Very little pedestrian movement

Operational Characteristics

Observations of the over-all operation of the new design indicate that the channelization is very successful.

We have not found any unsatisfactory elements of the design nor limitations of movement or control.

The design has reduced the accident record favorably, with the current accident record indicating that the majority of collisions are of the rear-end type and that they are not in excess of the number normally experienced at such a heavily travelled signalized intersection.

Figure 2: Looking west from another position

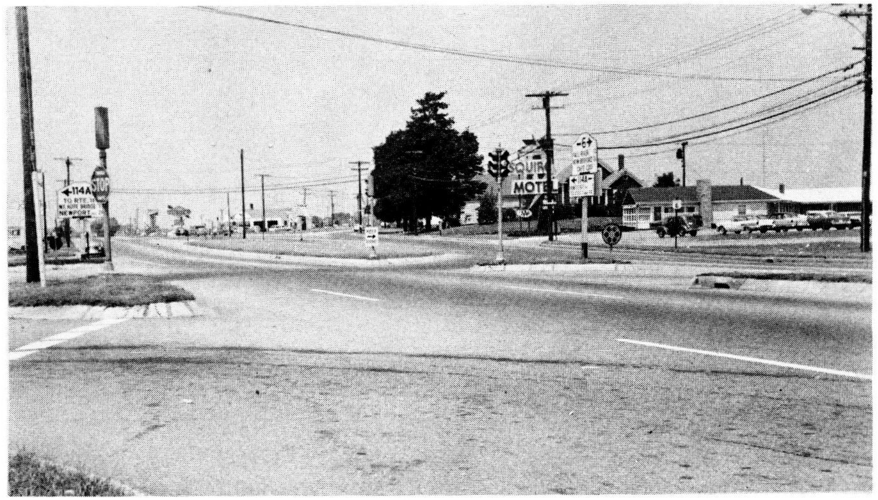


Figure 3: Looking northwest

Figure 1: Looking west

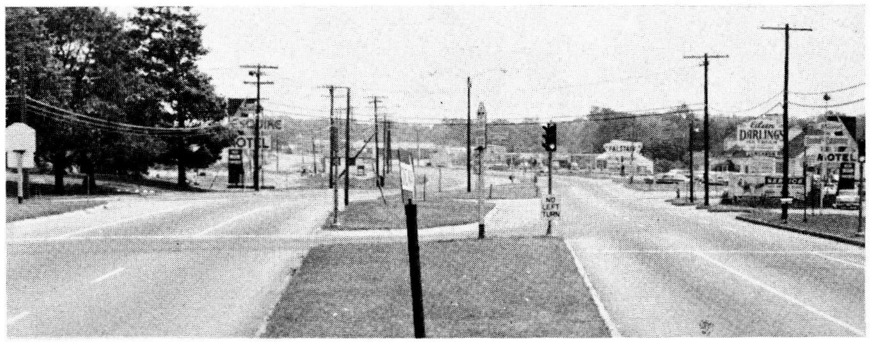
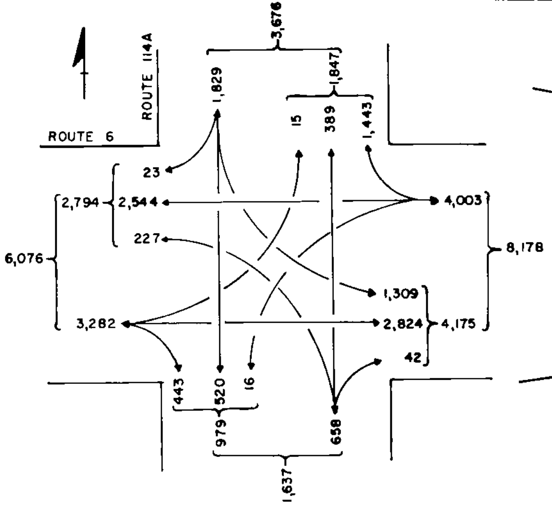


Figure 4: Looking east

Comments by Committee Members

1. ROBERT E. DUNN - This is a good example of bending a minor volume highway (Route 114A) to cross at right angles, merge at small angles, and diverge from the heavier volume highway (Route 6). The basic principles of channelization are appropriately applied. Although numerous islands are involved, they merely fill unusable space and provide well defined channels to guide both the major and minor movements safely through the wide area of the intersection.
   This intersection design with its wide separation of conflict points, good visibility of approach traffic and moderate volumes, might operate more efficiently through the overall period of the day without the use of traffic signal equipment. Whether or not this is true would be a matter of local determination; the point remains, however, that good channelization can forestall the need for traffic signal control.

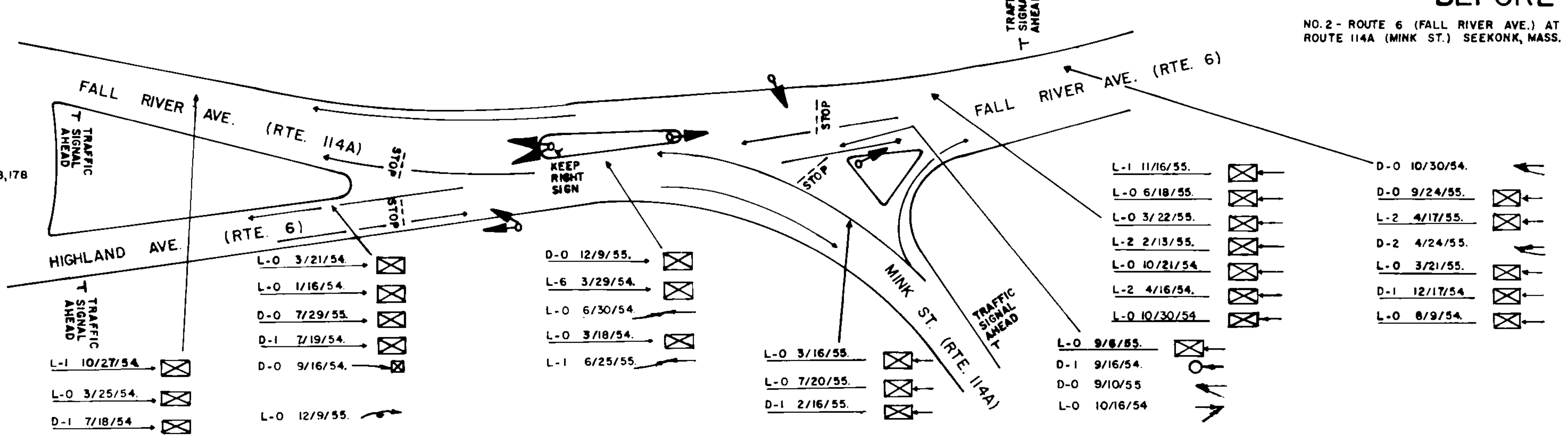
2. KARL MOSKOWITZ - This appears to be a good solution to a very complicated situation. Normally, we would not favor having as many islands as are shown here; however, in this situation, it appears that the islands shown were necessary.



INTERSECTION COUNT OF VEHICULAR TRAFFIC – FROM 11 A.M. TO 6 P.M. 3/30/55. BEFORE RECONSTRUCTION.

BEFORE

NO. 2 - ROUTE 6 (FALL RIVER AVE.) AT ROUTE 114A (MINK ST.) SEEKONK, MASS.

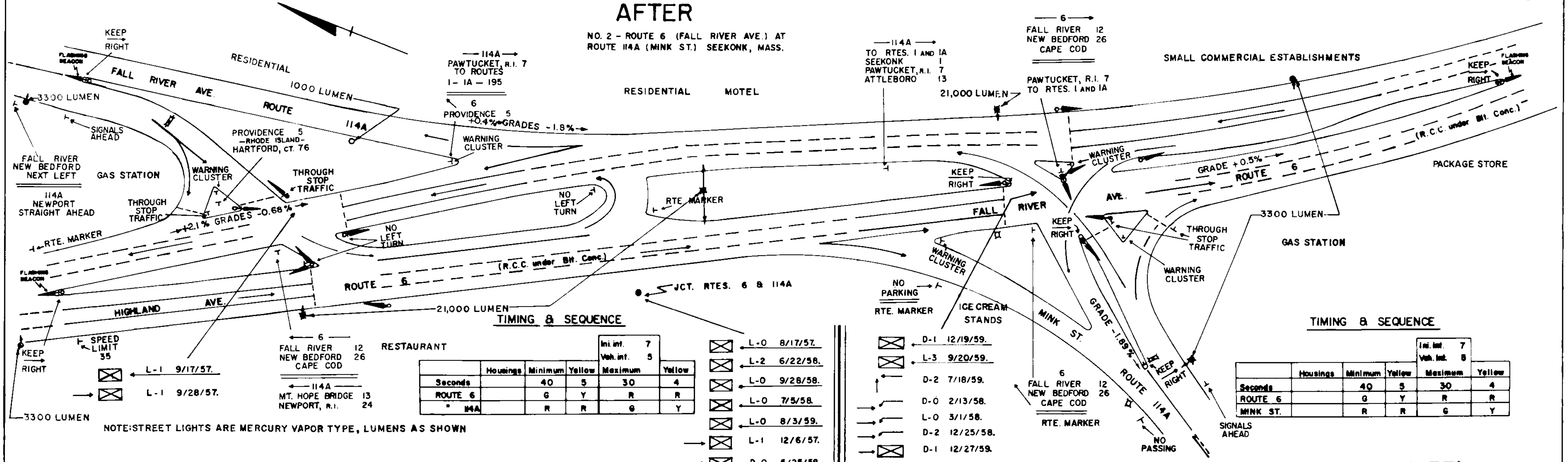


ACCIDENTS PLOTTED FROM FROM 1954 THRU 1955 TRAFFIC RECORDS. (TWO YEARS)

NO SCALE

AFTER

NO. 2 - ROUTE 6 (FALL RIVER AVE.) AT ROUTE 114A (MINK ST.) SEEKONK, MASS.



NOTE: STREET LIGHTS ARE MERCURY VAPOR TYPE, LUMENS AS SHOWN

TIMING & SEQUENCE

	Housings	Minimum	Yellow	Ini. int. 7 / Veh. int. 5 / Maximum	Yellow
Seconds		40	5	30	4
ROUTE 6		G	Y	R	R
" 114A		R	R	G	Y

TIMING & SEQUENCE

	Housings	Minimum	Yellow	Ini. int. 7 / Veh. int. 5 / Maximum	Yellow
Seconds		40	5	30	4
ROUTE 6		G	Y	R	R
MINK ST.		R	R	G	Y

ACCIDENTS PLOTTED FROM JUNE 1957 THRU DECEMBER 1959 TRAFFIC RECORDS. (2 YEARS & 7 MONTHS)

LEGEND

- CAR PARKED AT SIDE OF ROAD.
- CAR IN MOTION.
- L LIGHT
- D DARK
- L-1 LIGHT 1 INJURED
- PEDESTRIAN
- FIXED OBJECT
- OVERTURNED VEHICLE

EXAMPLE FO-4 (OFFSET)

MASSACHUSETTS, SEEKONK

FALL RIVER AVE. (ROUTE 114A) - HIGHLAND AVE. (ROUTE 6) - MINK ST. (ROUTE 114A)

0 50 100 Feet

SCALE:- 1" = 50'

<u>Location</u>

CALIFORNIA, Modesto
H-Scenic-Burney-Downey-Kimble Streets

<u>Type of Intersection</u>

Multiway

<u>Submitted by</u>

Douglas J. Carmody
Director of Parking and Traffic
P. O. Box 642, City Hall
Modesto, California

<u>Date Opened to Traffic</u>

About January, 1958

<u>Physical Data</u>

Grades: The grades for these streets will average .2% to .5%.
Surface Type
Roadways: The street surface is asphaltic concrete from curb to curb.
Transit Operations: This intersection is served by the Modesto Motor Bus Service. One loading zone is shown.
Right-of-Way: The right-of-way at this location does not affect the island design.

<u>Traffic Data</u>

Design Vehicle: 60' Commercial Vehicle
Speeds: The posted speed on all entering legs is 25 MPH. It is well observed and seldom exceeded.
Accidents: <u>Before Channelization</u> - there were none in the twelve months immediately preceding, although there were several accidents before that.
<u>After Channelization</u> - No accidents in three and one-half years.
Pedestrian: Volume is very low; probably less than 50 per day combined in all crossings.

<u>Operational Characteristics</u>

Comment on over-all operation of the channelized intersection: The intersection of H, Scenic, Burney, Downey and Kimble was channelized as part of Modesto's one-way street system. It has been very successful both in reducing accidents and as a traffic separator.

Comment on elements of design which contribute to any unsatisfactory operation: Because of business in the area more openings had to be made than were desired. However, these additional openings, which are uncontrolled, have not produced one single accident in the three and one-half years the island has been in operation.

General Comment: We, in the past, have used mostly raised bars for channelization, but are now beginning to use concrete raised islands. The change to concrete islands from raised bars is because of the high maintenance cost of raised bars.

Figure 1: Looking southwest from SCENIC DRIVE

Figure 2: Raised Traffic Bars

<u>Comments by Committee Members</u>

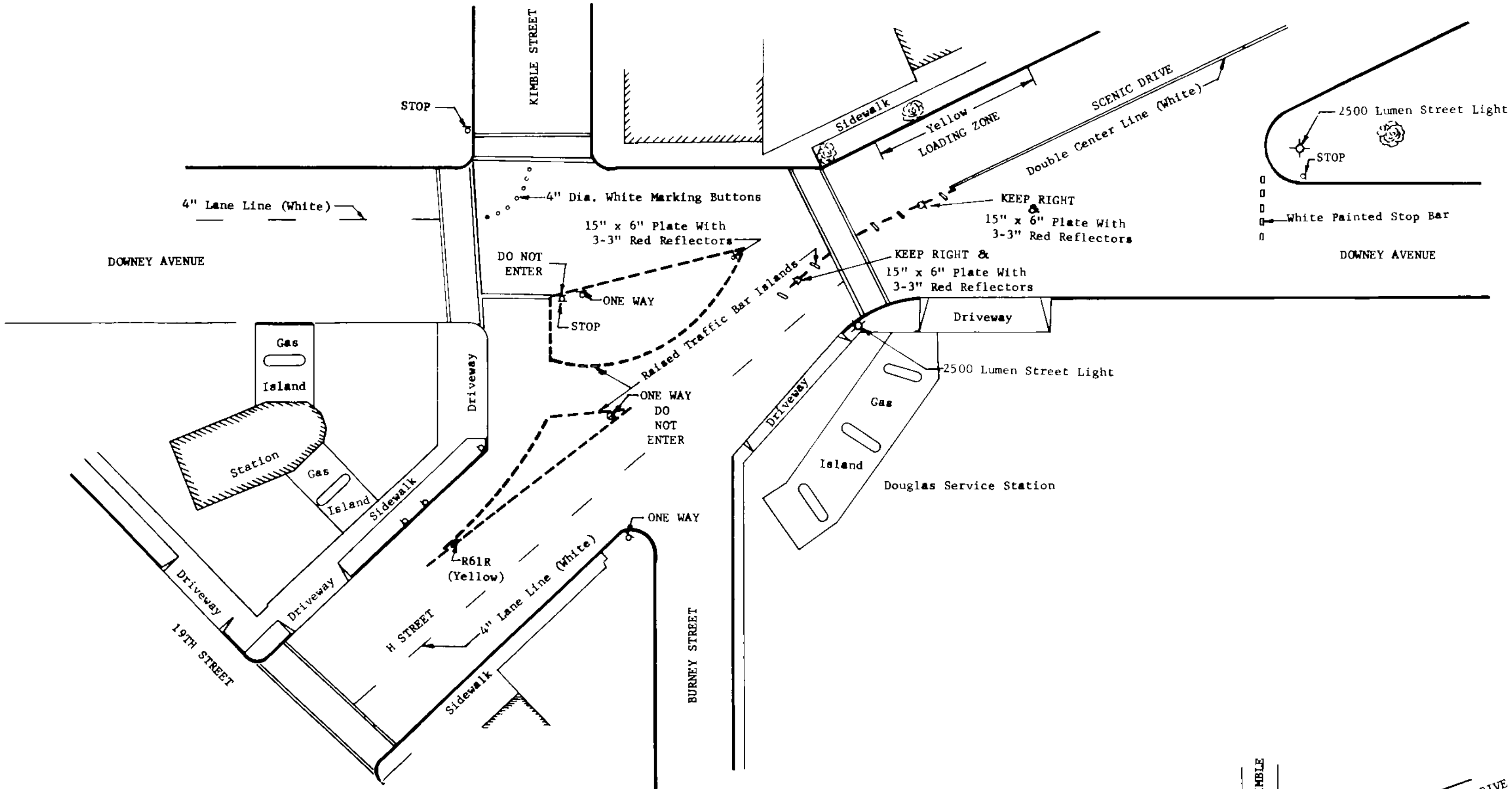
1. ROBERT E. DUNN - The inauguration of the one-way system eliminating the number of conflict points probably had more effect on the operations at the intersection than did the channelization.
   The semi-curbed islands correct the warrant condition and satisfy the principles involved. However, the type of curbing used and the service station opening reduce the potential effectiveness of the channelization.
   A single raised island and median divider formed by a continuous curb would be more effective by:
   a. Reducing the potential hazard of wheel and undercarriage damage to vehicles.
   b. Providing a better island profile for all weather and light conditions.
   c. Creating a better platform for installation of traffic signs.
   d. Establishing a more positive and safer traffic control.

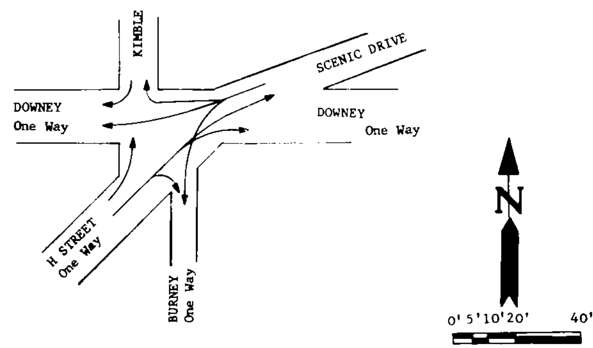
2. GEORGE J. FISHER - I concur with Dunn's comments. The channel between the two islands should be eliminated to simplify operation.

<u>Additional Comments by DOUGLAS J. CARMODY</u> - Raised traffic bars offer a greater safety factor to motorists than a single raised island formed by continuous curbs because: raised bars are only 3" high; the average continuous curb is 6" (plus) high. There are few if any automobiles in the world manufactured that have undercarriages lower than 3"--most are 5 or more inches above the pavement.

TRAFFIC VOLUMES
After Channelization

Street	24 Hour	Peak Hour
H Street	5,553	584
Downey	6,299	605
Burney	1,532	223
Scenic	12,054	1,251
Kimble	603	65





EXAMPLE M-1

CALIFORNIA, MODESTO
H STREET - SCENIC DRIVE - BURNEY STREET - DOWNEY STREET - KIMBLE STREET

Location

ARKANSAS, Magnolia
Courthouse Square

Submitted by

J. R. Henderson
Planning and Research Engineer
Arkansas State Highway Department
Highway Building
Little Rock, Arkansas

Type of Intersection

Multi-way

Date Opened to Traffic

March, 1959

Physical Data

Grades: Flat
Roadways:; Concrete or asphalt as shown
Traffic Control Devices
Markings: Crosswalks with Stop Bars (No Details)
8.5' Parking Stalls
Lighting: Unknown
Abutting Property: Business; some office buildings in the central business district; a county seat town of 10,650 population (1960) and a regional commercial center.
Transit Operations: Transit or taxis not pertinent
Right-of-way: Coincidental with Building Lines on Plan.

Traffic Data

Design Vehicle: C50
Speeds: Data not available; 25 MPH enforced.
Accidents: Accident data not available.

Operational Characteristics

Comment on over-all operation of the channelized intersection: A by-pass is being developed for US 79 and US 82, but at present through traffic is routed through the Courthouse Square.
This project was initiated because angle parking around the Square was seriously interfering with moving traffic. The main purpose of the channelization was to physically separate the moving from the parked traffic without destroying many parking spaces.
The channelization is operating very well and the main purpose has been satisfactorily achieved. Initial local opposition was minor and short-lived, and we have received many favorable comments from both local and out-of-area motorists.
Comment on elements of the design which contribute to any unsatisfactory operation: We have noticed two primary short-comings, both of which have been satisfactorily overcome by signing. One was the short weaving section at both ends of the narrow islands on the east and west sides of the square. East-west through traffic had some difficulty in merging with local traffic until "Yield" signs were installed to give the through traffic right-of-way. The other was the difficulty in getting east-west through traffic in the proper lane. This was solved by erecting over-sized "Guide Sign Assemblies" to give advance notice of route alignment.

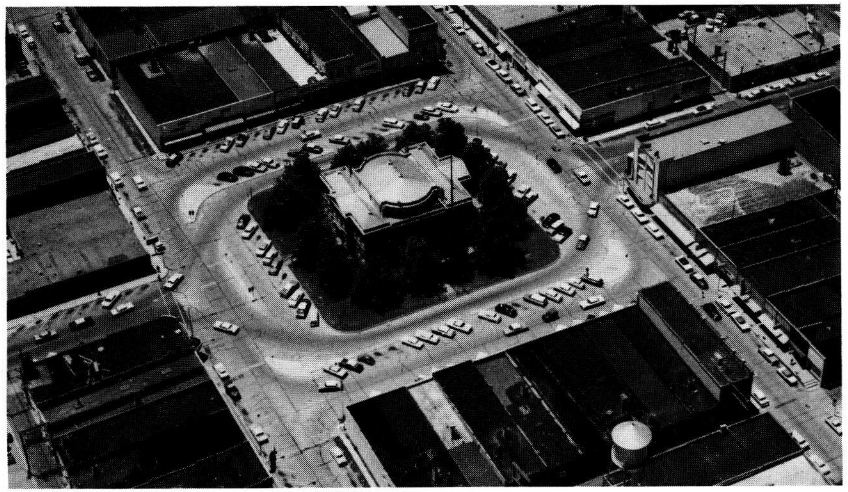


Figure I: Aerial view of the Courthouse Square, looking southeast.

Comments by Committee Members

1. W. R. BELLIS - A typical town square where the principle junction is to park as many cars in as small an area as possible. The contributor states that it works very well. In that case, I would leave well enough alone. Also, as stated, a bypass is being developed. This I highly recommend. It is best if through traffic can avoid such an area. Although this type of design is not good traffic-wise, it has its desirability in local civic pride and beauty.

2. WARREN TRAVERS - The basic purpose as indicated in the original submission is to eliminate interference to moving traffic by angle parking on the north and south sides of the square. The resulting plan adjusted to compensate for certain operating difficulties as stated, does not completely satisfy this objective. While the physical separation accommodates satisfactorily the east-west traffic through the square (Route 82), much of the north-south traffic, as well as certain turning movements from Route 82, is directed through the "angle parking" areas. This is particularly significant regarding southbound traffic on the north approach of Washington Street (360 peak hour). This volume, coupled with the movement from Route 82 westbound (120 peak hour) results in a peak volume of 480 through the "angle parking" area on the north side. No doubt some of these vehicles are parking in the area, but this probably is a relatively small portion of the total. Further, there are additional vehicles traversing this parking area from Washington Street northbound (including Jefferson Street northbound and Route 82 eastbound) which cannot be determined from the counts submitted. Thus, the conflict of parked to moving vehicles in this parking area is substantial. A similar, although much less critical, situation occurs in the "angle parking" area on the south side of the square. Accordingly, it is suggested that consideration be given to making Washington Street one way for at least one block north of the square and Jefferson Street one way south of the square, as shown. Jefferson Street north of the square and Washington Street south of the square are shown to be "preferential" southbound and northbound, respectively. This has the following advantages:
   a. Non-parking traffic is virtually eliminated from the parking areas.
   b. Vehicles approaching the square from north and south are better oriented.
   c. Turning movements, east to north and west to south, are more expeditiously served by virtue of the one-way exits on Washington and Jefferson Streets.

