Manual on
Uniform Traffic Control Devices
for
Streets and Highways

Approved as an American Standard
American Standards Association
November 7, 1935

American Association of
State Highway Officials
National Conference on Street
and Highway Safety

WASHINGTON, D.C.
Reprinted September, 1937
The American Association of State Highway Officials was organized in 1914. It is composed of the State Highway Departments of all of the States, the District of Columbia and the Hawaiian Islands, and the U. S. Bureau of Public Roads. The Association has its general offices in Washington, D. C., and is a clearing house for statistical information concerning the activities of these departments in their various responsibilities.

The National Conference on Street and Highway Safety is a cooperative organization, under the chairmanship of the Secretary of Commerce, sponsored by the U. S. Bureau of Public Roads, American Association of Motor Vehicle Administrators, American Automobile Association, American Mutual Alliance, American Transit Association, Association of American Railroads, Automobile Manufacturers Association, Chamber of Commerce of the United States, National Bureau of Casualty and Surety Underwriters and National Safety Council. The Conference has held four general meetings, in 1924, 1926, 1930 and 1934, attended by representatives of federal, state and municipal traffic authorities, traffic and safety engineers, bus and truck operators, manufacturers and distributors of motor vehicles, equipment and supplies, railroad and transit companies, insurance interests, educators and civic organizations.
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Joint Committee on Uniform Traffic Control Devices


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Manual on Uniform Traffic Control Devices for Streets and Highways

Introduction

This manual is a revision and consolidation of two previous manuals—that of the American Association of State Highway Officials for rural highways, and that prepared by the American Engineering Council for the National Conference on Street and Highway Safety to apply to city streets—and is the work of a Joint Committee on Uniform Traffic Control Devices appointed jointly by the American Association of State Highway Officials and the National Conference on Street and Highway Safety, pursuant to resolutions passed by the Executive Committee of the Conference on June 23, 1931, and by the Association at its annual meeting on September 28, 1931. The first meeting of the Joint Committee was held in Washington on March 24, 1932.

The first definite step towards standardization of traffic control devices was taken by the American Association of State Highway Officials in the preparation of its manual originally issued in January, 1927. That manual, prepared primarily for use on rural highways, covered signs only, including STOP signs and a few other regulatory signs, warning signs and guide signs. It established definite shapes and color combinations for different purposes and included standards for marking the newly adopted system of major United States highways.

Shortly after the completion of this first manual the American Engineering Council, at the request of the National Conference on Street and Highway Safety and in response to a growing demand for a similar manual for urban use, undertook the development of such a manual. Its manual was completed after extensive study of existing practice and was approved by the Third National Conference on Street and Highway Safety in 1930. In addition to signs, it embraced traffic signals, markings for pavements, curbs and objects, and safety zones.

Both manuals in their preparation were coordinated with the newly completed Uniform Vehicle Code and the Model Municipal Traffic Ordinance recommended by the National Conference on Street and Highway Safety, and the American Engineering Council manual adhered in nearly all particulars to the shapes and color combinations for signs of the Highway Officials' manual. The Joint Committee on Uniform Traffic Control Devices was created primarily to bring all standards for traffic control devices under one cover and to recog-
nize the rapid developments in the art of traffic control during the past four years. The new manual covers all of the subject matter of both of the other two and expands the treatment of islands (heretofore confined to safety zones for car riders and other pedestrians) to embrace traffic islands as well. It also presents much new matter, particularly with reference to the conditions warranting traffic signals, their design, operation and maintenance, and the details of island design and protection.

The new manual is in strict harmony with the Uniform Vehicle Code and Model Municipal Traffic Ordinance, including the changes adopted by the Fourth National Conference on Street and Highway Safety held May 23-25, 1934. It also takes into account the recommendation of the Sixth International Road Congress, held in Washington in 1930, that consideration be given to the more extensive use of symbols. The joint committee, while believing that on a great majority of signs symbols cannot safely replace word messages, sees very definite advantages in certain simple symbols, such as those for curves, and has eliminated the former word message from CURVE signs. The committee also emphatically urges universal adoption of the sign shapes as basic symbols.

The committee recommends night illumination of the outlines of STOP and slow-type warning signs, and believes the general use of such illumination will tend to make motorists conscious of the meaning of the shapes of such signs and instinctively obedient to them.

Recent extensive tests by the National Bureau of Standards in cooperation with the U. S. Bureau of Public Roads of color combinations for signs under a wide variety of conditions have confirmed the previous belief that a yellow background and black message provide the best possible color combination. This color combination is therefore used for those signs which are most important for motorists to see and observe at high speed—namely, the warning and STOP signs.

The committee deplores the independent procedure of certain jurisdictions in the selection of shapes and color combinations at variance with these standards, and hopes the importance of complete uniformity will be increasingly recognized.

**Use and Misuse of Traffic Control Devices**

Traffic control devices are increasingly necessary for regulating, warning and guiding traffic. The details in this manual indicate their wide range and their proper application and operation.

Intersections are the most critical points in traffic control, and a large percentage of the control devices in this manual relate to intersections. Accurate determination of the degree of control needed at an intersection is highly important, as is proper selection of the design and operation details to effect that degree of control. At many intersections no artificial control whatever is desirable.
Larger volumes of traffic, however, or special characteristics, such as obstructed view or heavy grades, make some form of control advisable, but the devices which will serve the purpose with the least inconvenience to traffic should be used. The normal progression is as follows: (1) A caution-type sign, (2) a slow-type sign, (3) a STOP sign, (4) a traffic control signal installation, (5) a rotary traffic development, and (6) a grade separation.