   This scheme has the disadvantage of forcing the rerouted vehicles which presently approach from the north and south on Washington and Jefferson Streets, respectively, and which desire to park on their respective "near sides" of the square, to traverse the entire square (they leave, however, without any circuitous routing). Considering that some of these vehicles will, however, re-orient themselves to approach the square via Route 82 and thus will have reasonably direct access, it appears that there would be very little circuitous routing involved.

   Another possible disadvantage, however, is that this proposed rerouting may cause problems at intersections beyond the square itself, thereby precluding the one-way operation as shown. Assuming this to be the case, it appears that the one-way segments could at lease be treated as "preferential" direction streets, thus approximating the scheme shown from an operating viewpoint through guide signing and control techniques.

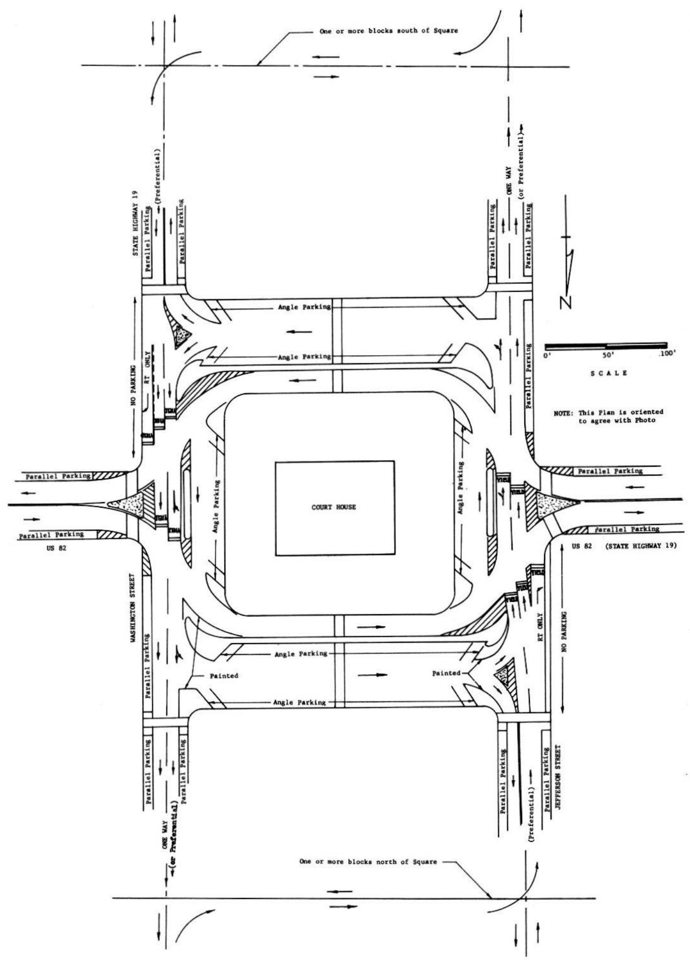
   Physical changes as shown in the revised plan include raised islands at the east and west approaches of Route 82, and raised islands at the exit end of each of the two parking areas. The physical additions are supplemented with more extensive pavement markings as shown, to better define vehicular paths.

   It appears that good lane and control point delineation and pedestrian refuge islands are particularly important in this instance, since none of these conflict points are signalized. The attempt here has been to clearly define the conflict points and keep the areas of exposure to conflict to a minimum.

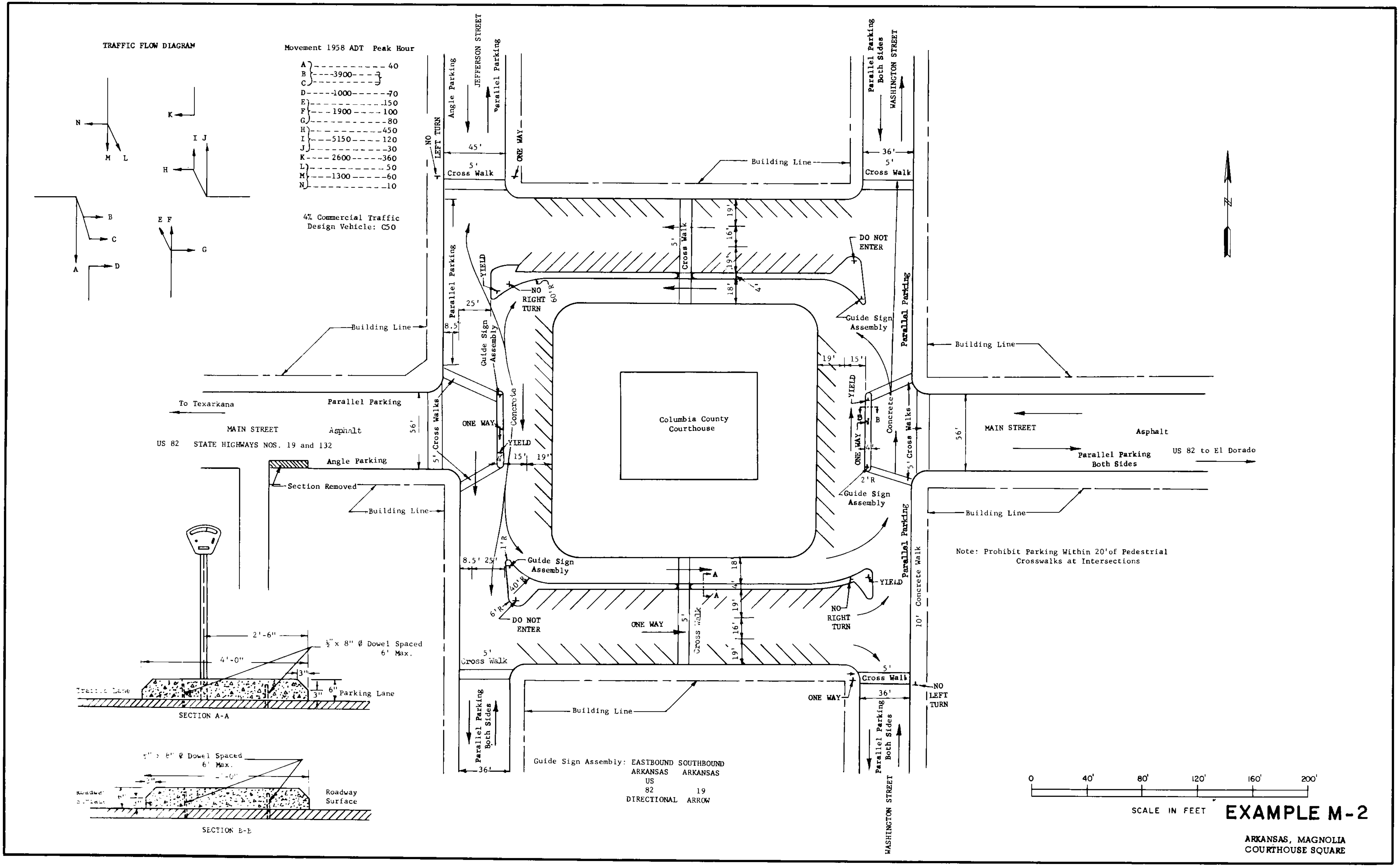
   The principal deficiency in this layout is the extremely short storage areas located between eastbound and westbound flows at the east and west sides of the square. Thus, through north-south traffic is required to yield twice within a very short distance. Fortunately this through traffic (north-south) is relatively light; however, at such time when signalization is deemed necessary, it would be desirable to eliminate this storage area entirely by pulling the eastbound and westbound roadways as close together as possible.

   One further comment--if pedestrian access is necessary between the Route 82 walks and the narrow islands on the east and west sides of the square, it appears that the walks could best be located to connect with the islands shown on Route 82 approaches, the crosswalk being located approximately where the "yield" indications are noted (forward end of the north-south storage areas). Thus, pedestrians on the Route 82 walks would be required to cross the Route 82 approach to the island and thence across the north-south storage areas to the narrow island.

Additional Comments by J. R. HENDERSON - Please be advised that Mr. Travers' assumption that the aerial photograph is more correct than the plan sheet is valid since there were some field changes in the design that were not reflected by the plan sheet.



by Warren Travers



EXAMPLE M-2

ARKANSAS, MAGNOLIA
COURTHOUSE SQUARE

Location

IDAHO, Twin Falls
East Five Points

Submitted by

E. L. Mathes
Assistant State Highway Engineer
Idaho Department of Highways
P. O. Box 879, Boise, Idaho

Type of Intersection

Multi-way

Date Opened to Traffic

October, 1960

Physical Data

Grades: 0%
Surface Type
Roadways: 0.3' Plant mix bituminous surface; 0.4' Cr. gravel base course 3/4" maximum; 0.8' Cr. gravel base course 1" maximum.
Islands: Paved with .17' plant mix bituminous surfacing.
Shoulders: None; only travelways with concrete curb and gutter.
Curbs: 6" high concrete curb and gutter.
Traffic separator and left turn bay are 5 3/4" high.
Traffic Control Devices
Lighting: All street lights are 21,000 lumen mercury vapor, 30' from pavement on 8' mast arms.

Traffic Data

Design Vehicle: C50
Speeds: Speed limit 25 MPH

Operational Characteristics

Comments on over-all operation of the channelized intersection: "Before the channelizing was constructed the traffic pattern indicated that due to the large expansion of pavement, drivers were often confused as to the probable action of others. Since the reconstruction with channelization the traffic movements are directed and confined in the proper channels.

Figure 1: Looking west before construction

Figure 2: Looking west after construction

Figure 3: Looking north after construction

Figure 4: Looking south after construction

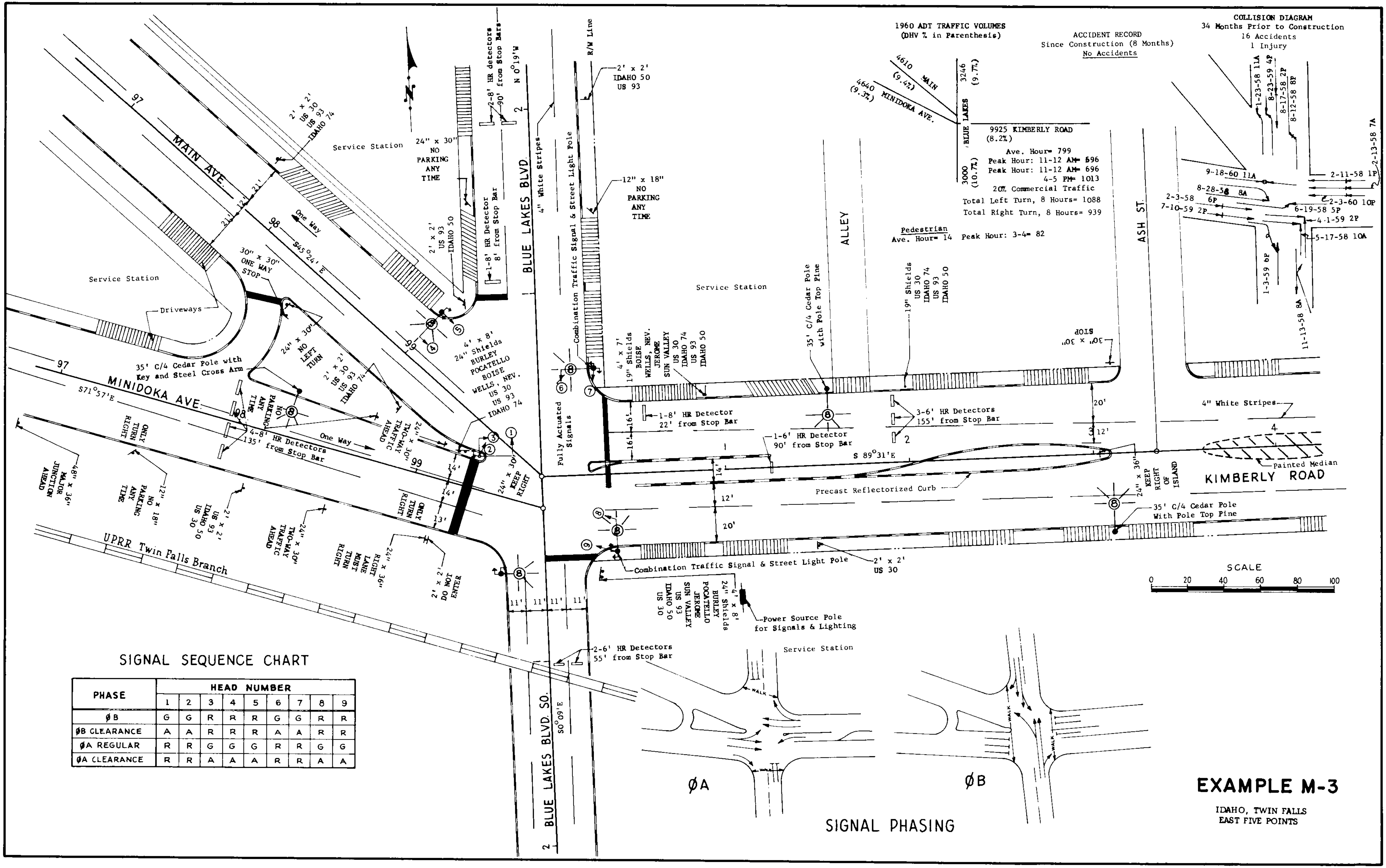
Figure 5: Looking southeast on Main after construction

Comments by Committee Members

1. IRV. WEINBERG - Channelization installed is uncomplicated and breaks up the former wide expanse of pavement into direct channels for traffic to follow. It should work very effectively.
   With the distance between curbs as great as it is on Kimberley Road at Blue Lake Blvd., the traffic separator between west bound and left turning (to south on Blue Lake Blvd.) traffic could be made wide enough to serve as a pedestrian refuge island (2 or 3 ft. wide).

2. EUGENE MAIER - The success of this channelization project is evidenced by the dramatic improvement in accident experience. Although the channelization may have been an important factor, the before and after photographs indicate that the channelization project provides an occasion for the installation of improved lighting, modernization of traffic signal controls, more effective information signs and improved pavement markings.
   The geometric design of the channelization appears quite adequate and the one-way traffic movement on Main Avenue and Minidoka Avenue west of Blue Lakes Boulevard have contributed to the simplification of a complex intersection.

Additional Comment by E. L. MATHES - We concur in Mr. I. Weinberg's comment that the traffic separators could be made wider to serve as pedestrian refuge islands. However, due to light pedestrian traffic and the cost involved in getting additional right-of-way this feature was not provided.



SIGNAL SEQUENCE CHART

PHASE	HEAD NUMBER 1	2	3	4	5	6	7	8	9
ØB	G	G	R	R	R	G	G	R	R
ØB CLEARANCE	A	A	R	R	R	A	A	R	R
ØA REGULAR	R	R	G	G	G	R	R	G	G
ØA CLEARANCE	R	R	A	A	A	R	R	A	A

EXAMPLE M-3

IDAHO, TWIN FALLS
EAST FIVE POINTS

Location

OREGON, Portland
US 26 - Canyon Rd. - SW 58th Ave.-
SW Skyline Blvd. - SW Canyon Ct.-
SW Humphrey Blvd.

Submitted by

F. B. Crandall, Traffic Engineer
Oregon State Highway Department
Salem, Oregon

Type of Intersection

Multi-way

Date Opened to Traffic

November, 1954

Physical Data

Surface Type
Roadways: Asphaltic concrete pavements except that Canyon Road (US 26) has a 1½" asphaltic concrete skin coat over concrete pavement.
Islands: The small narrow islands on the northerly side of the main intersection are concrete, 7" high. The long narrow median separators along Canyon Road (US 26) in the middle of the intersection are non-mountable concrete, 7" high.
Shoulders: All shoulders not shown on the drawing are gravel, approximately 2' wide.
The bus stops are paved.
Traffic Control Devices
Markings: Plain lines are yellow; a solid yellow stripe outlines the jiggle bar areas.
Jiggle Bars are 2½" high.

Traffic Data

Design Vehicle: For movements receiving traffic signal indication the Design Vehicle is C50; for other movements P or SU.

Operational Characteristics

This intersection is some four miles distant from the Portland central business district and services commuter-type traffic with corresponding relatively high peak hours. Over and above the commuter-type traffic, US 26 is a principal feeder highway between the Portland area and coast points and experiences some high seasonal peaks in the way of recreational traffic. This particular intersection has recently been remodeled with a "tight" diamond-type interchange.

Although probably not particularly pertinent to channelization aspects, I might mention that the grades at this intersection are at the crest of a vertical curve with respect to the main line, US 26, and during icy and snow conditions it is necessary to put the signals on flashing operation, with flashing amber to US 26 and flashing red to the crossroad to preclude a jam-up on the main line.

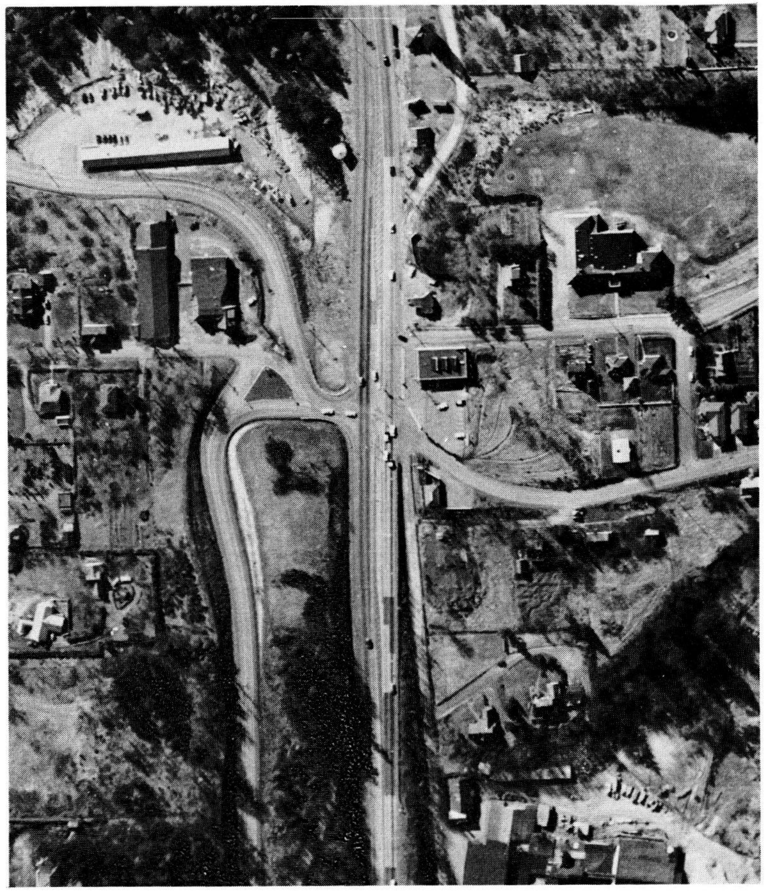


Figure 1: Aerial view, AFTER channelization.

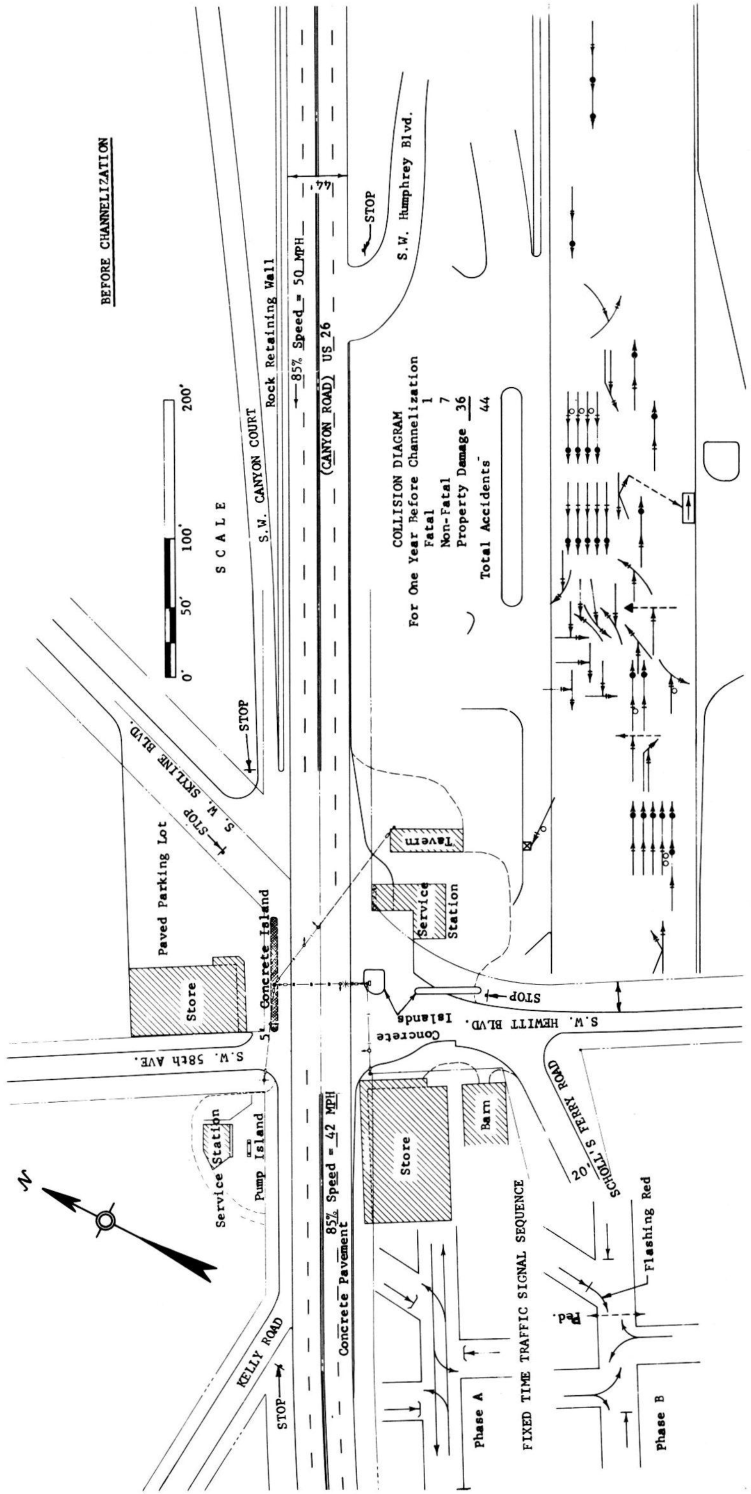
Comments by Committee Members

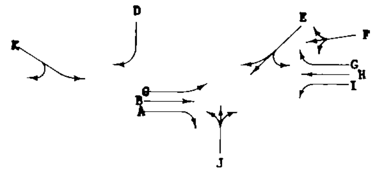
1. GEORGE J. FISHER - Appears to be an economical and effective treatment. Left-turn storage lanes well adjusted as to length, for volumes handled. Couldn't intersection be speed zoned to reduce rear-end collisions? Traffic efficiency is low anyhow and a reduced speed would not hurt much. Looks like a "natural" for the interchange which was built later.

2. DONALD H. SIDES - The "after" treatment was effective in reducing accidents, particularly the usually serious type between through and turning vehicles. The number, however, remained large after provision of the channelization which suggests that high approach speeds and limited sight distance at the crest intersection may be causative factors. The vertical geometry, a 700-foot vertical curve together with five percent approach grades, is suitable for a design speed of about 45 miles per hour. It is possible that the accident record entered into the decision to provide an interchange.

Additional Comments by F. B. CRANDALL - Comments on this example suggest speed zoning as a means of reducing rear-end type accidents. There was signed speed zoning of 35 MPH on the main line through this intersection (this should probably be indicated on the plan).

With regard to the comment, "...the accident record entered into the decision to provide an interchange", the warrant and desirability of providing an interchange was evident at the time the channelization was installed. The only deferrent to construction of the interchange at the outset was finance, and channelization was considered an interim treatment as would provide some measure of improvement commensurate with cost and monies available at the time.





TRAFFIC VOLUMES

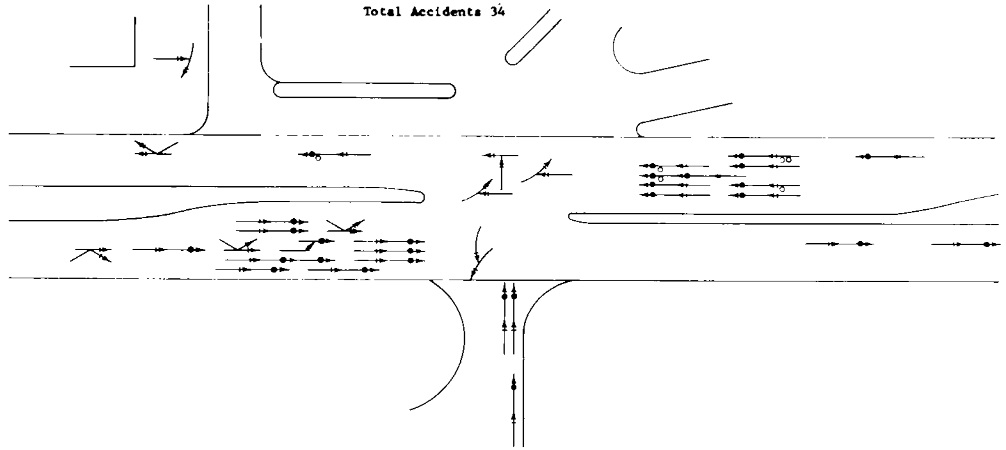
Movement	Ave. Daily Vol.	P. M. Peak Hr.	A. M. Peak Hr.
A. (Canyon Rd.)	412	37	15
B (Canyon Rd.)	8836	354	1352
C (Canyon Rd.)	313	18	38
D (S.W. 58th Ave.)	126	18	2
E (Skyline Blvd.)	525	54	28
F (Canyon Ct.)	104	25	9
G (Canyon Rd.)	345	30	13
H (Canyon Rd.)	7918	1355	263
I (Canyon Rd.)	1302	286	30
J (Scholl's F. Rd., Hewitt, & Humphrey)	2157	99	321
K (Kelly Rd.)	50 Est.	--	--

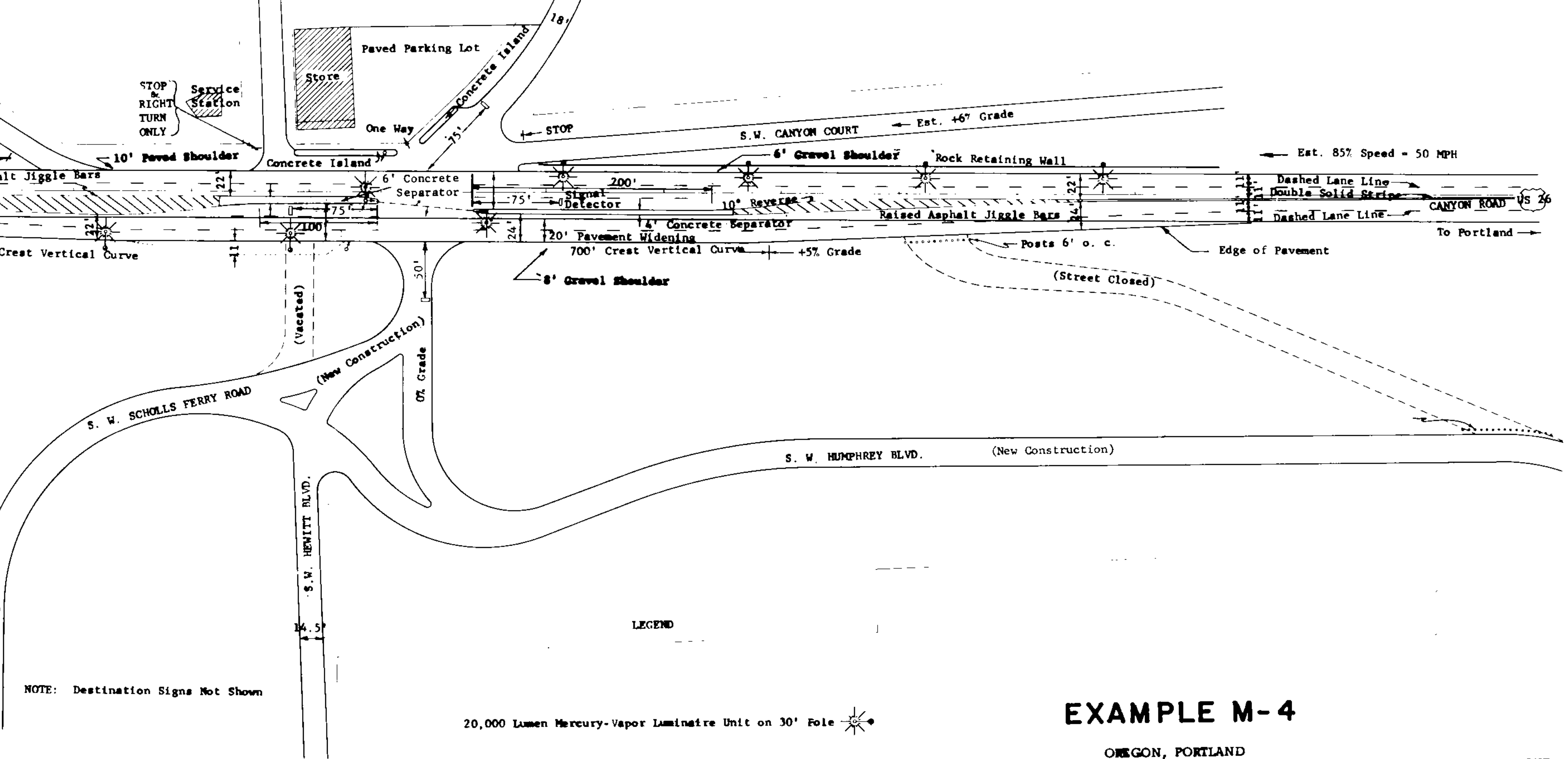
COLLISION DIAGRAM

For One Year After Channelization

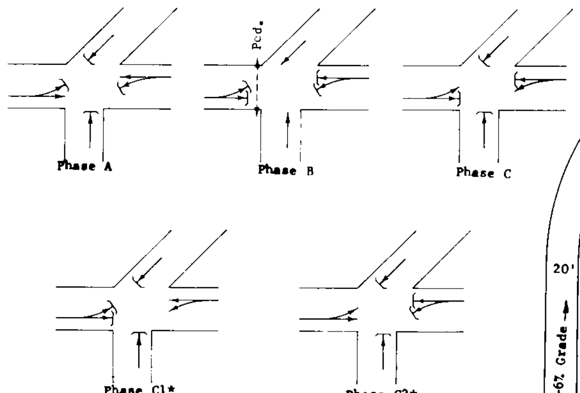
Fatal	0
Non-Fatal	5
Property Damage	29
Total Accidents	34

AFTER CHANNELIZATION





THREE PHASE SEMI-ACTUATED TRAFFIC SIGNAL SEQUENCE



*When left turn actuation from one direction only, Phase C1 or C2 replaces Phase C.

NOTE: Destination Signs Not Shown

LEGEND

20,000 Lumen Mercury-Vapor Luminaire Unit on 30' Pole

EXAMPLE M-4

OREGON, PORTLAND

US 26 - S.W. 58TH AVENUE - S.W. SKYLINE BOULEVARD - S.W. CANYON CT. - S.W. HUMPHREY BLVD.

Location

DISTRICT OF COLUMBIA, Washington
Constitution Avenue - Maryland Avenue - 2nd Street, N. E.

Type of Intersection

Multiway

Physical Data

Grades: None over 3%
Surface Type
Roadways: 2" asphalt concrete over reinforced concrete base.
Islands: Earth (grass)
Shoulders: Parking lanes are same construction as roadway.
Curbs: 8" granite barrier type.
Traffic Control Devices
Markings: Pavement markings all white.
Transit Operations: Bus stops not located in channelization; loading and unloading operations from passenger cars and taxis occur.

Traffic Data

Design Vehicle: C50
Speeds: 25 MPH legal speed
Accidents: During 12 months prior to construction there were 19 accidents of which four were personal injury and 15 were property damage.
In the year following construction there were nine accidents of which four were personal injury and five were property damage.

Operational Characteristics

This multiway intersection is located in the Capitol Hill area where the Capitol, several office buildings for Members of Congress, the Supreme Court Building, the Library of Congress, and other institutions are located. Traffic in the intersection is composed not only of a large volume of through traffic destined beyond the intersection but a significant number of vehicles are destined to the immediate area. The number of tourists or non-repeat drivers in the intersection is many times those experienced in most areas. Vehicles destined to the area are largely parked on adjacent streets. A large number of spaces are reserved for Members of Congress, their employees, the diplomatic corps, and governmental agencies. This local traffic is observed to be predominantly to and from the west.

Operation in the intersection has been quite satisfactory to date. Backups during the rush hours have been minor. The 3-dial radio master control of the signals is quite effective.

A large stadium was opened in October of 1961 about 20 blocks due east of this intersection. There is some concern that traffic to major events may cause congestion, particularly if the events are timed to fall at the peak hours, as the east-west route is one of the major routes to the stadium.

Submitted by

Francis E. Twiss, Deputy Director for Traffic Engineering and Operations
District of Columbia Department of Highways and Traffic
Washington, D. C.

Date Opened to Traffic

Late 1956

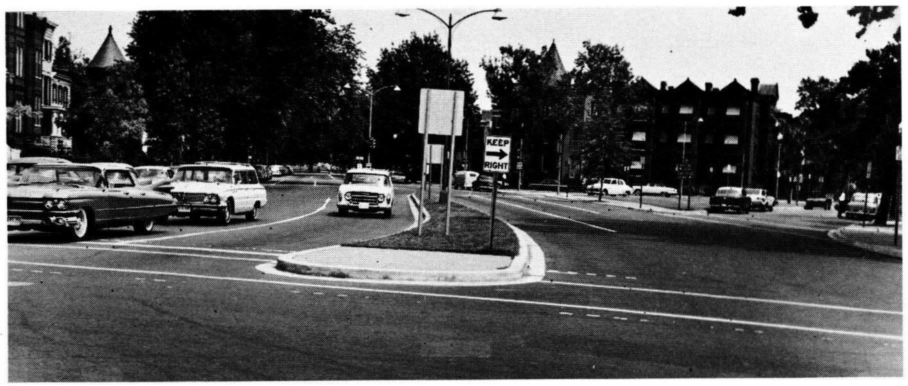


Figure 1: Looking northeast along Maryland Avenue at its intersection with Constitution Avenue and 2nd Street

Figure 2: Looking northeast on Maryland Avenue with Constitution Avenue diverging to the right.

Figure 3: Looking west along Constitution Avenue from its intersection with 2nd Street and Maryland Avenue

Comments by Committee Members

1. IRV. WEINBERG - A very good example of channelization principle, separation of conflicts by using channelizing islands (and traffic signals). The islands are used well to direct traffic into uncomplicated paths and to position the vehicles so that they are protected from conflicting traffic movements and yet be in the best position for safe traffic-maneuver judgment.

   The islands provide a location for traffic control devices and also provide for pedestrian refuge. It is worth noting that this intersection design is not cluttered up with many small islands, - a common fault sometimes noted in other multiple intersection treatment.

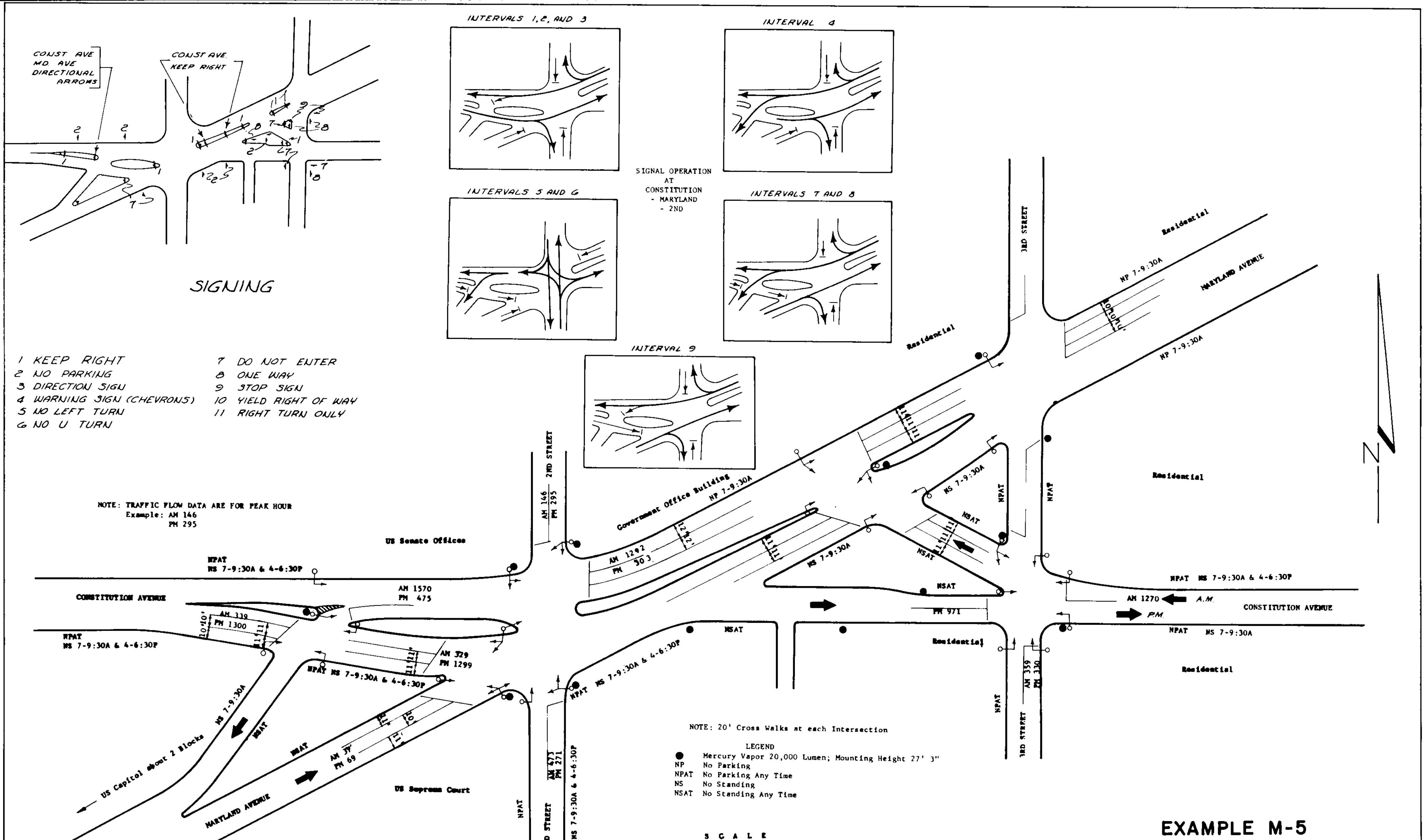
   Using a C50 vehicle as the design vehicle provides adequate turning radius, maneuver pavement and curb set-back.

2. CHARLES J. KEESE - This is a good treatment of a complex multiple intersection. The channelization is necessary for efficient operation and appears to be quite satisfactory and well planned.

   The signal phasing is necessarily complex but the channelization design appears to accommodate each movement satisfactorily.

   Vehicle paths are well defined and this appears to be a good solution to a bad problem.

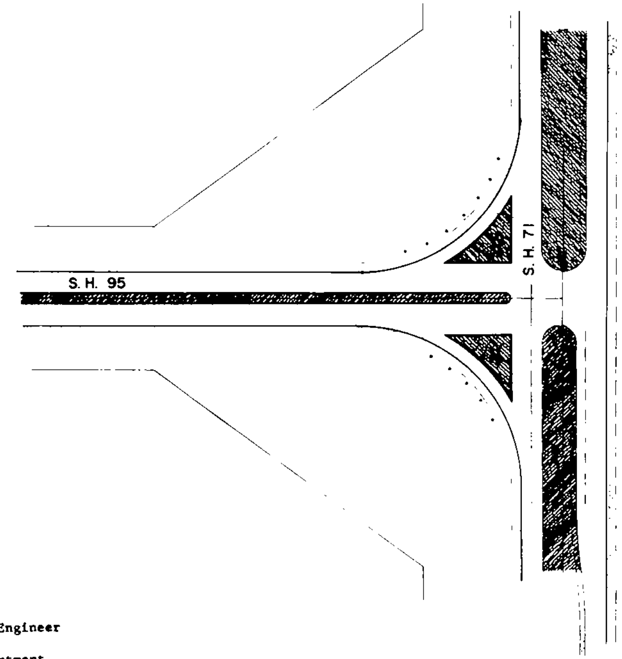
   Although signal phasing is not shown for all of the intersections in this group, it is assumed that all of the signals are coordinated to provide proper phasing through this area.



EXAMPLE M-5

DISTRICT OF COLUMBIA, WASHINGTON
CONSTITUTION AVE. - MARYLAND AVE. - 2ND STREET

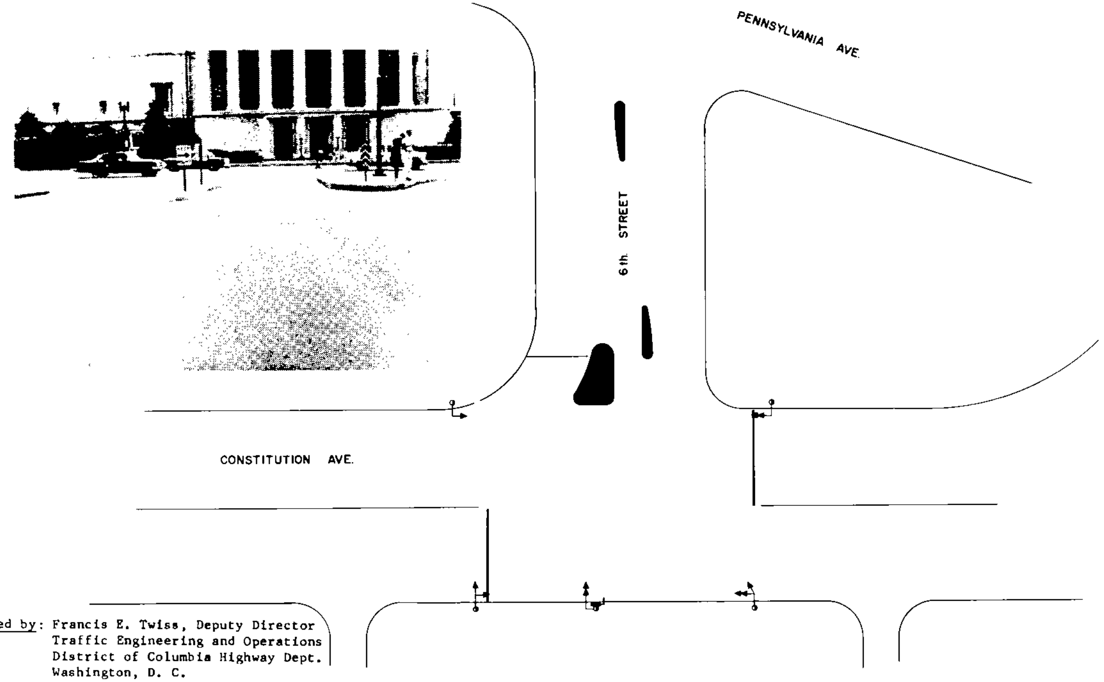
OTHER TREATMENTS T INTERSECTIONS



Submitted by: T. S. Huff, Chief Engineer
Highway Design
Texas Highway Department
Austin, Texas

INTERSECTION DETAILS
S.H. 71 & S.H. 95

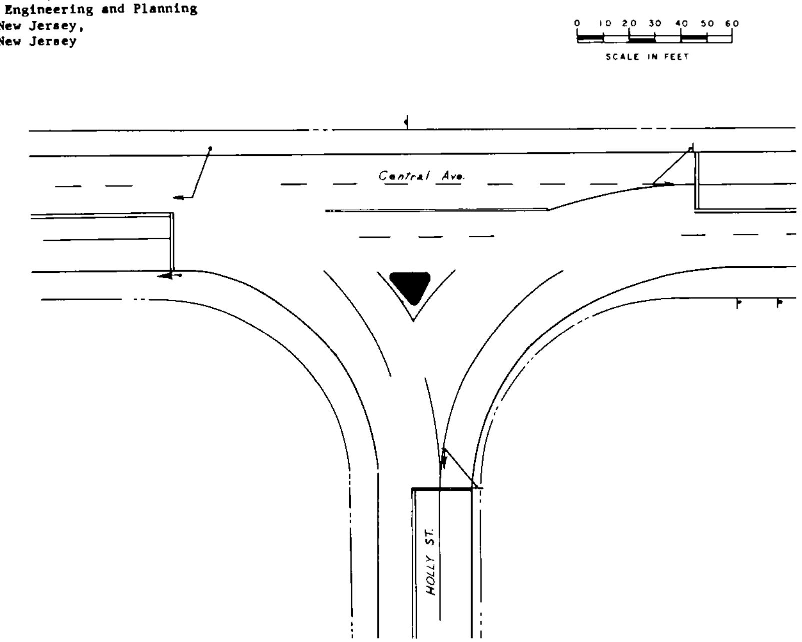
EXAMPLE T-A, STATE HIGHWAY 71 - STATE HIGHWAY 95, BASTROP, TEXAS



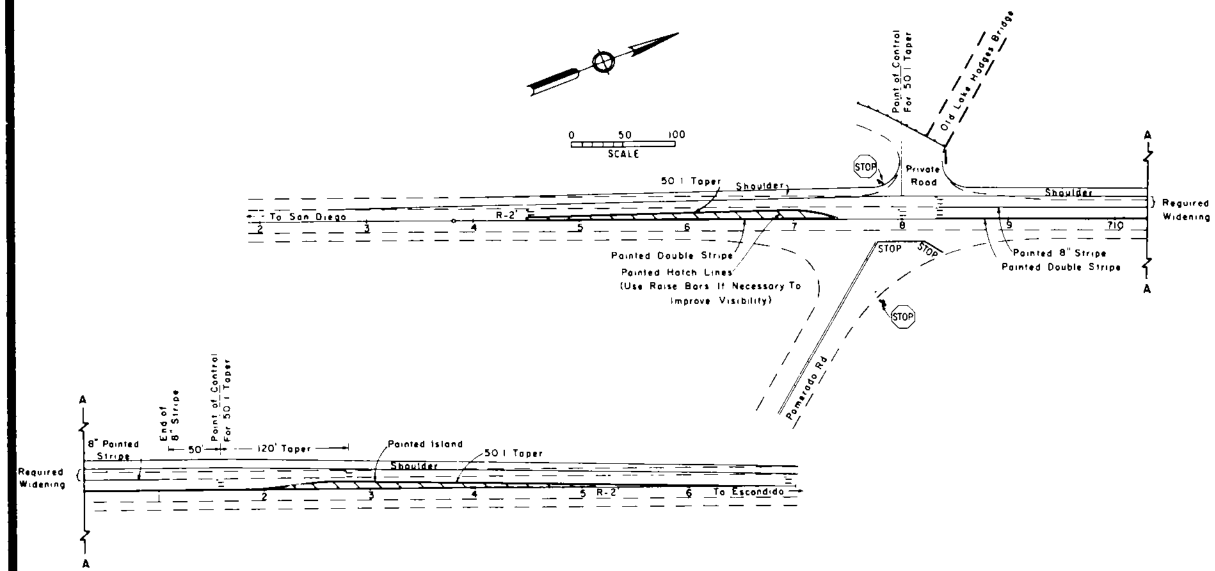
Submitted by: Francis E. Twiss, Deputy Director
Traffic Engineering and Operations
District of Columbia Highway Dept.
Washington, D. C.

EXAMPLE T-B, 6TH STREET - CONSTITUTION AVENUE, WASHINGTON, D.C.