For the first three of the foregoing, simple standards are provided. If the situation calls for any of the last three, there is need for careful study of the details of design and operation. The two major objectives are safety to vehicles and pedestrians, and the expediting of traffic. These two considerations are sometimes antagonistic, in that an extreme degree of control might increase safety to some extent but at the same time retard traffic too much for sound economic operation. In such cases a balance must usually be attained between these two factors, frequently with some modification on account of the cost of installation.

Adequate but not excessive use of signs to warn of hazards, signs to indicate the applicability of traffic regulations, route markers and destination signs all have great value in facilitating the orderly flow of traffic, as do well-considered pavement and curb markings and islands properly designed and located. Application of sound principles and the selection, installation and operation of traffic signals is of the highest importance.

Misapplication of these traffic-control devices, however, besides wasting public funds, has in numerous cases accomplished the reverse of the purpose intended, causing delay and confusion and promoting disrespect for and disregard of all control devices. In many communities the responsible authorities have not met the problem with scientific analysis but rather by haphazard experimentation, and as a result two fundamental errors have been prevalent. These are (1) placing traffic control devices without adequate study of the possible evil effect produced either there or at other points, and (2) in the case of traffic signals, operation at times not justified by the conditions.

Traffic control requirements in any specific case cannot be determined by guesswork. They should be based on sound engineering principles established by factual studies of accidents, speeds, delays and physical conditions which will show the exact nature of the difficulty and indicate what particular device or method of control is needed.*

Responsibility for Selection and Installation

There is wide variation in official responsibility for the selection, installation and maintenance of traffic control equipment. In most cities the responsibility is placed upon some branch of the police department, although in a number of the more progressive ones the planning of traffic control is under the direction of traffic engineers. In a few states only, broad regulatory authority has been established over the installation and operation of all traffic control devices throughout the state, including small communities and rural areas that otherwise would not have the benefit of expert engineering advice. This is a hopeful tendency in the direction of ultimate uniformity. Until uniform laws replace the present wide variation in state laws regarding signs and signals, some jurisdictions may have to permit deviations from the recommendations of this manual. Fortunately good progress is being made in bringing about the desired uniform laws, and eventually such deviations will be reduced to a minimum.

While considerable equipment now in use does not conform to the recommendations here made, a large part of it can be brought to substantial conformity without excessive cost. Whenever new equipment is purchased or replacements are made because of the need of repairs or because of obsolescence, strict adherence to the standards herein should govern the selection.

Definitions applicable throughout the manual follow this introduction. Four general groups of traffic control devices in common use are then treated, as follows: Part I—Signs, Part II—Markings, Part III—Signals, and Part IV—Islands.

Definitions

The following words and phrases when used in this manual shall be understood to have the meanings respectively ascribed to them:

A. Relating to the HIGHWAY

1) STREET or HIGHWAY. The entire width between property lines of every way or place of whatever nature when any part thereof is open to the use of the public, as a matter of right, for purposes of vehicular traffic.

2) ROADWAY. That portion of a street or highway improved, designed or ordinarily used for vehicular travel.

3) PAVEMENT. That portion of a roadway having a constructed surface to facilitate vehicular traffic.

4) SHOULDER. That portion of a highway between the edge of the pavement and the curb line or ditch.

5) CURB LINE. The boundary between a roadway and a sidewalk, usually marked by a fixed curb rising above the level of the roadway.
(6) Sidewalk. That portion of a street between the curb lines, or the lateral lines of a roadway, and the adjacent property lines, intended for the use of pedestrians.

(7) Crosswalk
(a) That portion of a roadway ordinarily included within the prolongation or connection of the lateral lines of sidewalks at intersections.
(b) Any portion of a roadway distinctly indicated for pedestrian crossing by lines or other markings on the surface.

(8) Intersection. The area embraced within the prolongation or connection of the lateral curb lines, or, if none, then the lateral boundary lines of the roadways of two highways which join one another at, or approximately at, right angles, or the area within which vehicles traveling upon different highways joining at any other angle may come in conflict.

(9) Island. Any area in a roadway from which vehicular traffic is excluded by official restriction.

(10) Safety Zone. The area or space lawfully set apart within a roadway for the exclusive use of pedestrians and which is protected, or is so marked or indicated by adequate signs as to be plainly visible at all times while set apart as a safety zone.

(11) Business District. The territory contiguous to and including a highway when fifty percent or more of the frontage thereon for a distance of three hundred feet or more is occupied by buildings in use for business.

(12) Residence District. The territory contiguous to and including a highway not comprising a business district when the property on such highway for a distance of three hundred feet or more is in the main improved with residences or residences and buildings in use for business.

(13) Private Road or Driveway. Every way or place in private ownership and used for vehicular travel by the owner and those having express or implied permission from the owner but not by other persons.

(14) Alternate Route. A route which starts at a point where it branches off the main numbered route and connects again therewith some miles distant. (This optional routing, which may pass through certain cities and towns, is provided for the purpose of eliminating lettered U. S. numbers which have been established but cannot be absorbed into some new route.)

(15) By-Pass Route. A route which branches from the regular numbered route through a city, bypasses the city and rejoins the regular numbered route beyond the city.