Submitted by: Herbert J. Klar, Chief
Bureau of Engineering and Planning
State of New Jersey,
Trenton, New Jersey



EXAMPLE T-C, HOLLY STREET - CENTRAL AVENUE, METUCHEN, NEW JERSEY



Submitted by: Karl Moskowitz, Assistant Traffic Engineer
California Division of Highways
Sacramento, California

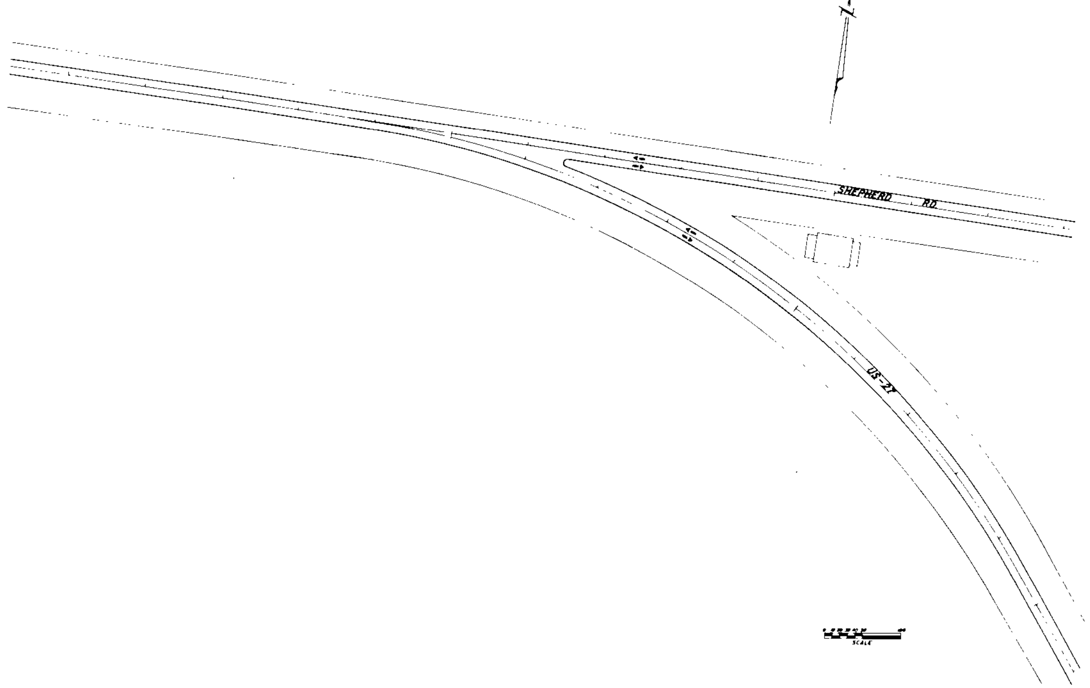
EXAMPLE T-D, ROUTE 77 - POMERADO ROAD, NEAR SAN DIEGO, CALIFORNIA

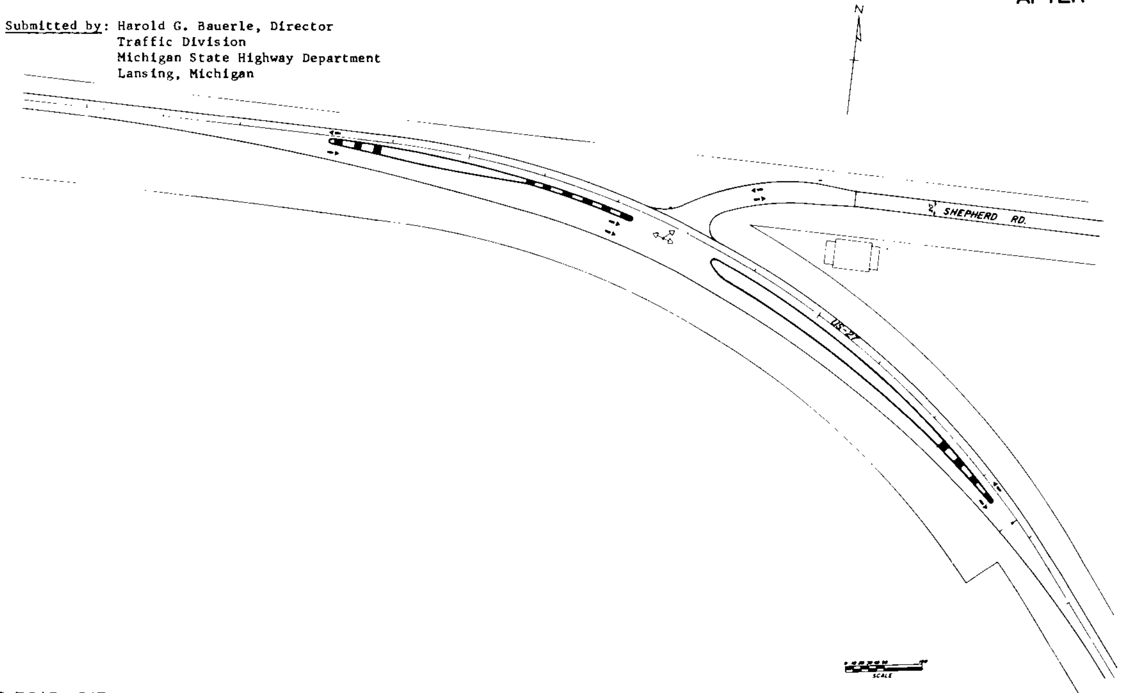
OTHER TREATMENTS Y INTERSECTIONS

BEFORE

AFTER

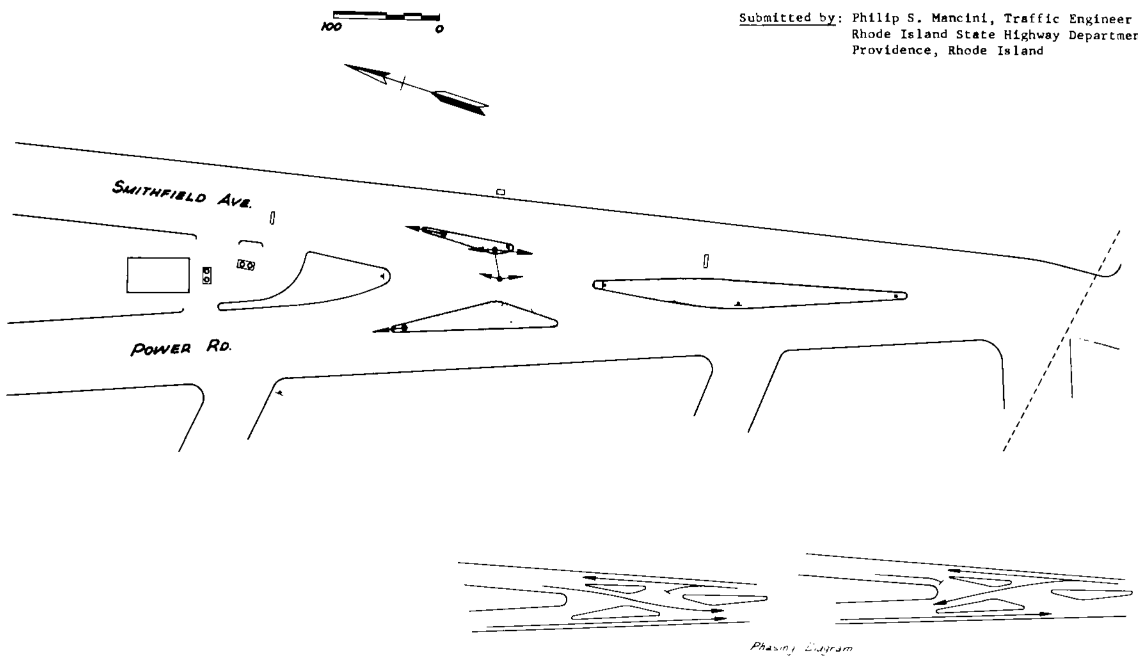
Submitted by: Harold G. Bauerle, Director
Traffic Division
Michigan State Highway Department
Lansing, Michigan





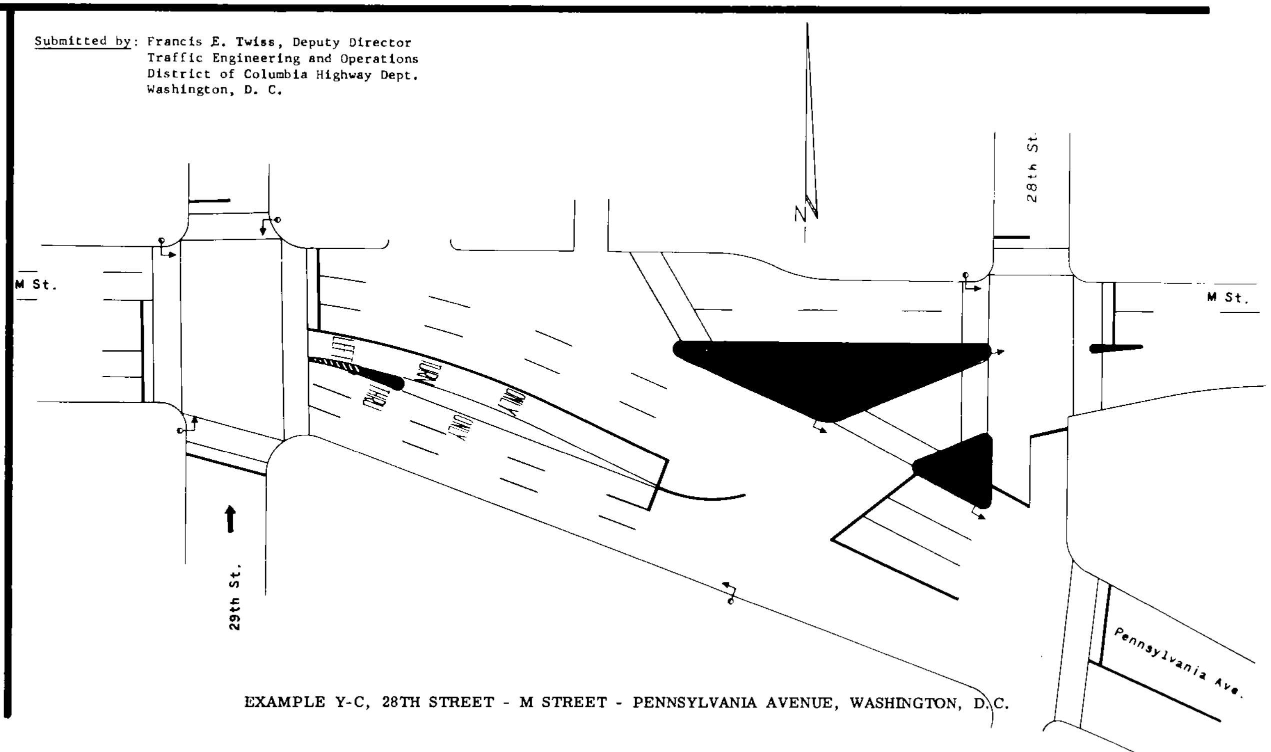
EXAMPLE Y-A, U.S. 27 - SHEPHERD ROAD, SHEPHERD, MICHIGAN

Submitted by: Philip S. Mancini, Traffic Engineer
Rhode Island State Highway Department
Providence, Rhode Island



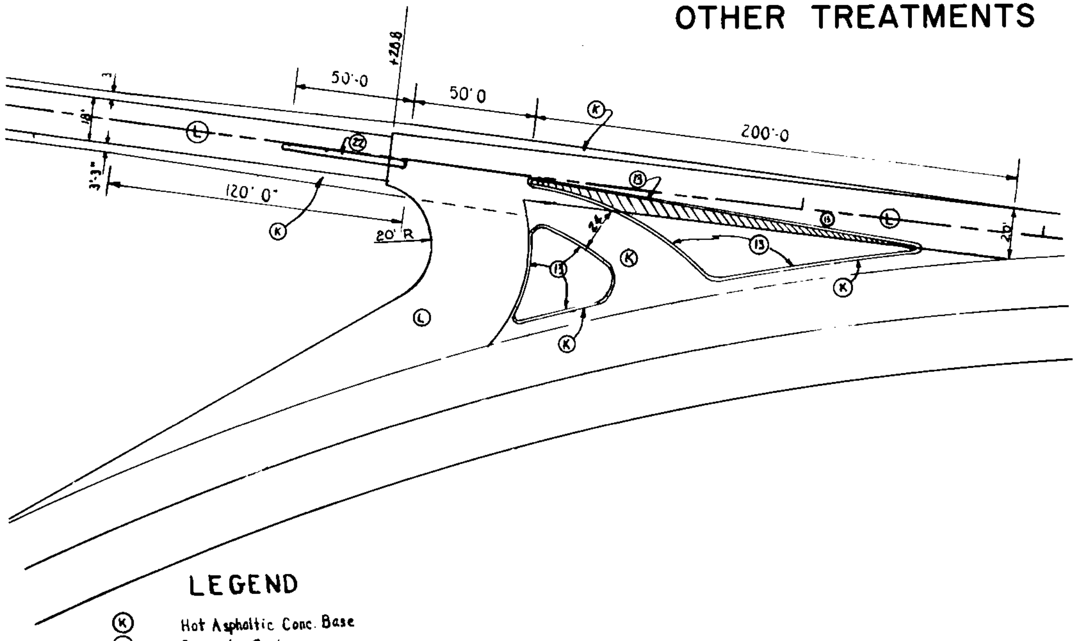
EXAMPLE Y-B, SMITHFIELD AVENUE - POWER ROAD, PAWTUCKET, RHODE ISLAND

Submitted by: Francis E. Twiss, Deputy Director
Traffic Engineering and Operations
District of Columbia Highway Dept.
Washington, D. C.



EXAMPLE Y-C, 28TH STREET - M STREET - PENNSYLVANIA AVENUE, WASHINGTON, D.C.

OTHER TREATMENTS — Y INTERSECTIONS

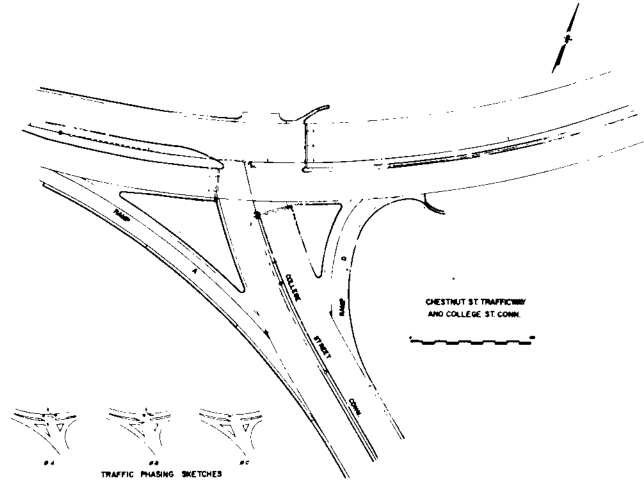


LEGEND

- (K) Hot Asphaltic Conc. Base
- (13) Concrete Curb
- (22) Bituminous Conc. Center Curb
- [hatched] Pvm't Removal
- (L) 90#/Syd. H.A Conc. Surface Type "B" & 210#/Sys. H.A Con\ Base

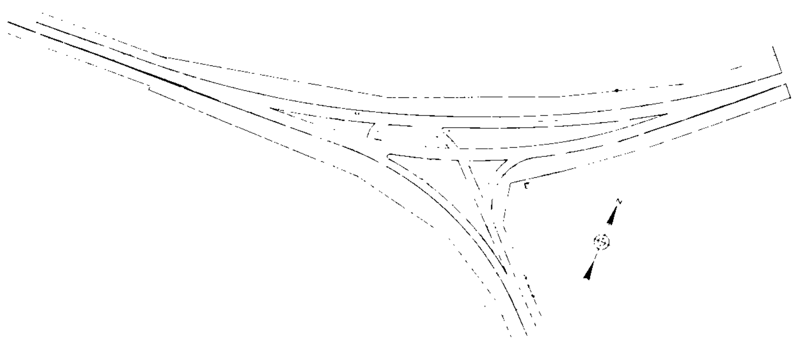
Submitted by: P. T. Vermillion, Chief
Division of Traffic
Indiana Department of Highways
Indianapolis, Indiana

EXAMPLE Y-D, INDIANA 14 - U S 24, FORT WAYNE, INDIANA



Submitted by: Leon W. Corder, Traffic Engineer
Missouri State Highway Department
Jefferson City, Missouri

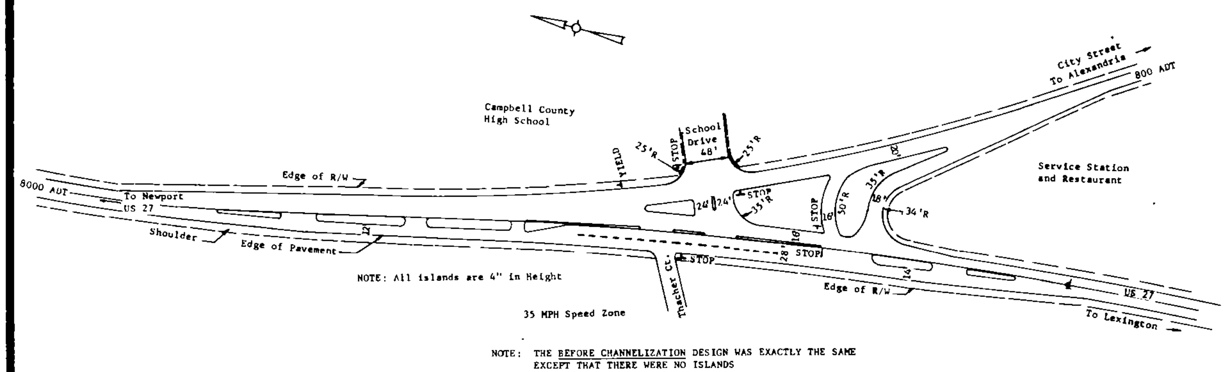
EXAMPLE Y-E, CHESTNUT STREET TRAFFICWAY - COLLEGE STREET, SPRINGFIELD, MISSOURI



Submitted by: M. A. Bebee, Director
Bureau of Highway Planning
New York State Department of Public Works
Albany, New York

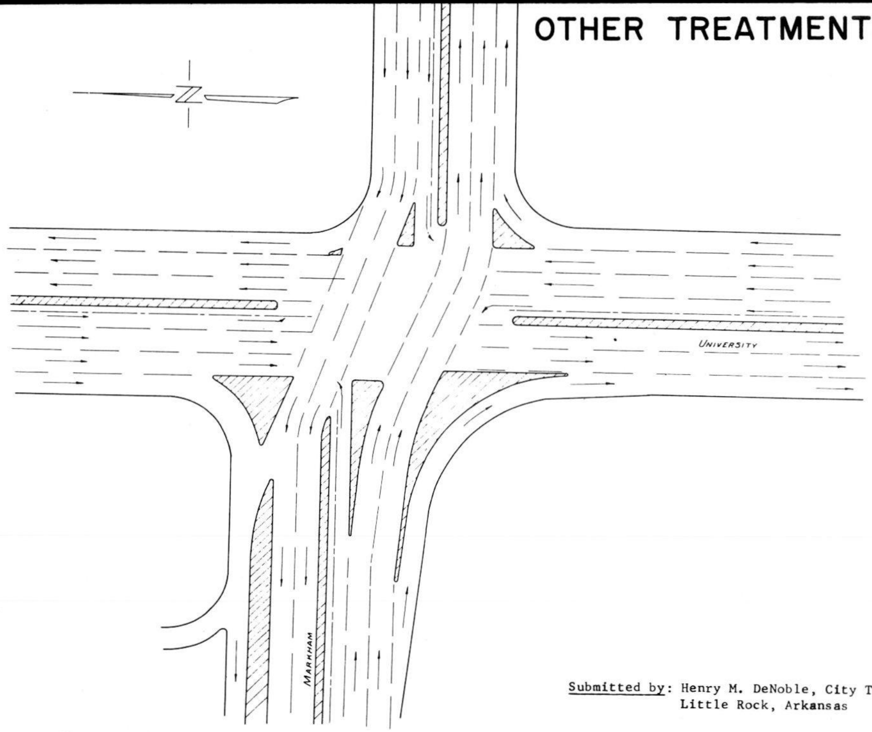
EXAMPLE Y-F, NEW YORK 5290 (WOLCOTT - RED CREEK) - NEW YORK 5290 (WESTBURY), WAYNE COUNTY, NEW YORK

Submitted by: K. B. Johns, Director
Division of Traffic
Kentucky Department of Highways
Frankfort, Kentucky



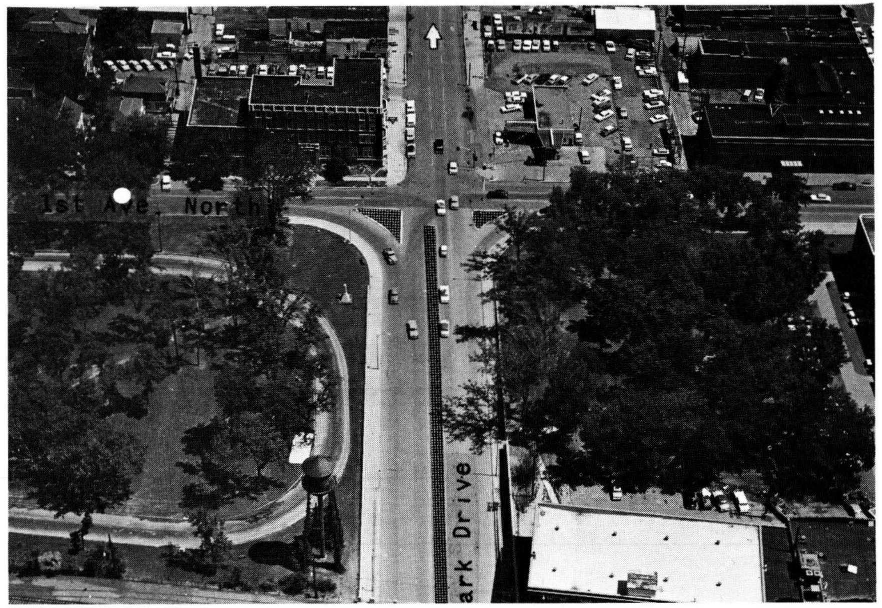
EXAMPLE Y-G, U S 27 - CITY STREET, ALEXANDRIA, KENTUCKY

OTHER TREATMENTS FR INTERSECTIONS



Submitted by: Henry M. DeNoble, City Traffic Engineer
Little Rock, Arkansas

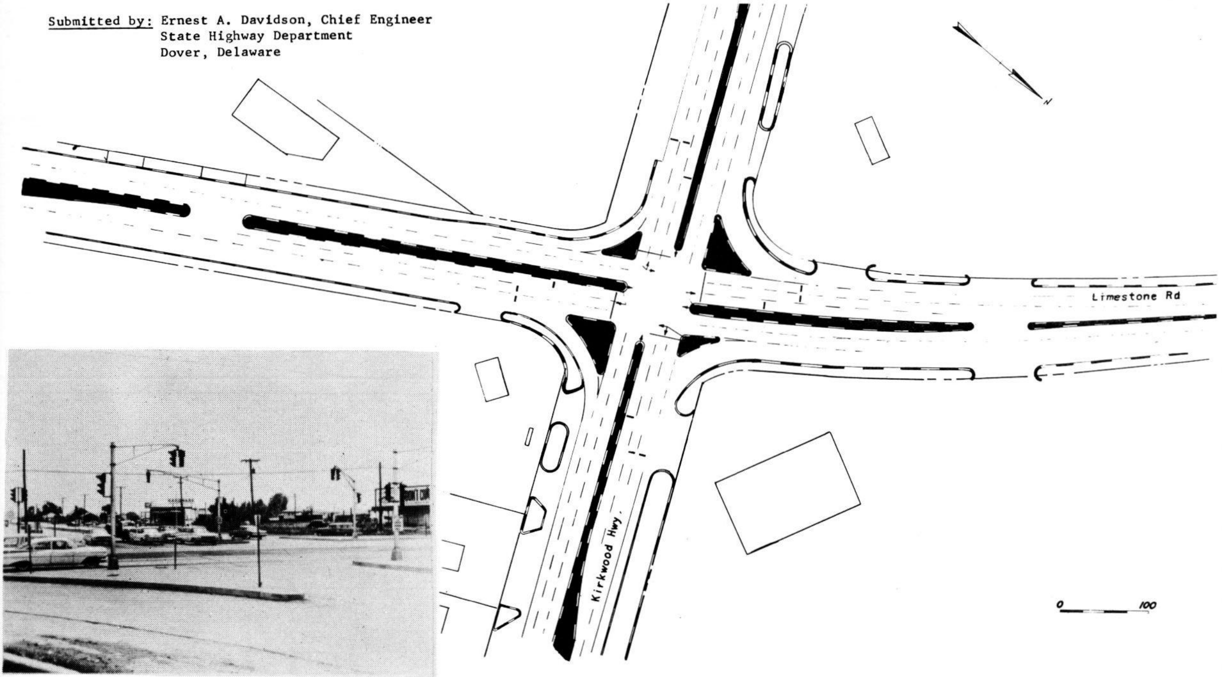
EXAMPLE FR-A, MARKHAM - UNIVERSITY, LITTLE ROCK, ARKANSAS



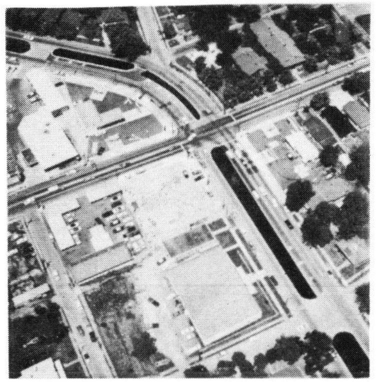
Submitted by: Maurice RiChey, Traffic Engineer
State Highway Department
Helena, Montana

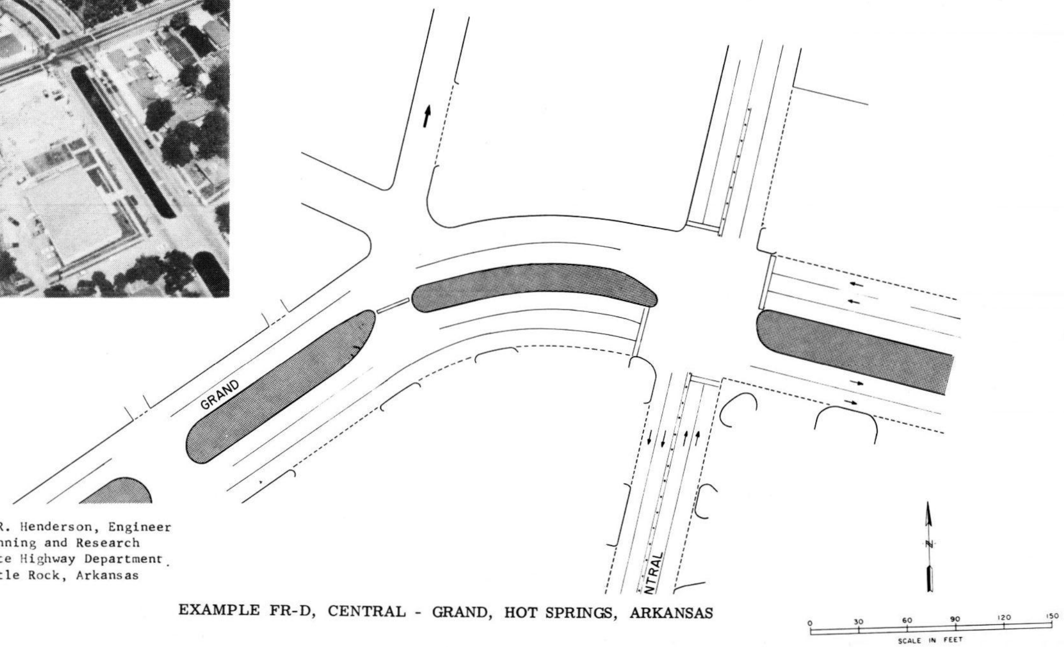
EXAMPLE FR-B, 1ST AVENUE NORTH - PARK DRIVE, GREAT FALLS, MONTANA

Submitted by: Ernest A. Davidson, Chief Engineer
State Highway Department
Dover, Delaware



EXAMPLE FR-C, LIMESTONE ROAD - KIRKWOOD HIGHWAY, WILMINGTON, DELAWARE

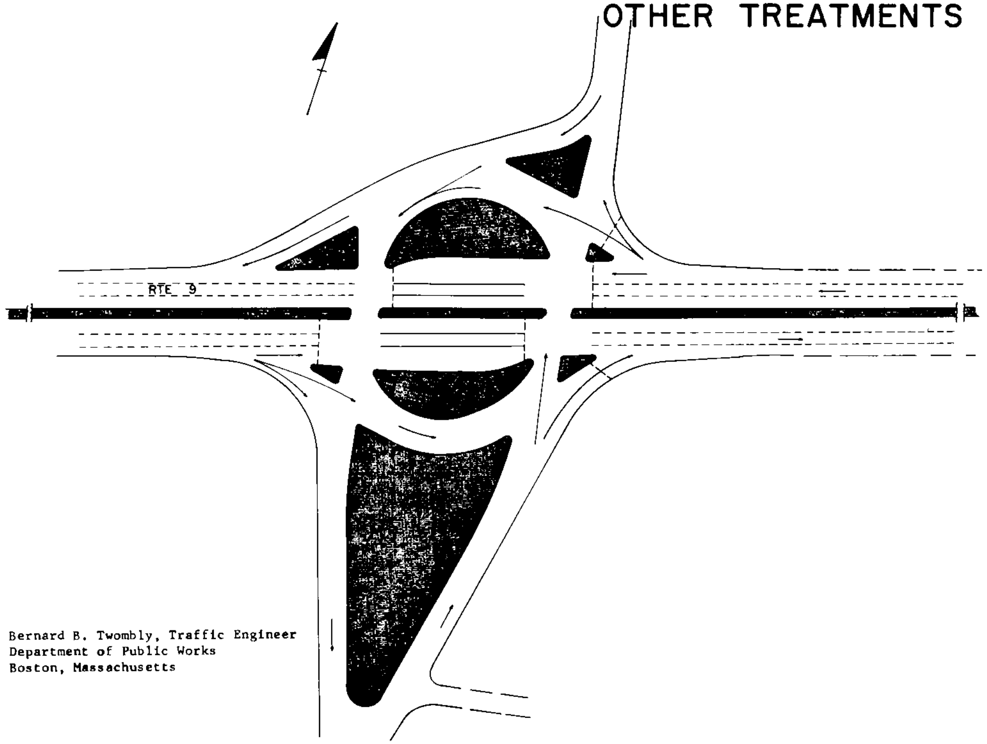




Submitted by: J. R. Henderson, Engineer
Planning and Research
State Highway Department
Little Rock, Arkansas

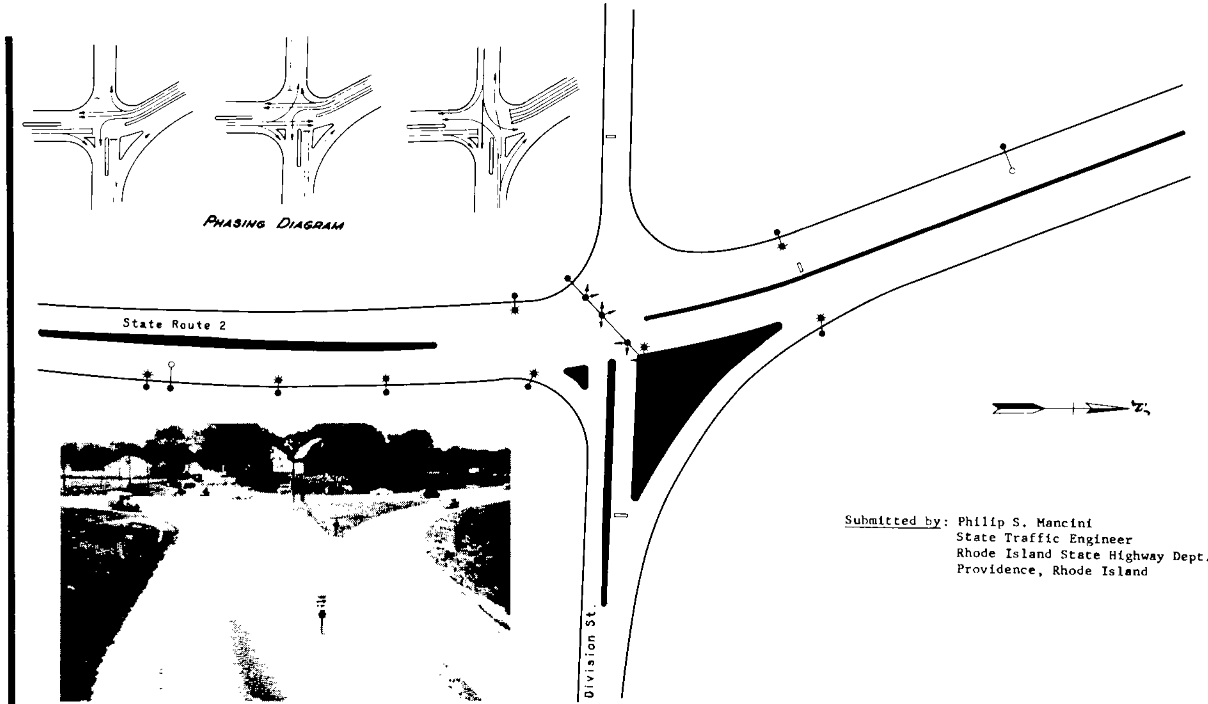
EXAMPLE FR-D, CENTRAL - GRAND, HOT SPRINGS, ARKANSAS

OTHER TREATMENTS FR INTERSECTIONS



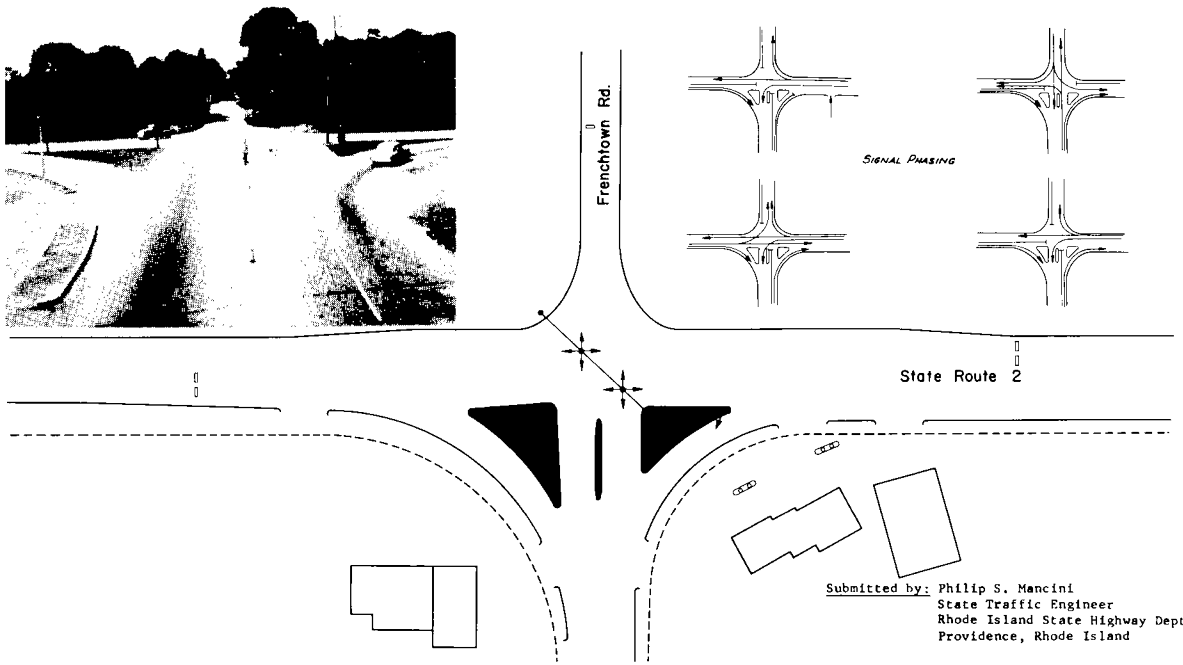
Submitted by: Bernard B. Twombly, Traffic Engineer
Department of Public Works
Boston, Massachusetts

EXAMPLE FR-E, ROUTE 9 - OAK STREET - RHODE ISLAND AVENUE - NATICK, MASSACHUSETTS



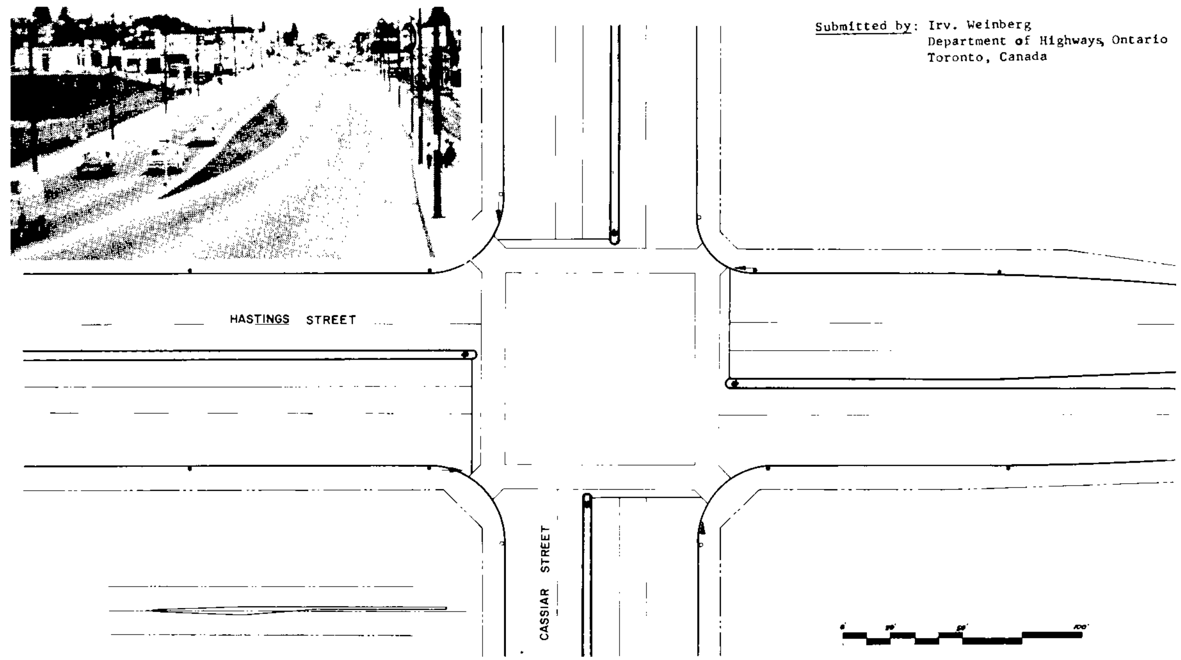
Submitted by: Philip S. Mancini
State Traffic Engineer
Rhode Island State Highway Dept.
Providence, Rhode Island

EXAMPLE FR-F, STATE ROUTE 2 - DIVISION STREET, PROVIDENCE, RHODE ISLAND



Submitted by: Philip S. Mancini
State Traffic Engineer
Rhode Island State Highway Dept.
Providence, Rhode Island

EXAMPLE FR-G, STATE ROUTE 2 - FRENCHTOWN ROAD, PROVIDENCE, RHODE ISLAND

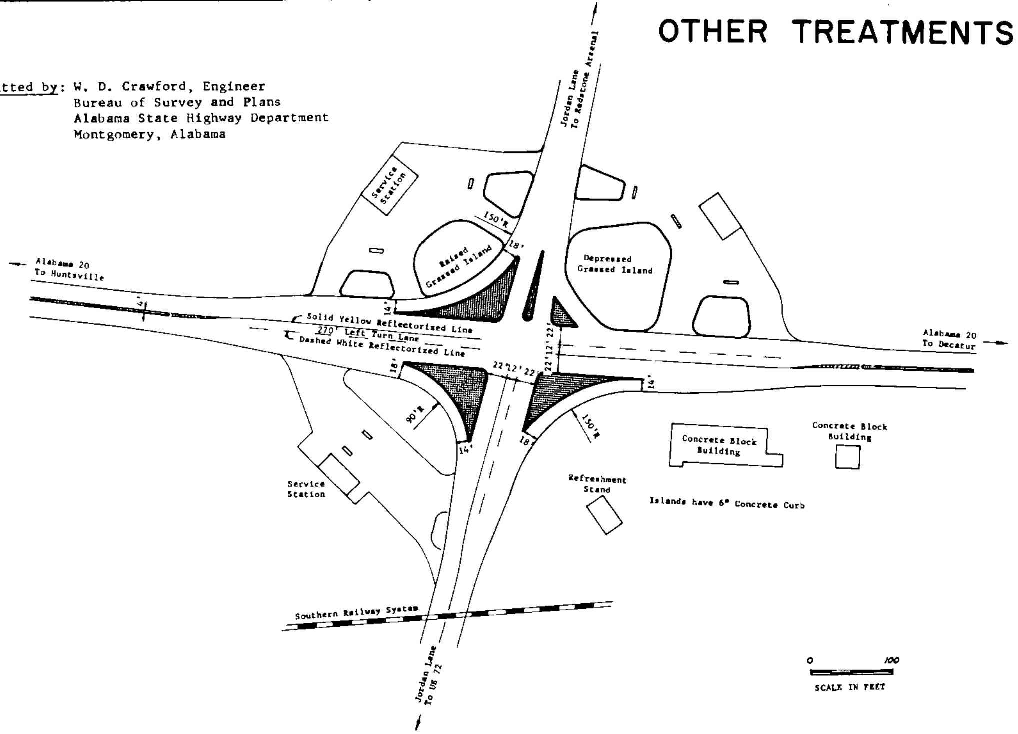


Submitted by: Irv. Weinberg
Department of Highways, Ontario
Toronto, Canada

EXAMPLE FR-H, CASSIAR STREET - HASTINGS STREET, VANCOUVER, BRITISH COLUMBIA, CANADA

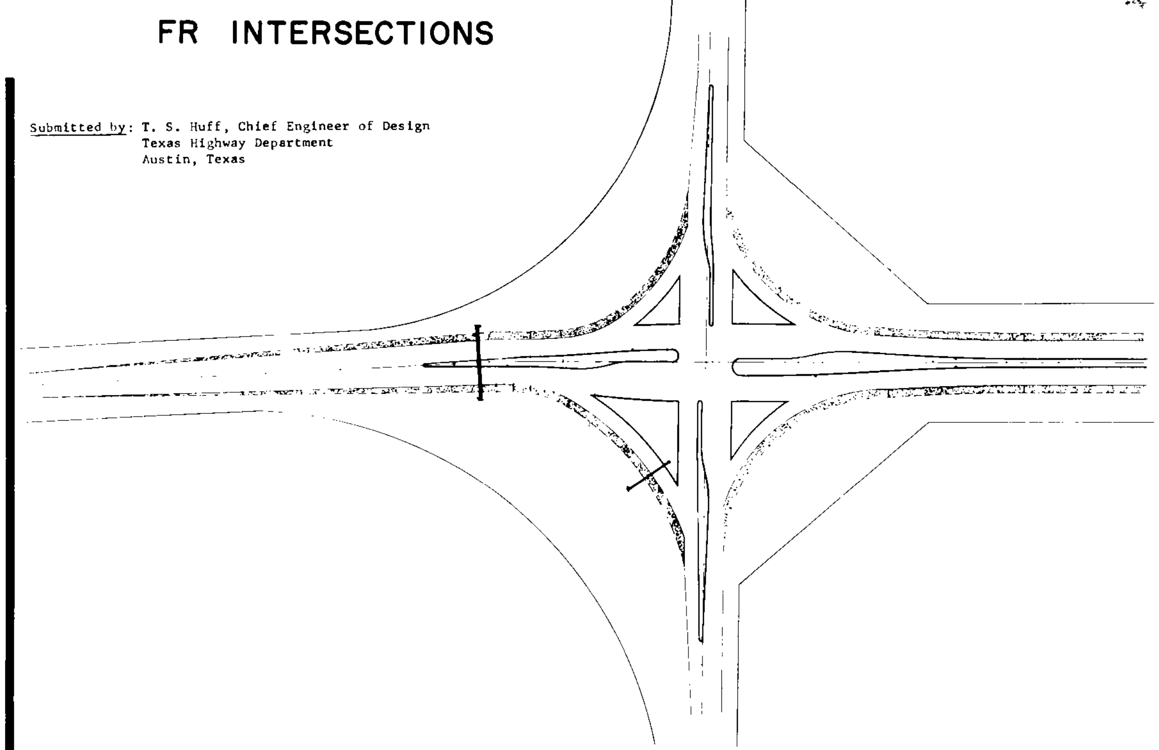
OTHER TREATMENTS FR INTERSECTIONS

Submitted by: W. D. Crawford, Engineer
Bureau of Survey and Plans
Alabama State Highway Department
Montgomery, Alabama

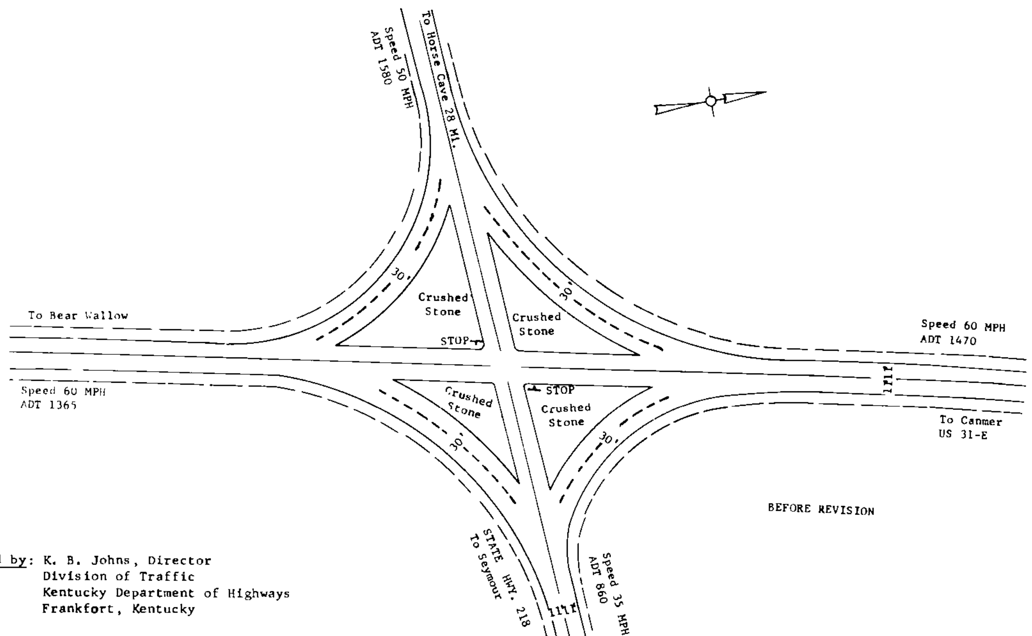


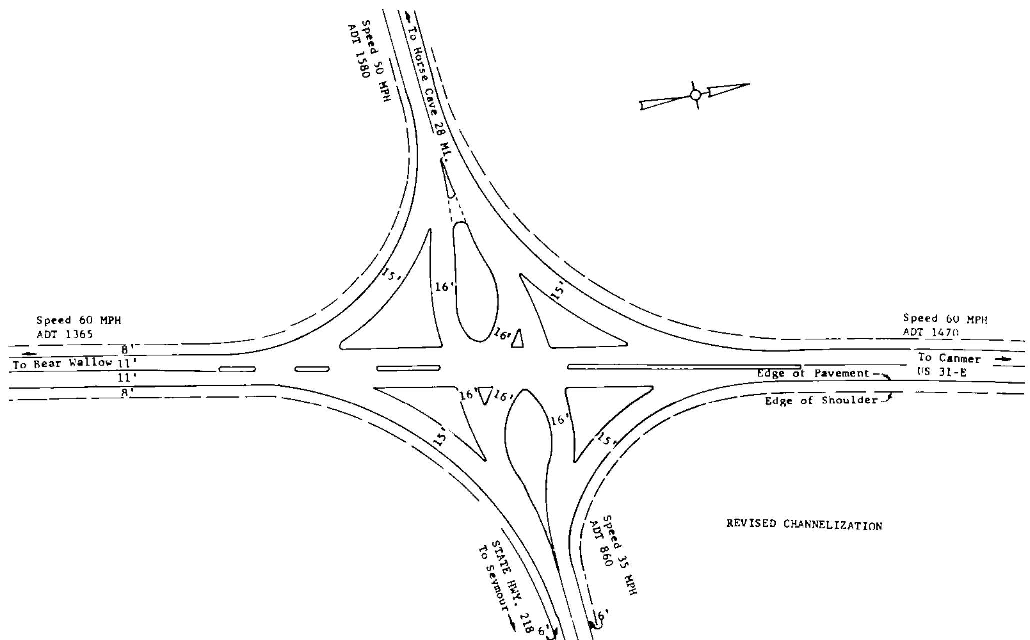
EXAMPLE FR-1, JORDAN LANE - ALABAMA 20, HUNTSVILLE, ALABAMA

Submitted by: T. S. Huff, Chief Engineer of Design
Texas Highway Department
Austin, Texas