(16) Business Route. A route which branches from the regular numbered route around the congested part of a city, passes
through the business part of the city and rejoins the regularly numbered route beyond that district.

(17) Temporary Route. A route carried temporarily over a road not intended as a permanent part of the route.

B. Relating to TRAFFIC

(1) Traffic. Pedestrians, ridden or herded animals, vehicles, street cars and other conveyances either singly or together while using any highway for the purposes of travel.

(2) Pedestrian. Any person afoot.

(3) Vehicle. Every device in, upon or by which any person or property is or may be transported or drawn upon a highway, except devices moved by human power or used exclusively upon stationary rails or tracks.

(4) Motor Vehicle. Every vehicle which is self-propelled and every vehicle which is propelled by electric power obtained from overhead trolley wires but not operated upon rails.

(5) Street Car. A car other than a railroad train for transporting persons or property and operated upon rails principally within a municipality.

(6) Railroad Train. A steam engine, electric or other motor, with or without cars coupled thereto, operated upon rails, except street cars.

(7) Traffic Lane. A strip of roadway intended to accommodate the forward movement of a single line of vehicles, customarily considered to be 10 feet wide.

(8) Traffic Control Devices. All signs, signals, markings and devices placed or erected by authority of a public body or official having jurisdiction, for the purpose of regulating, warning or guiding traffic.

C. Relating to SIGNS

(1) Traffic Sign. A device mounted on a fixed or portable support whereby notice is given in the form of words or symbols, officially erected for the purpose of regulating, warning or guiding traffic.

(2) Regulatory Sign. A sign used to indicate the required method of traffic movement or use of the public highway.

(3) Warning Sign. A sign used to designate conditions which are actually or potentially hazardous to highway users.

(4) Guide Sign. A sign used to direct or inform traffic.

(5) Stop Sign. A regulatory sign indicating that traffic shall stop before proceeding.

(6) Slow-Type Sign. A warning sign indicating that traffic should reduce speed for safety.
DEFINITIONS

(7) Caution-Type Sign. A warning sign indicating that traffic should proceed with caution in anticipation of a potential hazard which may require a reduction of speed for safety.

(8) Route Marker. A guide sign indicating the proper route to a desired destination.

D. Relating to Markings

(1) Traffic Markings. All devices, lines, patterns, words or colors embedded in the surface, applied upon or attached to the pavement, curbing or adjacent objects, officially placed for the purpose of regulating, warning or guiding traffic.

(2) Limit Line. A line behind which vehicles should stop when directed by traffic officer, traffic control signal, STOP signal or STOP sign.

(3) Center Line. The marked medial line of a roadway.

(4) Lane Markings. Lines marking the lateral limits of traffic lanes.

(5) Insert. A pavement marking accomplished by setting into or attaching to the pavement a material (other than paint) of contrasting color, practically flush with the surface.

(6) Button. A pavement marking consisting of an inflexible object attached to the pavement and projecting above the surface.

(7) Word Markings. Word messages to vehicle operators marked on the pavement.

(8) Flexible Sign. A pavement marking consisting of a sign having the bottom edge inserted in the pavement so that it stands vertically, the material of which is such that it will bend flat under the impact of moving traffic, and return to a vertical position.

E. Relating to Signals

(1) Traffic Signal. A device other than a sign, using light which flashes or otherwise changes, or having moving parts, by which traffic is warned or is directed to take some specific action.

(2) Traffic Control Signal. A signal, operated manually, electrically or mechanically, by which traffic is alternately commanded to stop and permitted to proceed.

(3) Stop Signal. A flashing signal having the same function as a STOP sign.

(4) Slow Signal. A flashing signal having the same function as a slow-type sign.

(5) Signal Head. Housing containing one or more signal faces which may be designated accordingly as one-way, two-way, three-way, four-way or multi-way.
(6) **Signal Face.** That part of a signal head capable of controlling traffic in a single direction, arranged with lights in either a vertical or horizontal row.

(7) **Signal Support.** The physical means whereby a signal head is installed in a particular location.

(8) **Signal Installation.** All of the equipment and materials involved in the signal control of traffic at one intersection.

(9) **Cycle.** The number of seconds necessary in any signal installation to provide one complete sequence for all of the intervals required to start and stop each movement of traffic at the intersection.

(10) **Interval.** That part of the cycle in seconds during which the traffic indication of any particular signal face does not change.

(11) **Manual Control.** Operation of a traffic control signal by hand.

(12) **Automatic Control.** Operation of a traffic control signal by a mechanism.

(13) **Combined Control.** Operation of a traffic control signal by hand or by mechanism as desired.

(14) **Fixed Time Control.** A type of automatic control in which consecutive cycles are equal and are made up of constant intervals.

(15) **Traffic Actuated Control.** A type of automatic control which is actuated, and in some cases limited, by impulses from individual vehicles or pedestrians, or both.

   (a) **Full Traffic Actuated Control.** Control in which all of the intervals are initiated or modified by impulses from traffic.

   (b) **Semi-Actuated Control.** Control in which only some of the intervals are initiated or modified by impulses from traffic.

(16) **Independent Control.** Operation of a traffic control signal installation not in coordination with any other signal.

(17) **Coordinated Control.** Operation of two or more traffic control signal installations with definite interrelation.

(18) **Signal System.** Two or more signal installations operating in coordination.

(19) **Offset.** The number of seconds that the green indication appears at a given signal after a certain instant used as a time reference base.

(20) **Out-of-Step.** That condition of a traffic control signal installation belonging to a signal system when its operation does not possess the intended relationship to the system.

(21) **Re-Coordination.** Restoration of the intended interrelationship of operation of signals in a signal system.

(22) **Simultaneous System.** A signal system in which all signals always give the same indication to a given street at the same time.
(23) **Alternate System.** A signal system in which alternate signals, or groups of signals, give opposite indications to a given street at the same time.

(24) **Progressive System.** A signal system in which the various signal faces controlling a given street give “GO” indications in accordance with a timing schedule to permit (as nearly as possible) continuous operation of groups of vehicles along the street at a planned rate of speed, which may vary in different parts of the system.

(25) **Flexible Progressive System.** A signal system in which the intervals at any signal may be independently adjusted to the traffic requirements at the intersection, and in which the “GO” indications at separate signals may be started independently at the instant which will give the maximum efficiency.

(26) **Synchronous Motor.** An automatic control mechanism which maintains a strictly constant time cycle.

F. Relating to ISLANDS

(1) **Loading Island.** A safety zone especially provided at a regular street car or bus stop for the protection of passengers.

(2) **Pedestrian Island.** A safety zone permanently located in a crosswalk.

(3) **Traffic Island.** Any restricted area permanently located in a roadway which provides structurally for the physical separation and sorting of traffic streams.

(4) **Divisional Island.** A traffic island so located longitudinally in a roadway as to separate traffic streams flowing in the same or opposite directions.

(5) **Channelizing Island.** A traffic island located in or near a widely extended roadway area to prevent the promiscuous movement of traffic through the area and to restrict it to definite channels.

(6) **Rotary Island.** A traffic island located in the center of an intersection to compel movement in a counterclockwise direction and thus substitute weaving of traffic around the island instead of direct crossings of vehicle pathways.
PART I—SIGNS

Introduction

Adequate traffic signs are of great assistance to the vehicle operator and are, therefore, an important and valuable means of safeguarding and expediting traffic. They should, however, be used only where control, warning or guidance is necessary for public safety and convenience. The necessity for installing the signs should be determined by facts and field studies. They are not needed to confirm well known or universally recognized rules of the road, such as that requiring drivers to keep to the right, but may be necessary to indicate the application of regulations pertaining to traffic movement or restriction at specific times or places only. They may also aid the pedestrian to anticipate turning movements or abrupt changes in normal traffic flow.

Classification

Signs for traffic control are classified into three major functional groups which can be further classified as follows:

A. REGULATORY
   1. Stop
   2. Speed
   3. Movement 
      (a) Turning
      (b) Signals
      (c) One-way
   4. Parking 
      (a) Prohibition
   5. Miscellaneous

B. WARNING
   1. Slow
   2. Caution
   3. Railroad advance
   4. Railroad crossing

C. GUIDE
   1. Route marker 
      (a) Route
      (b) Route turn
      (c) Directional arrow
   2. Destination
   3. Location 
      (a) Cities and towns
      (b) Rivers and streams
   4. Information

   (d) Alignment
   (e) Exclusion
   (b) Restriction
   (d) Junction
   (e) Detour
   (c) Mountains
   (d) Historical sites

High Speed Requires Uniformity

Modern highway speeds and complex intersections require signs which can be seen at long distances and understood almost instantly. This calls for a simple method of standardization.
The following characteristics of signs have been standardized and made simple and obvious to provide uniformity of significance in the signs themselves and make familiarity with them easy to acquire by the most casual driver:

(a) Application  (d) Location  (g) Wording
(b) Shapes      (e) Dimensions  (h) Lettering
(c) Colors      (f) Symbols     (i) Illumination

**Excessive Use of Signs Undesirable**

Care should be taken not to install too many regulatory or warning signs. Traffic will move with less delay and more safety at many average intersections, curves, hills or other potential accident or congestion points if there is no artificial control. On the other hand, a frequent display of judiciously placed route signs will not lessen their value. Therefore, a fairly liberal use of route markers and a conservative use of regulatory and warning signs are desirable.

**Article I—Legal Authority**

Signs lose a large part of their effectiveness unless their legal authority is definitely established and they are made to play an important part in the law enforcement program.

**Section 101—Legal Authority**

Traffic signs shall be placed only by the authority of a public body or official having jurisdiction for the purpose of regulating, warning or guiding traffic.

A suitable model for the legal authority for the placing of signs is presented in Article V of the Uniform Vehicle Code—the Uniform Act Regulating Traffic on Highways (Sections 17, 28, 29, 30 and 31) and in the Model Traffic Ordinances (Part I, Section 21, and Part II, Section 13). Interference with signs is prohibited in the Uniform Act (Section 35).

It is essential that signs be installed only by the designated governmental authorities, otherwise they cannot be enforced and violators will be dismissed in court. Signs placed without authority by private organizations do not fit the program, are frequently poorly placed and maintained, and are not legally binding. The Uniform Act (Section 34) prohibits the display of unauthorized signs, and all unofficial and non-essential signs should be removed, as they weaken the value of the necessary signs.

The regulations set forth by signs should be zealously enforced. Otherwise, no matter how effectively the signs may be designed and placed, the results desired will not be obtained.
Article II—Application

The value of any sign must depend upon its correct and consistent application. Unless signs tell the motorist the truth they will soon be disregarded. The following sections provide the proper application of all signs.