EXAMPLE FR-J, TEXAS 95 - TEXAS 71 (LOOP 150), BASTROP COUNTY, TEXAS





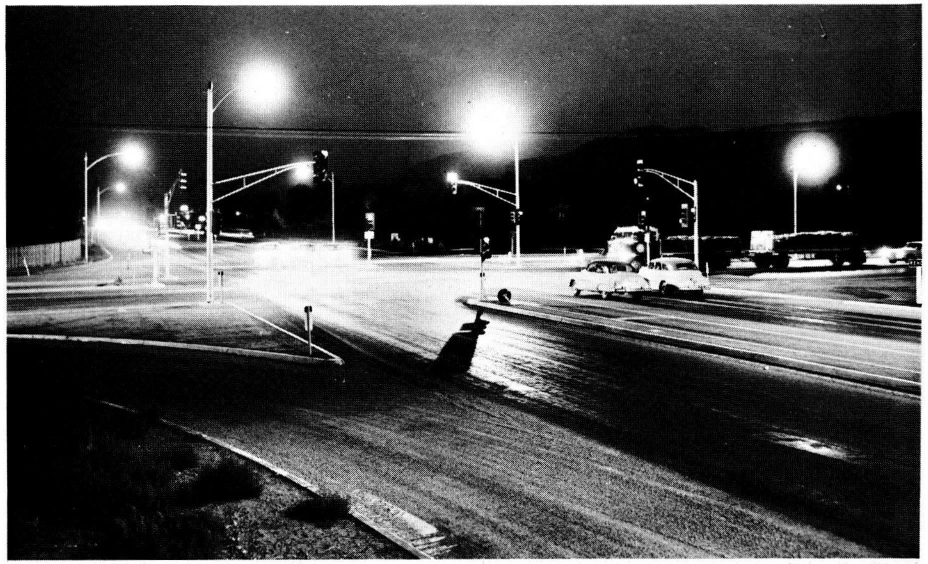
Submitted by: K. B. Johns, Director
Division of Traffic
Kentucky Department of Highways
Frankfort, Kentucky

EXAMPLE FR-K, U S 31 - KENTUCKY 218, HART COUNTY, KENTUCKY

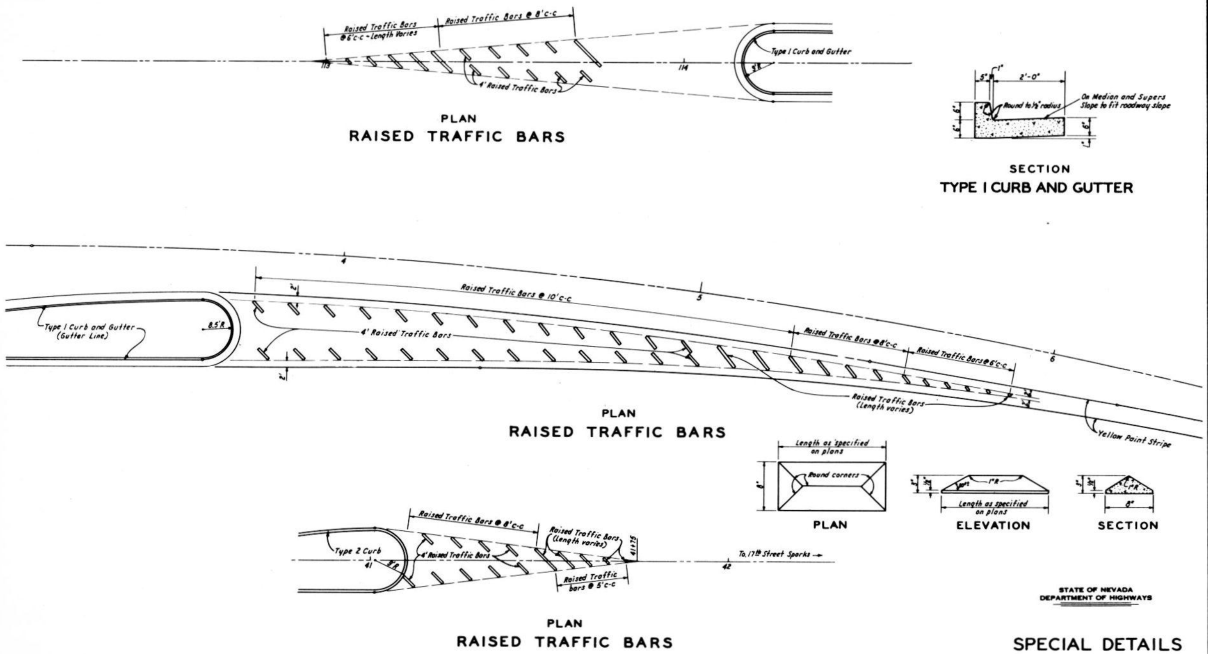
OTHER TREATMENTS FR INTERSECTIONS

Submitted by: Oren W. Walker, Chief Road Designer
Nevada State Highway Department
Carson City, Nevada

EXAMPLE FR-L, KIETZKE LANE - EAST SECOND STREET, RENO, NEVADA
SIGNAL INSTALLATION



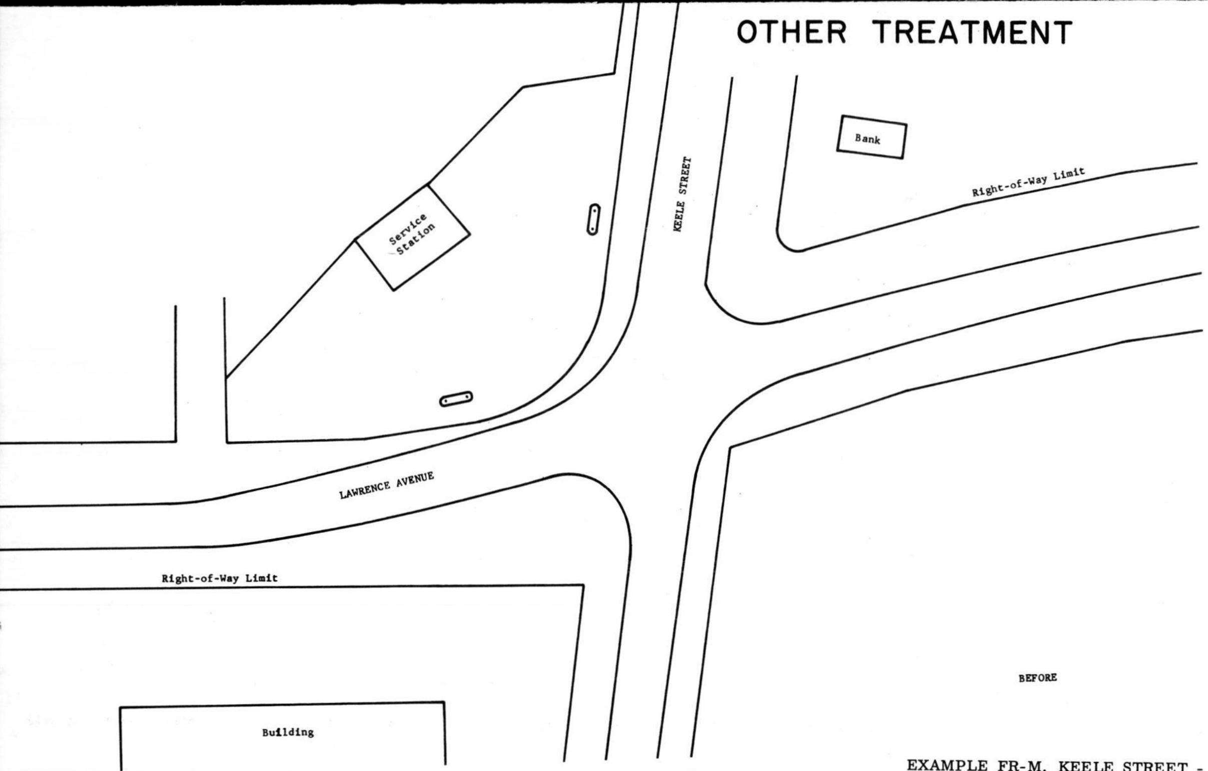
EXAMPLE FR-L, KIETZKE LANE - EAST SECOND STREET, RENO, NEVADA
ILLUMINATION



EXAMPLE FR-L, KIETZKE LANE - EAST SECOND STREET, RENO, NEVADA
DELINEATION

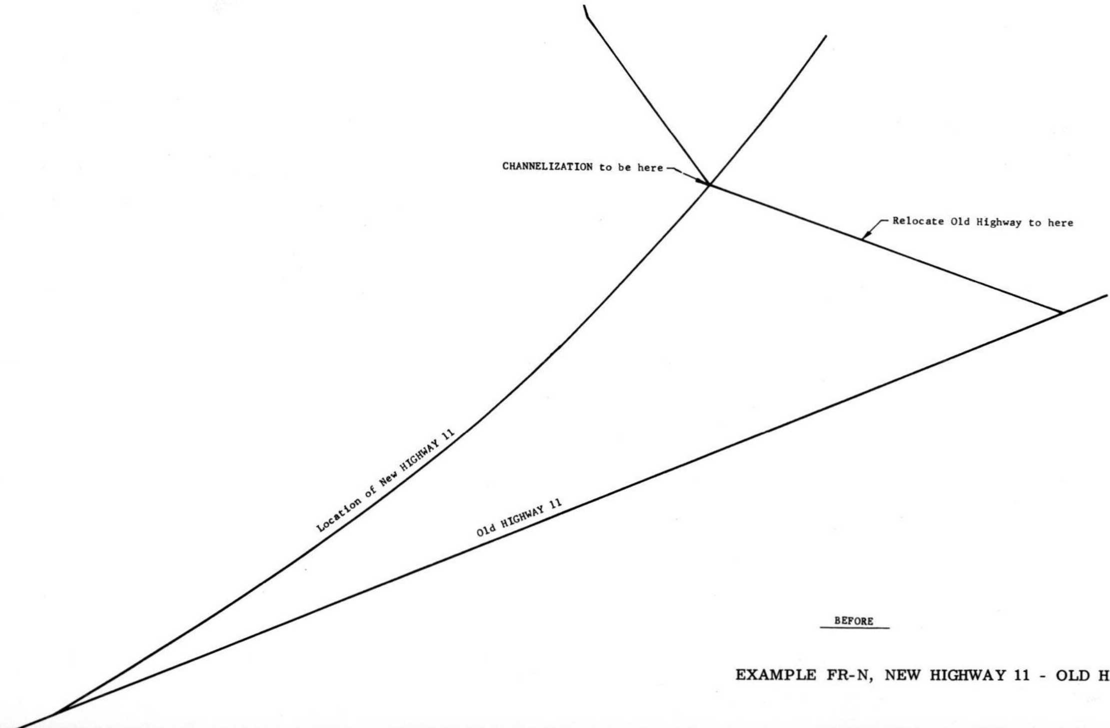
EXAMPLE FR-L, KIETZKE LANE - EAST SECOND STREET, RENO, NEVADA
AERIAL VIEW OF TREATMENT

OTHER TREATMENT FR INTERSECTIONS

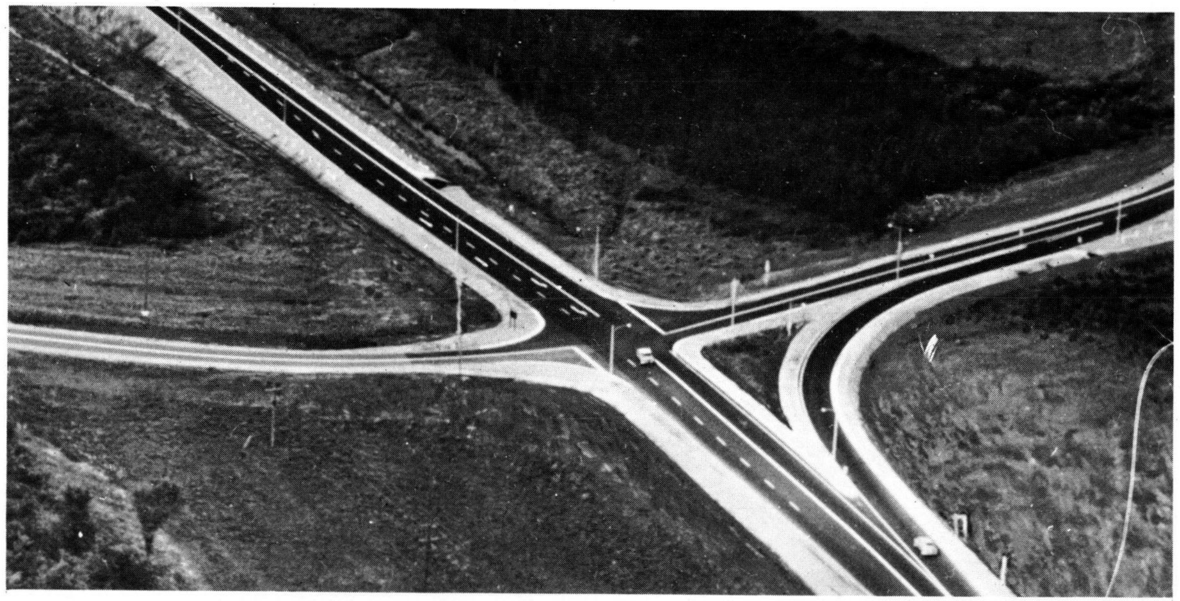


Submitted by: Irv. Weinberg
Department of Highways, Ontario
Toronto, Canada

EXAMPLE FR-M, KEELE STREET - LAWRENCE AVENUE, TORONTO, CANADA

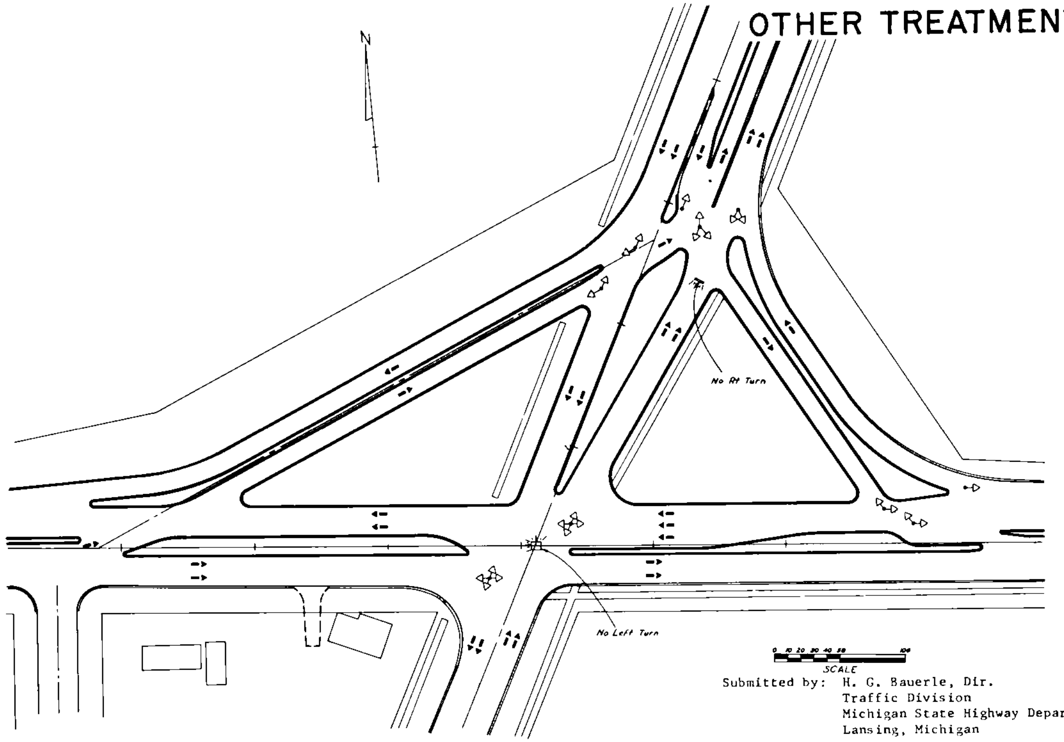


Submitted by: Irv. Weinberg
Department of Highways, Ontario
Toronto, Canada



EXAMPLE FR-N, NEW HIGHWAY 11 - OLD HIGHWAY 11 RELOCATION, NEAR HUNTSVILLE, CANADA

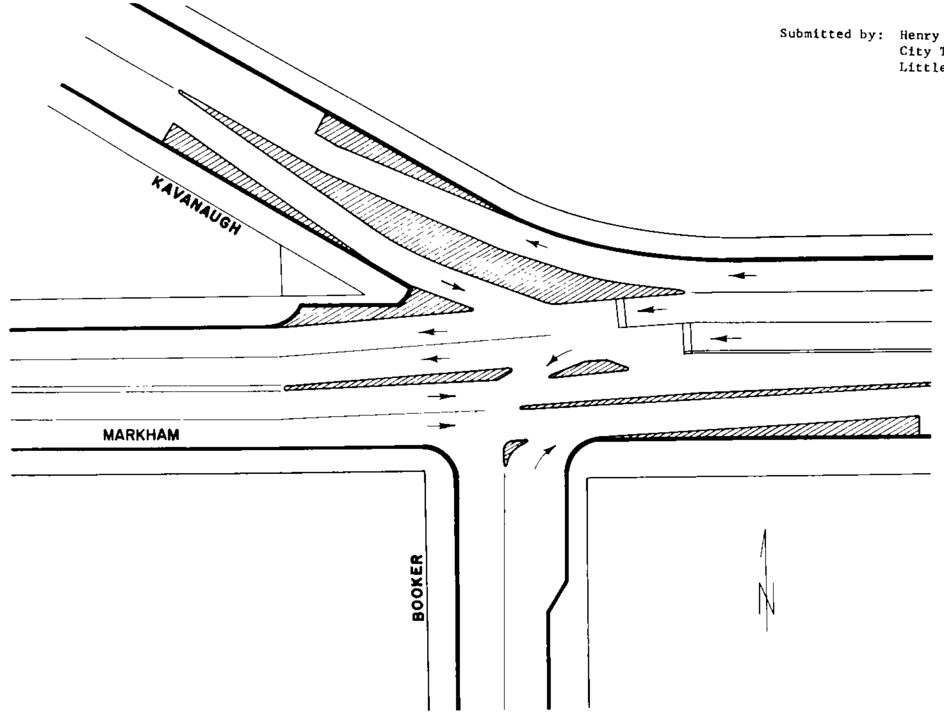
OTHER TREATMENTS FO INTERSECTIONS



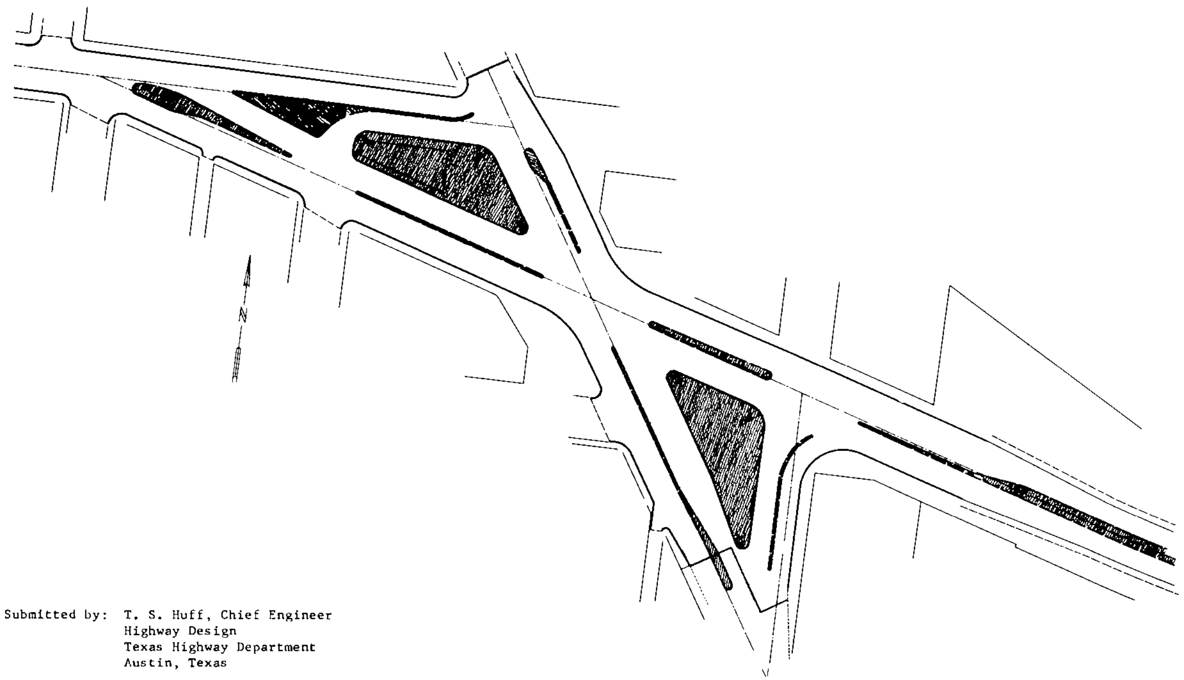
Submitted by: H. G. Bauerle, Dir.
Traffic Division
Michigan State Highway Department
Lansing, Michigan

EXAMPLE FO-A, WASHINGTON AVE. - RUST STREET, SAGINAW, MICHIGAN

Submitted by: Henry M. DeNoble
City Traffic Engineer
Little Rock, Arkansas

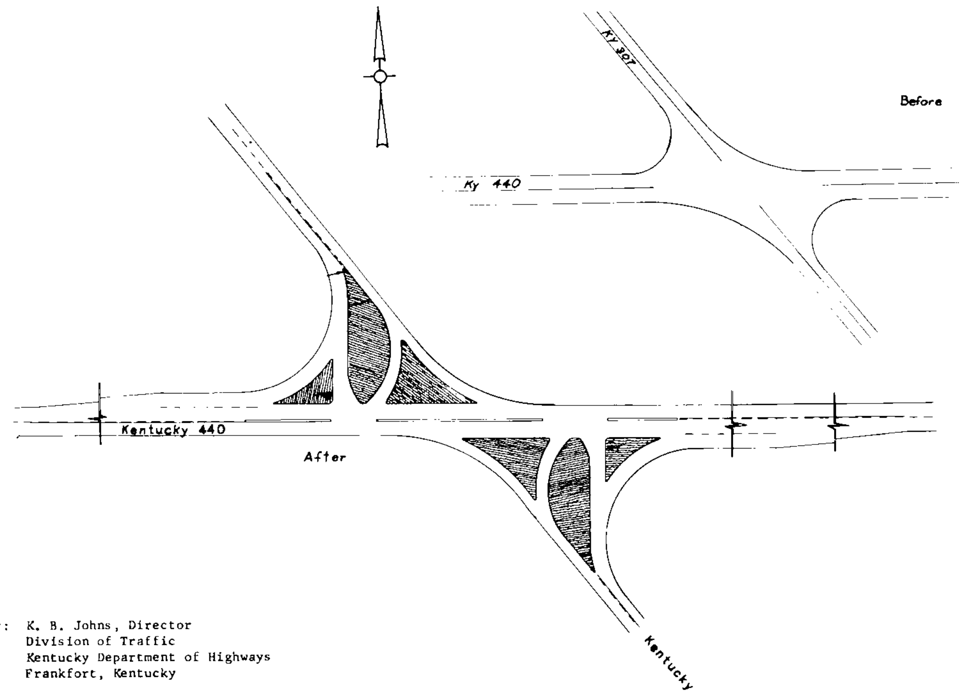


EXAMPLE FO-B, MARKHAM - KAVANAUGH - BOOKER, LITTLE ROCK, ARKANSAS



Submitted by: T. S. Huff, Chief Engineer
Highway Design
Texas Highway Department
Austin, Texas