Section 102—Conditions Warranting Signs

Traffic signs shall be used only under conditions where regulation, warning or guidance are necessary to provide public safety or convenience.

The need for traffic signs should be established by accident records, field studies of volume, speed, origin and destination, and law enforcement. Unless a factual basis is used signs may actually increase accidents or delay.

Section 103—Uniformity of Application

Traffic signs shall be applied uniformly. Identical conditions shall always have the same application of signs, no matter where the particular conditions occur. Each sign shall be displayed for one definite and specific purpose only.

Uniformity of application is equally as important as standardization of the signs themselves. A sign must tell the motorist the same story wherever it is found.

Generally the need for display of a particular sign decreases as the special condition which it indicates increases in frequency. It is far more important to display a warning sign before a curve at the end of a long tangent where high speeds are common than where curves are of regular occurrence. Where curvature is more or less continuous or meandering, occasional WINDING ROAD signs may be sufficient.

Section 104—Degree of Emphasis

Where conditions require increased emphasis, it shall be attained by one or more of the following methods:

(a) Dimensions increased (proportionately) above the specified standards for better daylight visibility.
(b) Sign supports marked with standard colors for better daylight visibility.
(c) Additional illumination for better night visibility.
(d) Use of an advance warning sign, as where a curve or other obstruction in the approach hides the sign.

The standard sign normally has sufficient attracting power to fulfill its purpose. However, a small percentage of the locations requiring signs may have conditions of abnormal hazard or restricted visibility requiring additional emphasis. At these points the power
of the standard sign may be increased as indicated above without affecting the uniformity of its appearance or use. These large signs should be used sparingly or all smaller signs will be considered unimportant.

Section 105—Regulatory Signs

Regulatory signs, disregard of which constitutes a misdemeanor, are essential to indicate the applicability of legal requirements that would not otherwise be apparent. Great care must be exercised so that they are erected wherever needed to fulfill this purpose, but unnecessary mandates should be avoided.

Section 106—Stop Signs

A STOP sign shall be used only under the following conditions and then only where it is necessary that vehicles come to a stop before proceeding cautiously:

(a) Where restricted view so requires.
(b) Intersection of two main highways.
(c) Intersection of a secondary with a main highway.
(d) End of a roadway having no outlet.
(e) Railroad grade crossing where a stop is required by law.
(f) Approach to a drawbridge where a stop is required by law.
(g) Unsignalled intersections in a signalized area.

STOP signs are classified separately from other regulatory signs and are given a distinctive shape, for the reason that violation of them is extremely hazardous. They also have the highest inconvenience factor. Therefore, they should be used only where warning signs would be inadequate. Use at less dangerous points fosters disregard of all STOP signs. Isolated STOP signs, as in (a) above, should not be installed unless based on visibility and speed studies.

Whenever a main highway is protected by STOP signs a “through highway” regulation should be in force, and an “ending” sign should be installed at the end of the section so protected.

Section 107—Other Regulatory Signs

Other regulatory signs shall be erected only as specific promulgations of legal operating requirements.

While the general rules of the road should be matters of common knowledge requiring no use of traffic signs, there are many regulations, limited to special conditions or locations, which are not matters of common knowledge and cannot be enforced unless signs indicate their application at the place specified.

For convenience, these signs are classified as “speed,” “movement,” “parking” and miscellaneous, as indicated in the general classification.
Section 108—Speed Signs

Speed limit signs should be erected on main thoroughfares at entrances to business or residential districts in municipalities and at other points where established prima facie limits are changed.

It should be noted that the speed limits indicated in the Uniform Vehicle Code are prima facie limits. Therefore, where the code is in effect speed limit signs will indicate the maximum presumptively proper speed under normal conditions.

It is frequently desirable to erect confirmatory speed limit signs at selected points within speed zones.

Section 109—Movement Signs

Certain uses of movement signs are mandatory, others permissible, as follows:

109a. Turning signs shall be used at all intersections, whether or not controlled, where left, right and/or “U” turns are prohibited.

The Uniform Vehicle Code and Model Traffic Ordinances permit left and right turns at all intersections unless otherwise indicated, and the Ordinances permit “U” turns where they can be made safely without interfering with other traffic. Therefore any prohibition of such turns must be indicated by a sign.

The Code and Ordinance formerly permitted the alternatives of a green arrow or a special sign to authorize turns on a STOP indication. In the 1934 revision only the green arrow is authorized for this purpose, hence no sign for such purpose is presented herein.

109b. Traffic signal regulatory signs are often desirable in conjunction with signals to indicate the speed for which signals are timed, to warn pedestrians and for other purposes.

The foregoing paragraph refers only to regulatory signs. Advance warning signs are sometimes desirable to indicate the approach to a signal or signalized area.

109c. ONE-WAY signs shall be erected at every intersection where one-way traffic is in force on one or more highways and traffic could otherwise enter in the wrong direction.

The Uniform Vehicle Code (Act V, Section 61) and the Model Traffic Ordinances (Part I, Section 40), in authorizing the designation of one-way streets, require this.

109d. Alignment signs should be used where it is desired to keep traffic to certain lanes, either to facilitate the movement of through and turning traffic or to prevent overtaking and passing at hazardous points.