EXAMPLE FO-C, U.S. 82 - U.S. 87, LUBBOCK COUNTY, TEXAS

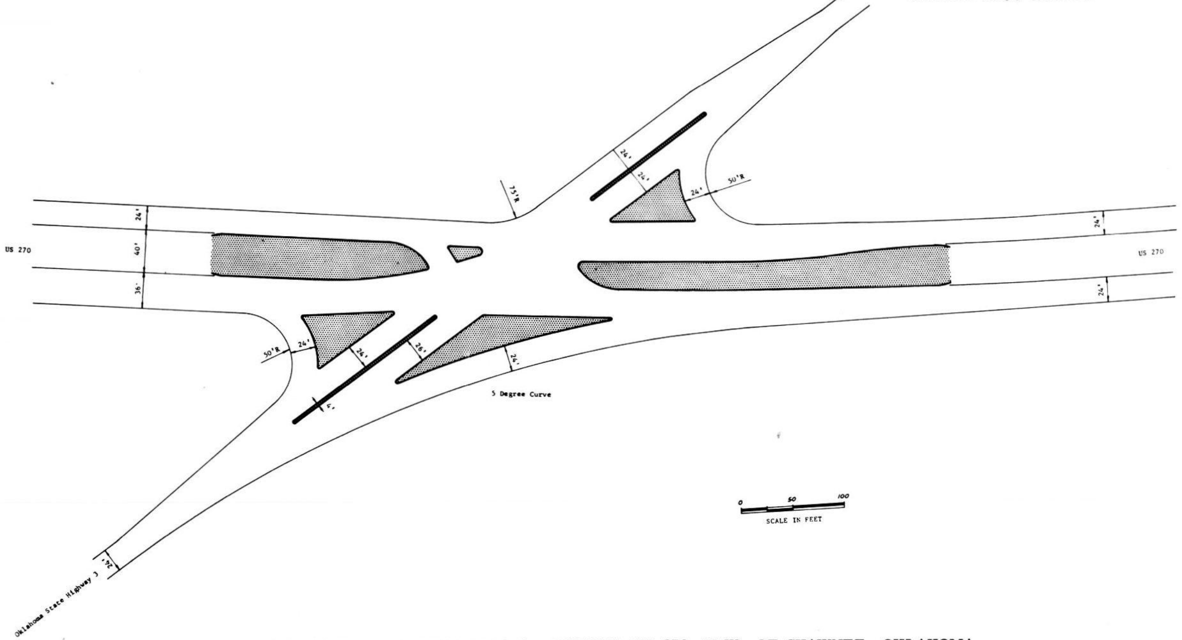


Submitted by: K. B. Johns, Director
Division of Traffic
Kentucky Department of Highways
Frankfort, Kentucky

EXAMPLE FO-D, KENTUCKY 440, KENTUCKY 307, CARLISLE COUNTY, KENTUCKY

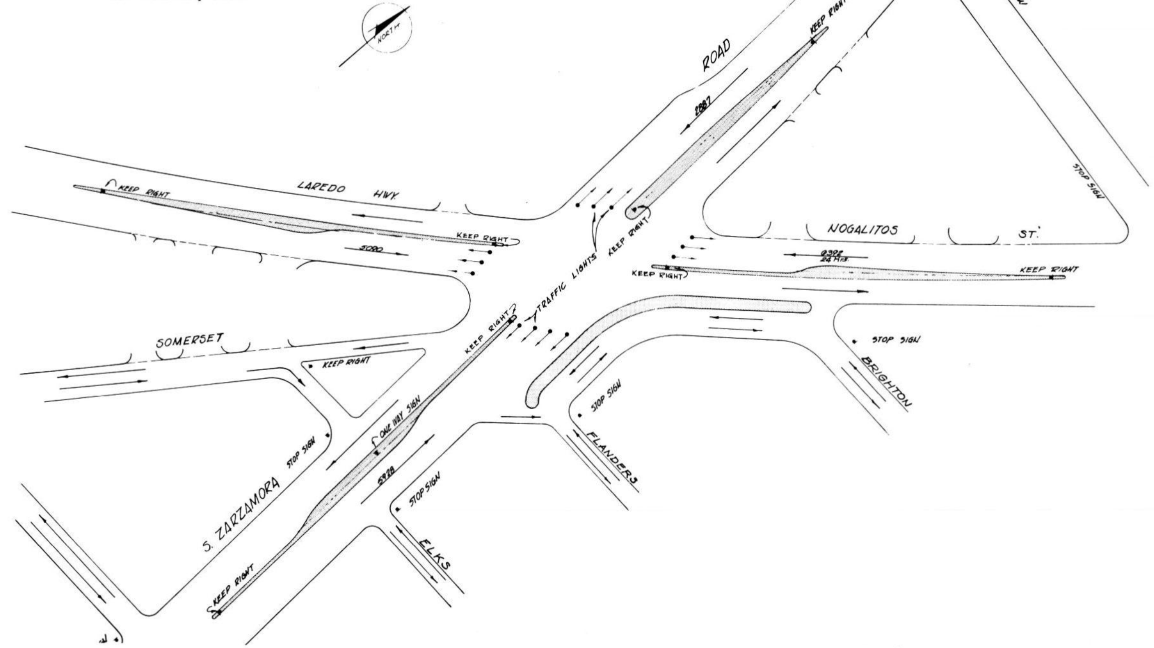
OTHER TREATMENTS

Submitted by: G. H. Bittle, Chief Engineer
Oklahoma Department of Highways
Oklahoma City, Oklahoma



EXAMPLE FO-E, OKLAHOMA 3 - FUTURE U S 270, N.W. OF SHAWNEE, OKLAHOMA

Submitted by: Stewart Fischer, City Traffic Engineer
San Antonio, Texas



EXAMPLE FO-F, NOGALITOS STREET - LAREDO HIGHWAY - ZARZAMORA ROAD, SAN ANTONIO, TEXAS

Submitted by: Irv. Weinberg
Department of Highways, Ontario
Toronto, Canada

EXAMPLE Y-H, TORONTO, CANADA

Submitted by: Irv. Weinberg
Department of Highways, Ontario
Toronto, Canada

EXAMPLE T-E, HIGHWAY 27 - HIGHWAY 2, TORONTO, CANADA

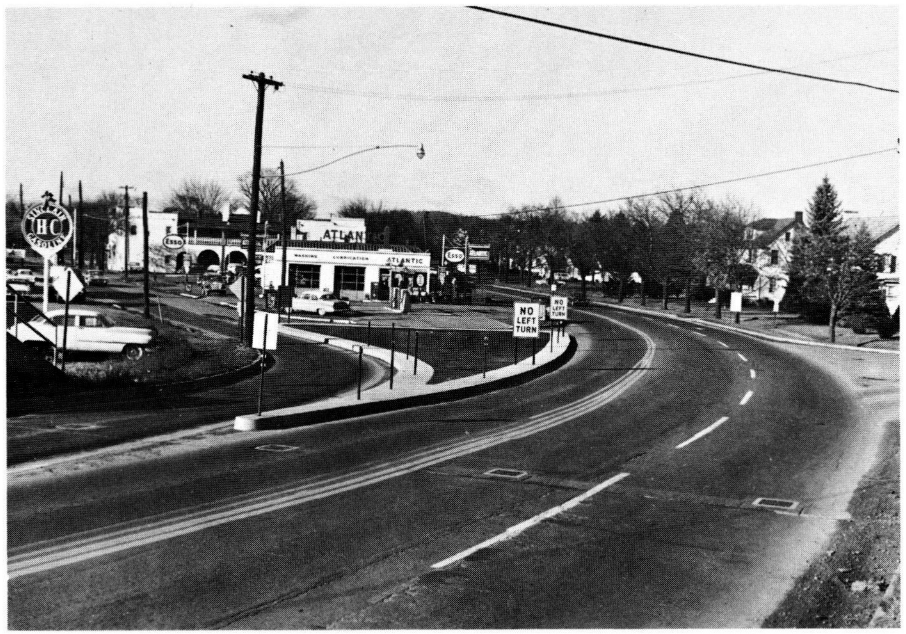
OTHER TREATMENTS FO INTERSECTION

EXAMPLE FO-G, E. THIRD STREET - WASHINGTON BOULEVARD - FAXON PARKWAY
LOYALSOCK TOWNSHIP, LYCOMING COUNTY, PENNSYLVANIA

Submitted by: Edmund R. Ricker, Director
Bureau of Traffic
Pennsylvania Department of Highways
Harrisburg, Pennsylvania

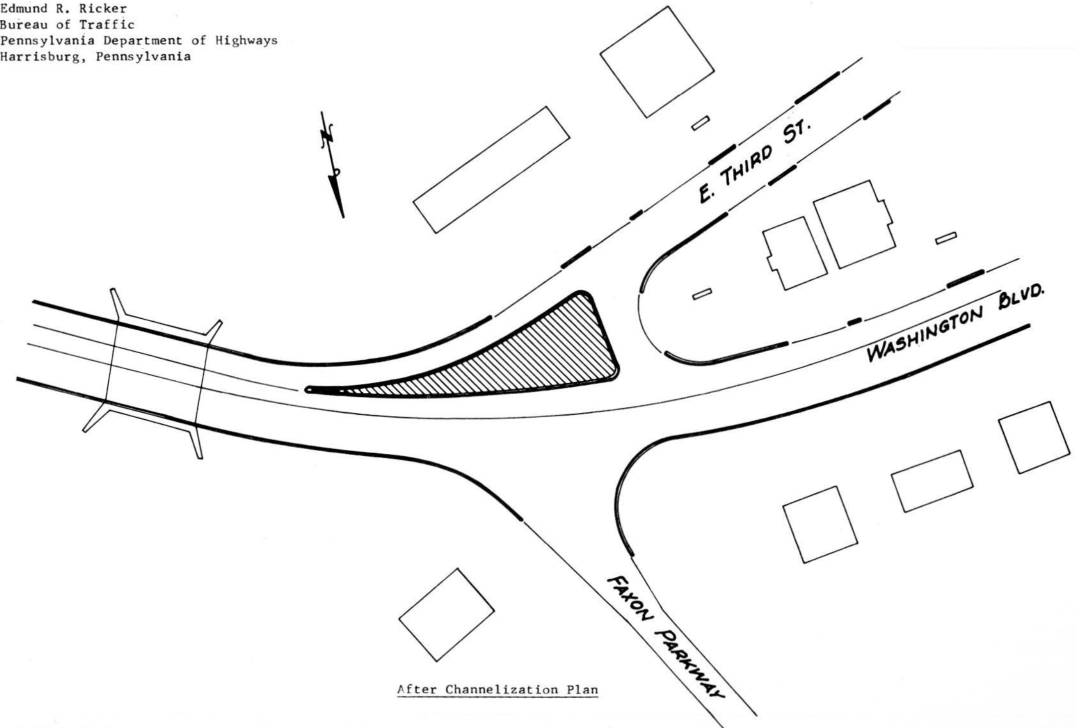
During Temporary Channelization
Looking Westbound

During Temporary Channelization
Looking Eastbound from Third Street Approach



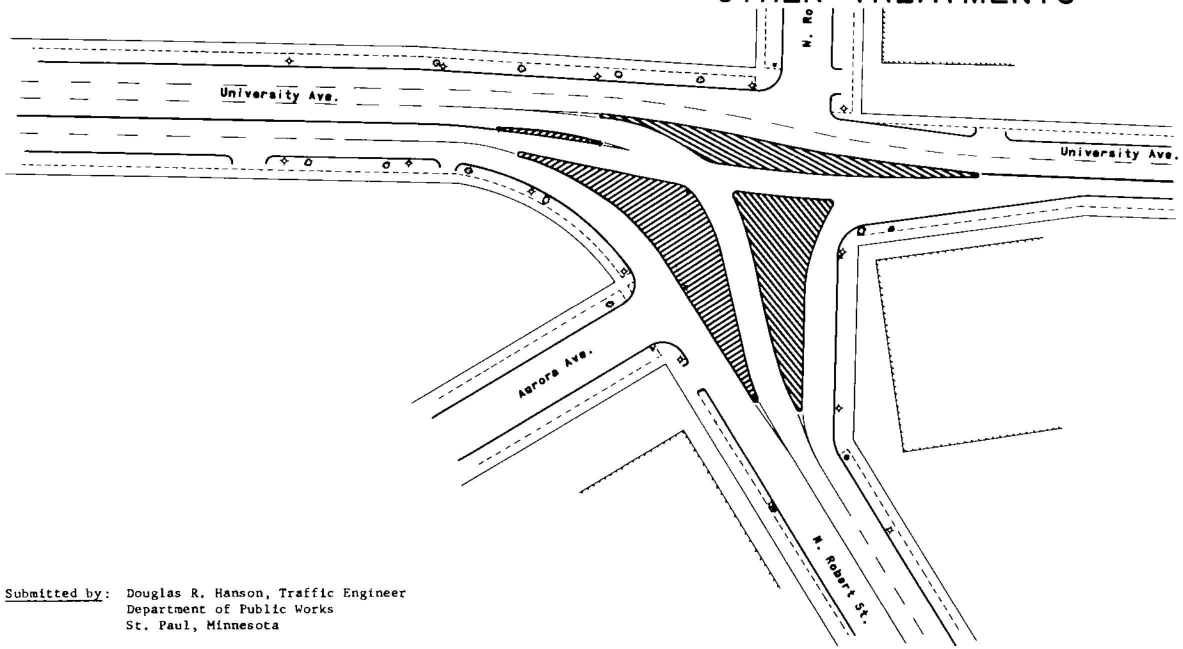
After Permanent Channelization
Looking Westbound

Submitted by: Edmund R. Ricker
Bureau of Traffic
Pennsylvania Department of Highways
Harrisburg, Pennsylvania



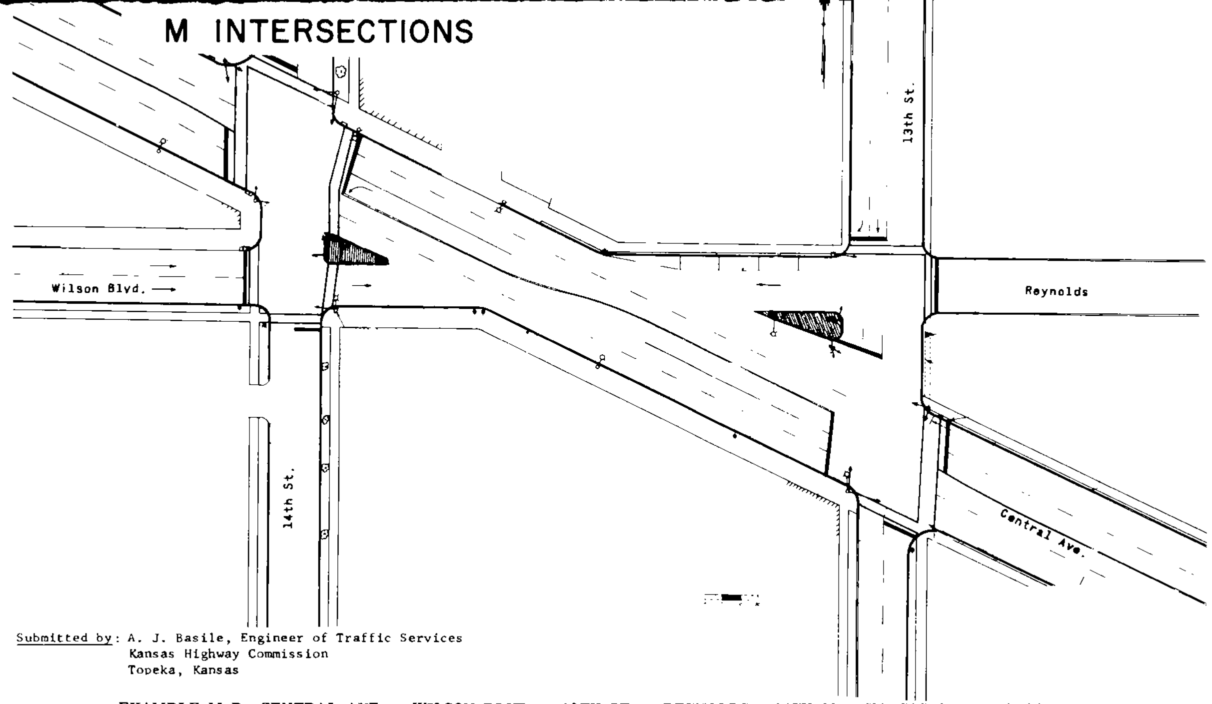
After Channelization Plan

OTHER TREATMENTS M INTERSECTIONS



Submitted by: Douglas R. Hanson, Traffic Engineer
Department of Public Works
St. Paul, Minnesota

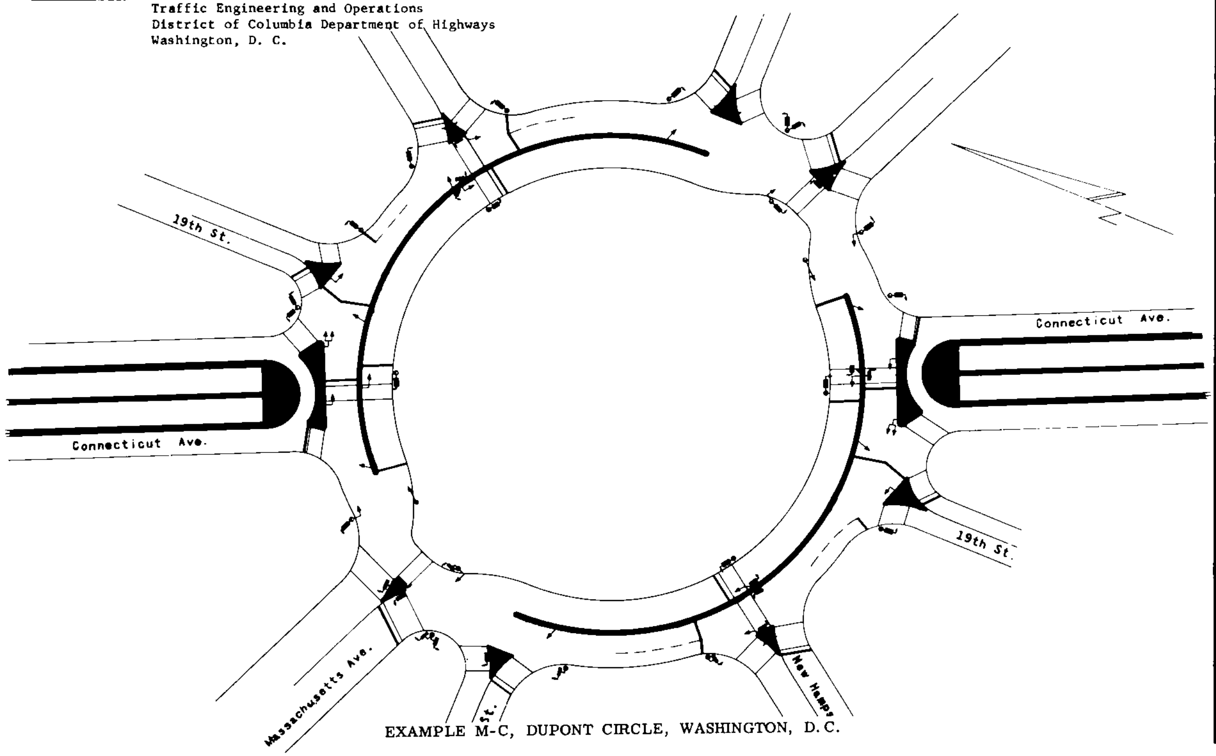
EXAMPLE M-A, UNIVERSITY AVENUE - ROBERT STREET - AURORA AVENUE, ST. PAUL, MINNESOTA



Submitted by: A. J. Basile, Engineer of Traffic Services
Kansas Highway Commission
Topeka, Kansas

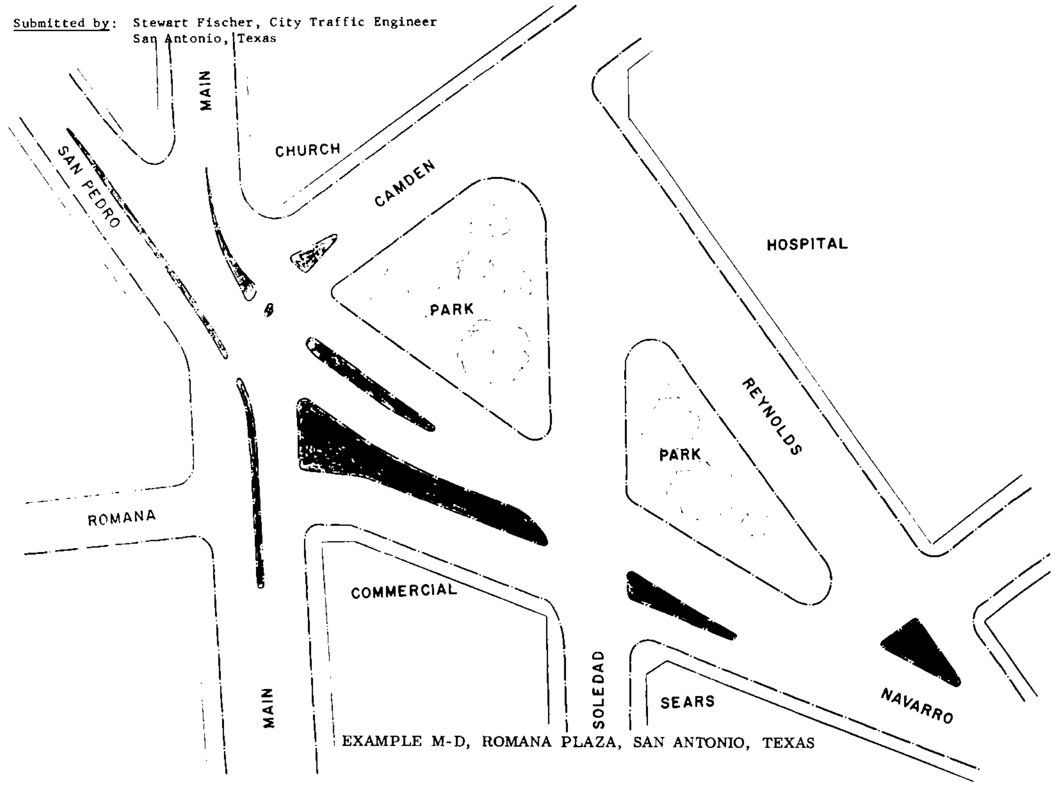
EXAMPLE M-B, CENTRAL AVE. - WILSON BLVD. - 13TH ST. - REYNOLDS - 14TH ST., KANSAS CITY, KANSAS

Submitted by: Francis E. Twiss, Deputy Director
Traffic Engineering and Operations
District of Columbia Department of Highways
Washington, D. C.



EXAMPLE M-C, DUPONT CIRCLE, WASHINGTON, D.C.