109e. Exclusion signs should be used where it is desired to exclude all vehicular traffic, or certain stated kinds of traffic, from the roadway.
Section 110—Parking Signs

110a. Parking prohibition signs shall be used to indicate areas where parking is prohibited at all times. They shall also be used to indicate areas where parking is prohibited part of the time or to certain classes of vehicles, and shall indicate the nature and limits of the prohibition.

The Uniform Vehicle Code (Act V, Section 92) lists thirteen types of places, such as within intersections, in front of driveways, etc., where parking is prohibited at all times, and signs indicating that fact are not necessary at such places. Signs are required to make enforceable full or partial prohibitions at other points.

110b. Parking restriction signs shall be used to indicate areas and limits where parking is restricted, and shall state the restriction.

The Model Traffic Ordinances require the erection of such signs to make the parking restrictions enforceable.

Section 111—Warning Signs

Warning signs shall be used only to indicate physical or operating hazards.

The four types of warning signs are indicated under “Classification” on page 10.

Section 112—Slow-Type Signs

A slow-type sign shall be used only for the following conditions where permanent physical hazards always require a reduction in speed for safety:

(a) Turns having radii of less than 200 feet.
(b) Curves having radii of 200 feet or more where conditions require a reduction in speed.
(c) Reverse curves.
(d) Successions of curves with or without short tangents.
(e) Hills having down grades of 6 percent or more.
(f) Dips.
(g) Narrow bridges or roadways.
(h) Other points of limited clearance.
(i) Drawbridges.
(j) Safety zones of similar obstructions.
(k) Intersections which do not warrant a STOP sign but are sufficiently hazardous to require a reduction in speed.
(l) Street car crossings and turns.
(m) Advance warnings of obscured STOP signs.
(n) Stated speed locations.

CURVE signs should be used only where a reduction of speed is required for safety because of degree of curvature, visibility, width of pavement, banking or similar conditions.
A REVERSE CURVE sign should be used only to indicate two curves in opposite directions separated by little or no tangent. In case of a double reverse curve or a number of distributed curves close together, a WINDING ROAD sign should be used.

HILL signs should be used in advance of down grades exceeding six percent, and at grades exceeding ten percent stated speed signs should be used. (See Table, Appendix A.)

NARROW signs should be used to indicate the beginning of a reduction in width of pavement on any highway, particularly one having only two traffic lanes. They are not warranted on a section of roadway having a 16-foot width on a highway with moderate traffic, but should be used if the traffic is heavy. The beginning of a reduction in width below 16 feet on any two-lane roadway should be indicated.

A SAFETY ZONE sign should be used at the approach end of every safety zone, and in the case of loading islands (see Part IV) the sign should indicate by arrows whether traffic is permitted to pass only to the right of the zone, or may also pass to the left.

Appropriate slow-type signs should be placed in advance of tunnels, low bridges, viaducts and similar fixed structures which have limited road widths or limited overhead clearance. In addition, information signs should state the amount of clearance or width.

A slow-type sign should also be used in advance of a STOP sign not visible a sufficient distance ahead.

Stated speed slow-type signs bearing the message "Slow to ___ Miles" shall be erected at approaches to intersections, curves or other points where serious hazards require for safety that vehicles proceed at a speed not greater than that indicated.

A stated speed sign should be considered for the following conditions:

(a) A serious accident record involving collisions between vehicles coming from different streets or directions.
(b) Obstructed view at corners where prevailing approach speeds are too high for safety.
(c) Where highway conditions produce prevailing high speeds on one of the intersecting highways and where studies show that the normal safe approach speed on the other highway is not low enough to warrant a stop sign.

Slow-type signs which are non-specific may be interpreted variously by different drivers. The stated speed sign indicates a definite speed beyond which it is not safe to proceed.*

If the computed approach speed is found to be less than six or eight miles per hour, a STOP sign or signal would usually be installed. Stated speed signs

would be used for speeds above six or eight miles per hour up to about 20 miles per hour in urban territory. It is generally unwise in urban territory to install such a sign bearing a speed higher than 20 miles per hour, as this might then be an invitation for increasing speed.

In both urban and rural territory such stated speed signs should be used only if the speeds which they are to indicate are appreciably less than those found to be in common use at the location prior to the installation of the sign.

**Section 113—Caution-Type Signs**

A caution-type sign shall be used only for the following conditions where there is a potential operating hazard, requiring vehicles to proceed with caution:

- (a) Highway intersections.
- (b) Advance warning of traffic control signals.
- (c) Road construction or repairs.
- (d) Other temporary road conditions.
- (e) Pedestrian zones.
- (f) Animal crossings.

A highway intersection which is not sufficiently hazardous to warrant a STOP or slow-type sign, but which is sufficiently above average hazard or importance to be called to motorists’ attention, should be indicated by a caution-type sign bearing a symbol showing the plan of the intersection (see Section 144). Such signs are not usually necessary in cities where intersections are expected.

The MEN WORKING sign should be mounted on a portable standard in the roadway. A red flag may be displayed above it to increase the emphasis. The distance of the sign in advance of the place where the men are working should be determined by the prevailing speed of traffic and the visibility at that point.

Signs of the types indicating school zones, pedestrian zones and animal crossings, which give warning of conditions that are intermittent in occurrence, should be installed so that they can be removed when the hazard does not exist. There is a trend toward the mounting and placement of such signs on portable standards like the MEN WORKING sign.

**Section 114—Choice of Intersection Signs**

The intersection sign with the lowest effect and inconvenience which will serve the purpose at each intersection shall be used.

The following is the normal order of installation:

- (a) Caution-type sign, indicating the presence of an intersection requiring caution.
- (b) Slow-type sign, indicating a “bad corner” requiring a reduction in speed.
- (c) STOP sign, requiring a stop before proceeding with caution.

Intermediate stages to take care of increasing importance or hazard may be provided by increasing the dimensions, marking the sign
supports, providing additional illumination or erecting an advance warning sign.

Most intersections whose presence is obvious, whose visibility is not restricted and at which the cross traffic is slow and infrequent, do not require signs. Signs when properly observed cause operators varying degrees of inconvenience. If the sign selected causes more than the minimum necessary inconvenience, public disregard will result. Where a marked difference in traffic volume exists on the intersecting street and it has been found necessary to sign such street, caution-type signs should be placed against the heavier traffic and the slow-type signs against the lighter, or slow-type signs against the heavier and STOP signs against the lighter.

Section 115—Railroad Advance Warning Signs

A railroad advance warning sign shall be placed along each approach to every railroad grade crossing except that of a minor siding or spur.

A minor siding or spur should be understood to be one infrequently used, when a member of the train crew guards the crossing during its use.

Section 116—RAILROAD CROSSING Signs

A RAILROAD CROSSING sign shall be placed on each side of the tracks at every railroad grade crossing except that of a minor siding or spur.

Even if a grade crossing is further protected by signals, gates or a flagman, both of these signs are necessary, the advance sign to warn of proximity to a railroad crossing and the crossing sign to show the location of the tracks. Care should be taken to remove all signs from tracks no longer in use.

RAILROAD CROSSING signs are usually on the railroad right of way and are furnished and placed by the railroad company. Railroad advance warning signs are usually off the railroad right of way and should be the responsibility of the highway authorities.

Section 117—Guide Signs

Guide signs shall be used at intersections to furnish the traveler with directional and locational information only.

United States highways and state, county and city numbered routes between important points are usually indicated by route signs. At the junction of two or more highways it is also customary to erect guide signs indicating the name, presence, direction and distance of localities, cities, mountains, streets and points of historic or other general interest.

In laying out through routes, it should be the practice to avoid congestion where possible by means of bypasses around the business
centers of cities and the larger towns, but alternative local route markings should be installed to conduct those who wish to go to the business center by the best route.

Section 118—Route Markers

Route markers shall be used only to indicate United States highways and state, county or city routes (Fig. 147). Route markers shall be placed at all intersections on a marked route wherever traffic would be likely to lose the route, such as:

(a) At all important intersections.
(b) At all intersections where the route turns.
(c) At all irregular intersections, such as a “Y,” a “T” or where the roadways meet at irregular angles.
(d) At all intersections where the type of surface changes.
(e) In cities on straight streets at intersections not more than two blocks apart.

Route markers should also be placed on straight open stretches of highway at intersections not more than one mile apart, or, if there are no intersections, at random intervals as necessary to indicate the route. Such markers at intersections furnish immediate information to those coming upon the marked route from a side road.

The system of route markers in this code was developed by the American Association of State Highway Officials and the U. S. Bureau of Public Roads for use primarily on United States highways, and the shield-shaped sign is to be used only on such highways. The same system, however, with markers of distinctive shape, is equally applicable to state highways not in the United States system, and to local systems.

Section 119—Route Turn Markers

A turn in the route at an intersection shall be indicated by a route marker with the letter “R” or the letter “L” in advance of the intersection, a route marker with confirmatory arrow at the intersection, and a confirmatory marker beyond the intersection. Each route or group of routes turning in one direction shall be treated separately, on a separate post, in this same manner. The letter or arrow shall be below the route marker.

When some routes turn while others proceed straight through the intersection, only markers for the routes turning shall be displayed in advance of the intersection, while markers for all of the routes going straight ahead shall be placed conspicuously on the far side of the intersection.

Route turn markers may be omitted where the character of roadway shows clearly the course of the route.

An alternate method of marking a complicated intersection at which routes turn is by means of a sign carrying an intersection diagram showing the general arrangement of highways diverging from the intersection, with arrow heads
on each of the marked routes, and the route number alongside the arrow head. The diagram should be large enough and placed sufficiently in advance of the intersection to be read easily by approaching traffic.

Section 120—Route Junction Markers

When a marked route is crossed or joined by another route, the junction shall be indicated on each route as it approaches the intersection by an auxiliary junction sign over a marker indicating the other route.

This combination should be mounted on an individual post separate from the markers of the approaching routes. If more than one junction sign is required, the most important should be at the top.

Section 121—Overlapping Routes

When one highway serves for two or more routes which go straight through the intersection, the route markers for all shall be placed on the same post.

Section 122—Route Markers on Auxiliary Routes

Route markers shall be used on route detours and on alternate, by-pass, business and temporary routes in the same manner as on regular routes, except that each marker shall have mounted above it an auxiliary sign indicating the type of auxiliary route.

A special detour route marker may be used in place of the combination of route marker and auxiliary detour sign.

Since detours frequently necessitate the use of unimproved and poorly defined roads, the likelihood of making a false turn is much greater than on a clear, direct open right of way with surfaced roadway. Therefore detour markers should be used more frequently than on the regular route, and placed as conspicuously as possible. When the regular route is restored all detour markers should be removed immediately.

Great care should be taken to see that when temporary route numbers are permitted they are properly designated as temporary. This will obviate much hard feeling when it is necessary to change a number to the permanently established route.