Submitted by: Stewart Fischer, City Traffic Engineer
San Antonio, Texas

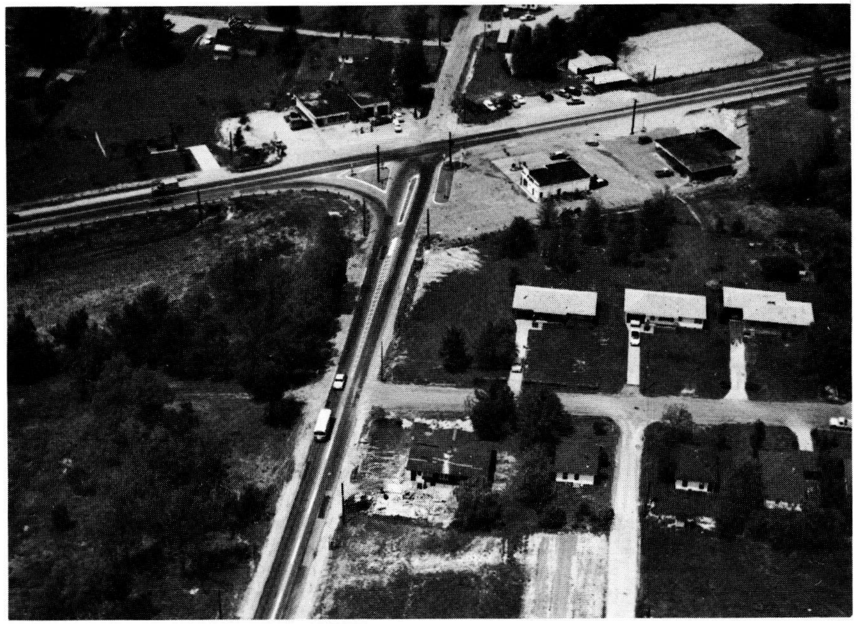


EXAMPLE M-D, ROMANA PLAZA, SAN ANTONIO, TEXAS

APPROACH-END TREATMENTS

NOTE: Figure 3 of Example T-7 illustrates the application of large jiggle bars in approach-end treatment.

Submitted by: J. R. Henderson, Planning and Research Engineer
Arkansas State Highway Department
Little Rock, Arkansas



EXAMPLE AE-A, CARAWAY ROAD - JOHNSON STREET, (ARKANSAS 173) - (ARKANSAS 1), JONESBORO, ARKANSAS

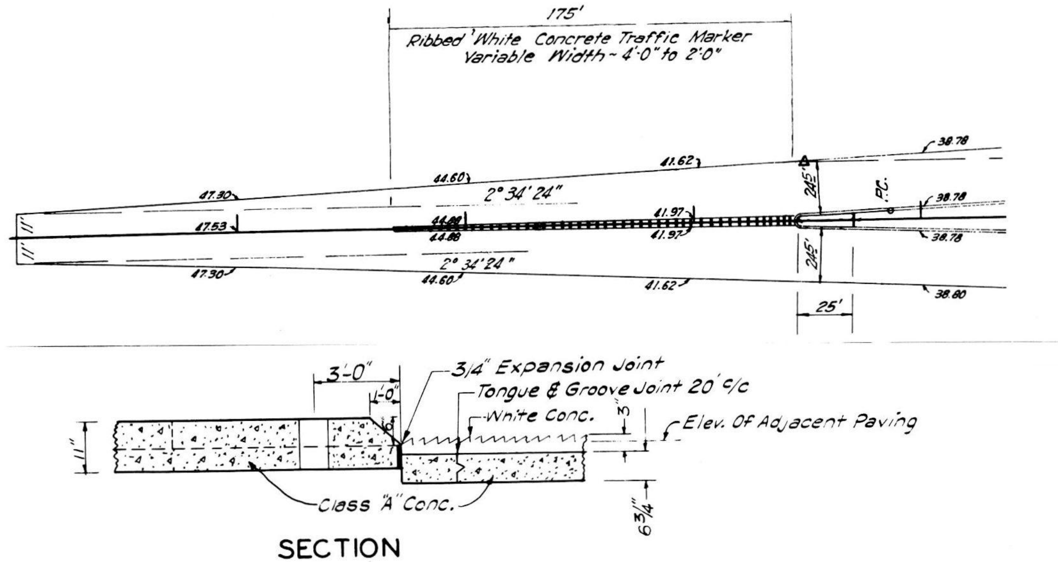
Submitted by: David S. Johnson, Jr., Director
Bureau of Planning and Design
Connecticut State Highway Department
Hartford, Connecticut

EXAMPLE AE-B, U S 44 - U S 44A, ASHFORD, CONNECTICUT

Submitted by: M. K. Lingle, Engineer of Traffic
Illinois Division of Highways
Springfield, Illinois

EXAMPLE AE-C, ROUTE 16 - ROUTE 9, NEAR ASHMORE, COLES COUNTY, ILLINOIS

Submitted by: G. H. Bittle, Chief Engineer
Oklahoma Department of Highways
Oklahoma City, Oklahoma



ILLUSTRATING WHITE CONCRETE USED FOR JIGGLE BARS
TO FOREWARN DRIVERS OF DIVISIONAL ISLAND

EXAMPLE AE-D, OKLAHOMA 29 - OKLAHOMA 76, SOUTH OF LINDSAY, OKLAHOMA

Appendix

Templates for Turning Paths of

Design Vehicles

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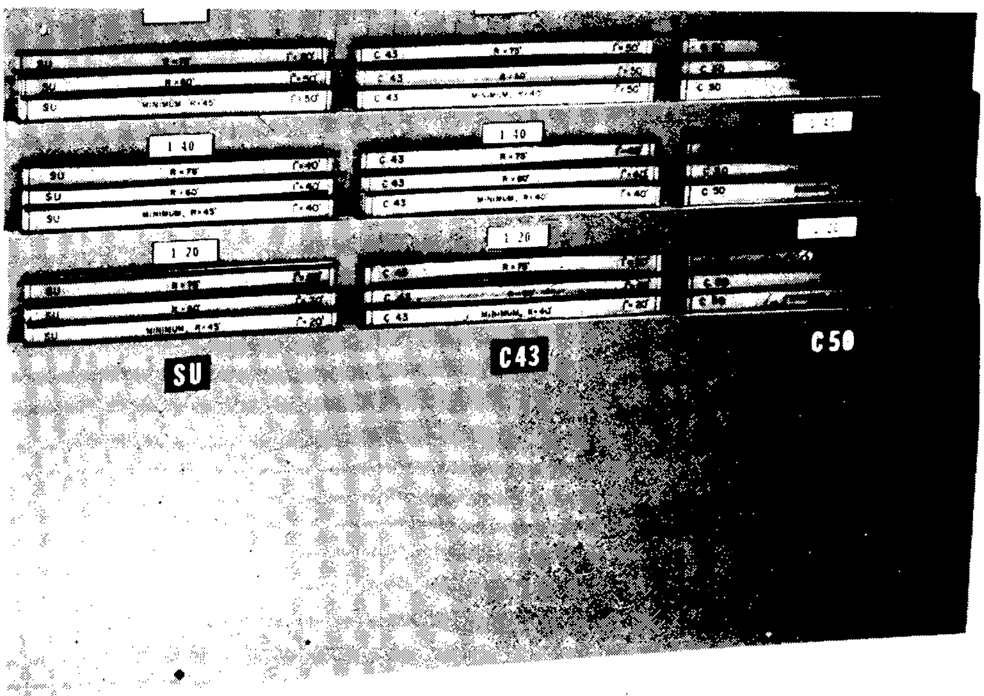
Introduction

The use of "design vehicles," as established by the American Association of State Highway Officials, has provided a way for proper design of highway intersections and certain ramp terminals at interchanges. Criteria for layout of intersection curves, turning roadways, and interchange ramps--based on the turning characteristics of these vehicles--are now included in the "rural" and "urban" policies of the Association.

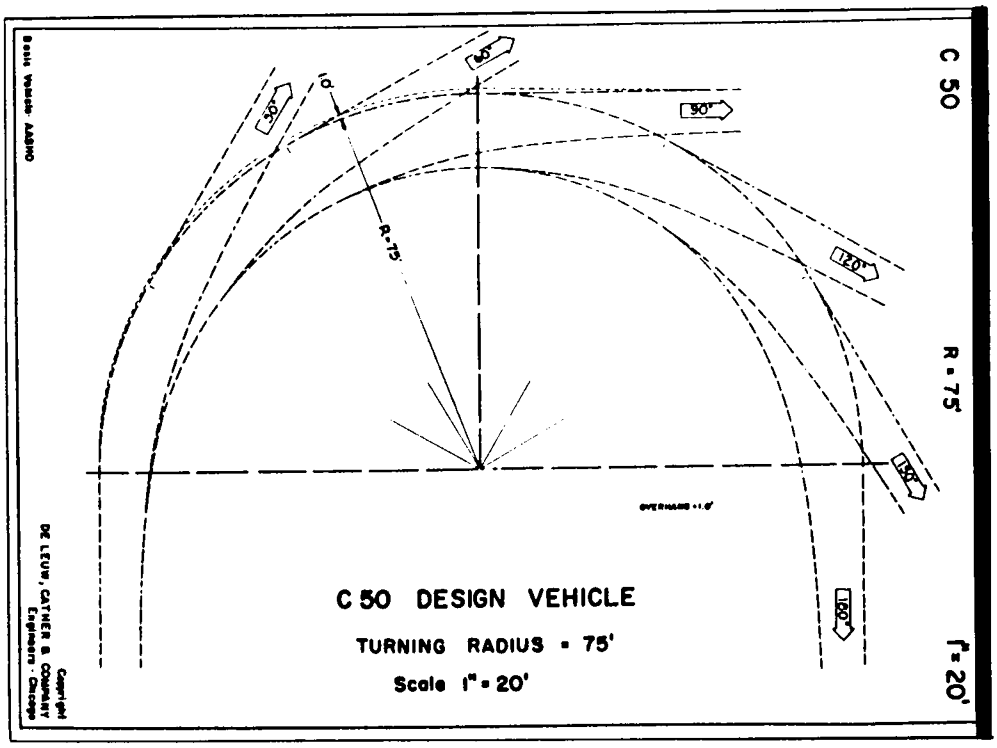
To encourage the application of these data and to greatly facilitate the layout of intersections, a set of templates for turning vehicle paths has been developed. The set, illustrated below, consisting of 27 transparencies, pro-



Set of Templates in Wall Box

vides for a variety of design conditions, including three types of trucks, * three turning radii, and three scales. Trucks represented are the SU--single-unit; C43--intermediate semitrailer combination; and C50--large semitrailer combination. Turning radii, described by the outer-front wheel, are 45 feet (or less), 60 feet, and 75 feet.** Scales used to fit the usual range and size of layouts are 1" = 50', 1" = 40', and 1" = 20'. Each transparency includes paths for a variety of turning angles, viz., 30, 60, 90, 120, 150, and 180 degrees.

The templates may be used (1) in review and check of intersection plans, or (2) in design of intersections. In the former, appropriate templates laid over the plan and the superimposed vehicle paths properly positioned indicate whether or not the layout is proper and what adjustment may be necessary. In the latter case, the appropriate templates are laid over a skeleton or base of the intersection plan; and the wheel paths, when located in a desired position, are transferred to the layout. The design is then sketched in, fitting these paths. The transfer of the turning paths is made by placing pencil dots through the perforations provided on the templates. By manipulation of the template, the center hole permits the paths to be adapted to any odd angle of turn.



Typical Template

* See "A Policy on Geometric Design of Rural Highways," pages 429 and 432.

** The 45-foot turning radius is the minimum for the SU vehicle; for the C43 and C50 vehicles, minimum radii are 40 and 44 feet, respectively. Minimum turning radii, or near-minimum (60 to 75 feet), are normally employed in intersection design.

Illustrative Problem

The technique in the use of these templates is demonstrated in the following design problem, shown in the sequence of Figures 1 to 6.

The basic condition of the intersection is illustrated in Figure 1, in which a divisional island, about eight feet in width, is to be introduced on the intercepted road, and a small directional (triangular) island introduced in the acute-angle quadrant. A complete layout is to be established, including the position and shape of the median opening.

With the approximate position of the divisional island assumed, left-turning paths are next established by placing the template in desired position and making pencil dots through perforations, as in Figure 2, thus transferring the wheel paths to the drawing. Minimum paths (red-band templates) usually apply to acute-angle turns while the larger turning radii, of 65 and 75 feet (green- and blue-band templates) generally apply to obtuse-angle turns. Right turning paths are shown on the front of the template (arrow showing direction of travel). The same templates apply to left-turning movements by using the reverse side.

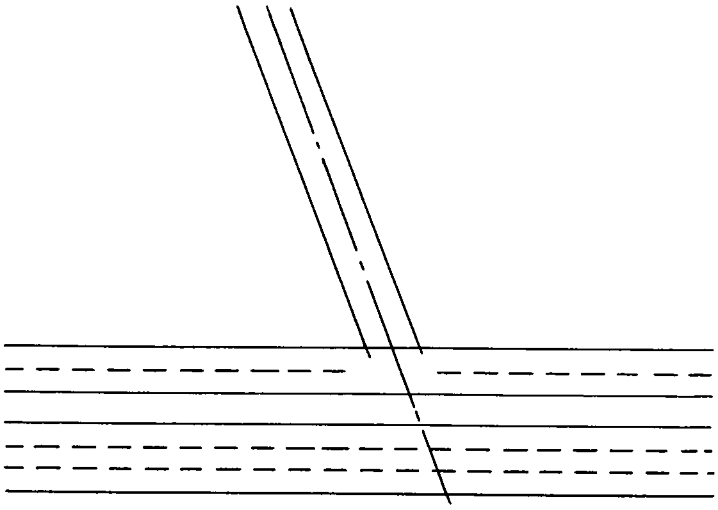


Figure 1.

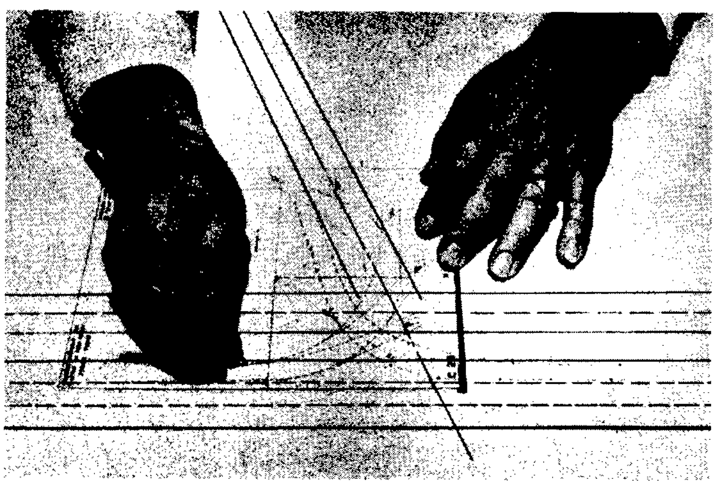


Figure 2.

In Figure 3 the two left turns, by the method described above, have been transferred to the plan and shown by dotted lines.

At this point, the median opening and the crossroad divisional island are sketched in fitting the left-turning paths, as shown in

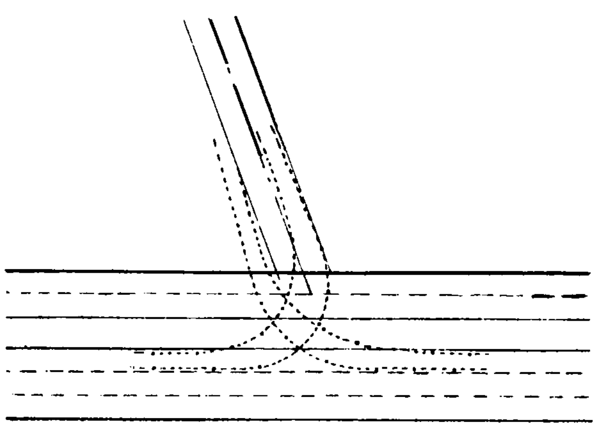


Figure 3.

Figure 4. Normally, the edges of pavements and islands are set at 3 to 4 feet outside the wheel paths. Approach noses of islands, however, are offset several feet more.

The right-turning paths, Figure 4, are added to the plan, by the use of the templates, and the remainder of the plan is sketched in, Figure 5. The plan is completed, as shown in Figure 6, by refining the layout and, where appropriate, fitting calculated lines to it.

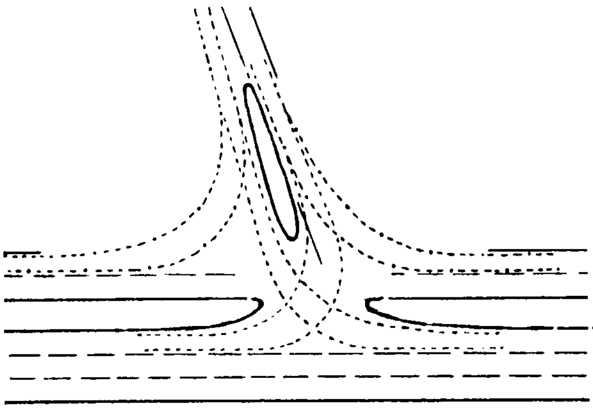


Figure 4.

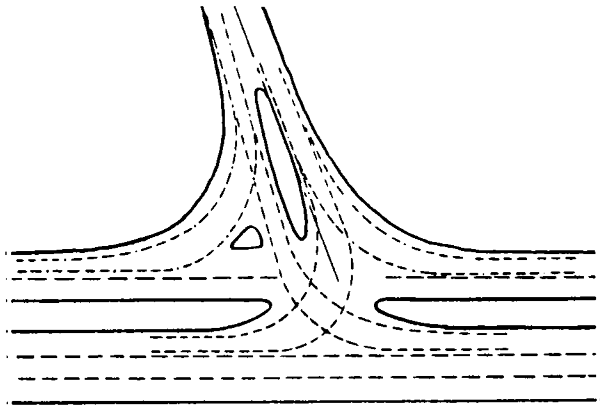


Figure 5.

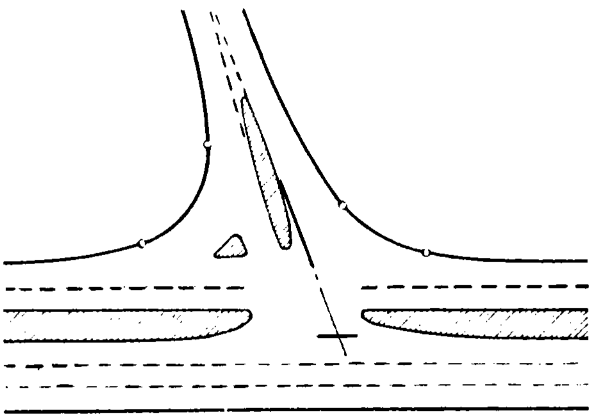


Figure 6.

Use of Templates for Odd Angles of Turn

In cases where the paths, as shown for each 30-degree increment, do not fit the angles of intersection on the plan closely enough, the template can be manipulated to produce a turning path for any angle of intersection.

Consider the example discussed above, in which the angle of intersection is 68 degrees, and the angle of left turn, therefore, 112 degrees. Thus, the desired path is between the 90- and 120-degree angles available on the template; these are the stippled or shaded paths indicated in Figures 7 and 8.

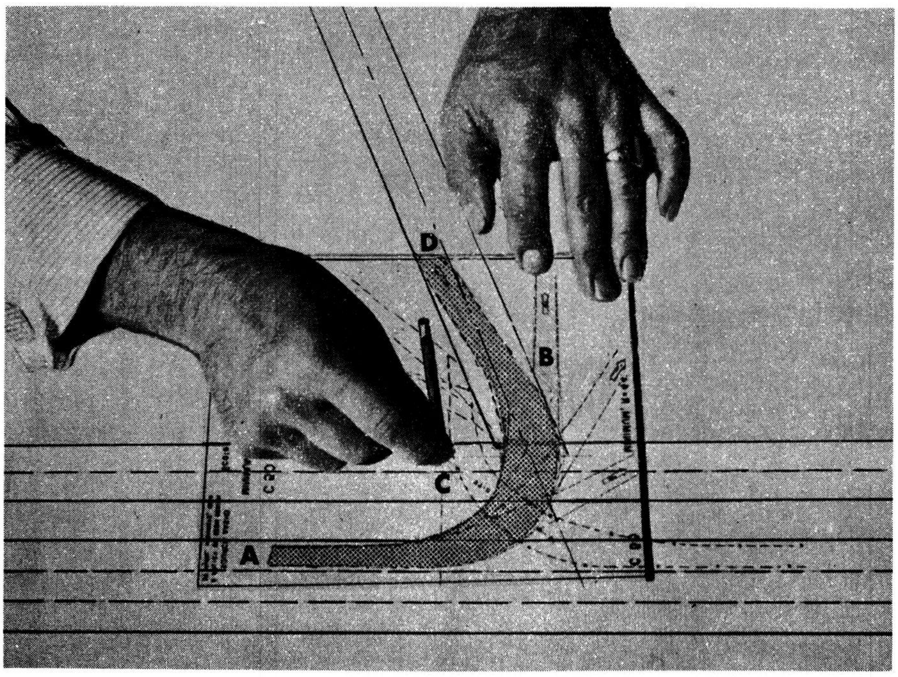


Figure 7.

The adjustment for the proper angle of turn is made by placing the template with the beginning portion of the path in a proper position, as illustrated in Figure 7; i.e., the vehicle approach marked (A), is centered on and made parallel to the lane from which the turn is begun, and at the same time the bulge of the outer wheel path (B) is placed so as to permit proper entry into the intersecting road. With the template so located, a sharp pencil is placed through the center hole (C) in the template. The pencil is held firmly and the far end of the path (D) is swung clockwise into position by revolving the template; see Figure 8.

When the template is in its initial position, Figure 7, the beginning portion of the path is transferred to the layout by marking through the perforations, as

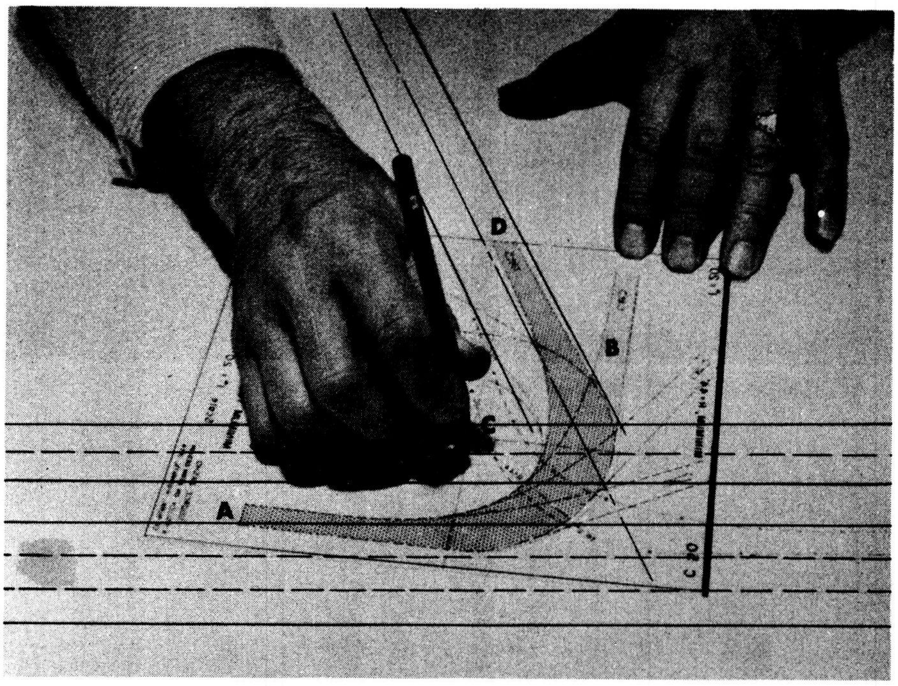


Figure 8.

previously illustrated in Figure 2. The remainder of the path is transferred after the template is swung into the latter position, Figure 8. Thus, the effect produced is a described path for the specific or the odd angle of turn required.