Section 123—Destination Signs

Destination signs shall be placed at intersections and other points where it is advisable to inform traffic of the direction and distance to various destinations.

The principal destination sign at an intersection should preferably not carry more than four names—two in each direction. From the
top down these names should be the ultimate principal city to the right, the next town of importance to the right, the ultimate principal city to the left and the next town of importance to the left.

A multiplicity of names on a sign makes it difficult for motorists to discern any one name, and thus tends to defeat the purpose of the sign. In hilly, populous country, however, where the same route is to be followed some distance to reach a number of widely separated points of importance, it is highly desirable to indicate those points. This should be done with an additional sign or signs carrying the names desired in smaller letters than those on the principal destination sign.

A temporary destination sign should be placed at the beginning of a detour to indicate points reached by the detour.

Identification of all main traveled highways by route markers on the ground and the proper numbers on road maps would greatly lessen dependence on destination signs. Destination signs at important cross roads and forks will still be needed, however, particularly to direct travelers going short distances without maps or knowledge of route numbers, and to indicate distances.

Section 124—Location Signs

Location signs shall be used at the entrances to named communities.

Location signs may also be used to indicate prominent physical features contiguous to a highway, such as lakes, mountains, streams and spots of historic interest (Fig.124).

Section 125—Information Signs

Information signs may be used to convey important information that does not come under any of the preceding classifications, such as the following:

125a. Limited Clearance. In addition to a warning sign at a point of limited clearance, an information sign shall indicate the amount of clearance.

125b. Certified Water Supply. Bacteriological surveys by State health agencies are now provided in many States, and official designation of potable water supplies should be provided by signs carrying a certificate of the health agency and the State Highway Department.

125c. Tourist Camp. Tourist camps are now so common and require such a degree of control that they should be clearly designated, both for the benefit of the traveler and for the protection and health of the community.

125d. Rest Station. Standard rest station signs should be supplied to garages, filling stations, merchants and others desiring them for appropriate display.
Article III—Design

With modern speeds signs must give practically instantaneous indications at points that will permit operators to act upon them. The general plan of this system of signs is based on the principle that each functional group shall have a distinctive significance indicated primarily by shape and secondarily by color combination. It is only by reducing the hundreds of necessarily different signs to functional groups that they can be made intelligible to motorists traveling at high speeds under complex conditions.

Section 126—Shape and Color

All signs shall be of the shape and color indicated in the table below. All square corners shall be rounded on a radius of 1½ inches, and all embossed metal signs shall have a border of ⅛ inch set in ⅛ inch from the edge.

<table>
<thead>
<tr>
<th>Type</th>
<th>Shape</th>
<th>Background</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulatory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stop</td>
<td>Octagon</td>
<td>Yellow</td>
<td>Black or red</td>
</tr>
<tr>
<td>Speed</td>
<td>Vertical¹</td>
<td>White</td>
<td>Black</td>
</tr>
<tr>
<td>Movement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turning</td>
<td>Vertical</td>
<td>White</td>
<td>Black</td>
</tr>
<tr>
<td>Signals</td>
<td>Vertical</td>
<td>White</td>
<td>Black</td>
</tr>
<tr>
<td>One-way</td>
<td>Arrow²</td>
<td>White</td>
<td>Black</td>
</tr>
<tr>
<td>Alignment</td>
<td>Vertical</td>
<td>White</td>
<td>Black</td>
</tr>
<tr>
<td>Exclusion</td>
<td>Vertical</td>
<td>White</td>
<td>Black</td>
</tr>
<tr>
<td>Parking</td>
<td>Vertical</td>
<td>White</td>
<td>Red</td>
</tr>
<tr>
<td>Prohibition</td>
<td>Vertical</td>
<td>White</td>
<td>Green</td>
</tr>
<tr>
<td>Restriction</td>
<td>Vertical</td>
<td>White</td>
<td>Black</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slow</td>
<td>Diamond</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Caution</td>
<td>Square</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Railroad advance</td>
<td>Circle</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Railroad crossing</td>
<td>Cross-buck</td>
<td>White</td>
<td>Black</td>
</tr>
</tbody>
</table>

| Guide              |            |            |             |
| Route marker       |            |            |             |
| U S                | Shield     | White      | Black       |
| State              | Special³   | White      | Black       |
| Auxiliary signs    | Horizontal⁴| White³     | Black³      |
| Destination        | Horizontal | White      | Black       |
| Location           | Horizontal | White      | Black       |
| Information        | Horizontal | White      | Black       |
| Rest station       | Clover leaf| Green      | White       |

¹Rectangle with longer dimension vertical.
²Alternate, horizontal rectangle with arrow on it (see Section 142).
³See last paragraph, Section 118.
⁴Rectangle with longer dimension horizontal.
Reasons for departure from the standard group shapes in special cases are:

STOP signs are octagonal because their importance justifies an exclusive shape for instant identification.

The arrow-shaped sign or rectangle with horizontal arrow for one-way streets, detours and turns in a numbered route conveys its meaning symbolically and has been established by long usage.

The circular railroad advance warning sign and the cross-buck RAILROAD CROSSING sign have long been in common use and the latter has been standardized by the Joint Committee on Grade Crossing Protection of the Association of American Railroads.

Route markers serve a distinctive purpose justifying distinctive shapes. The shield has been adopted by the American Association of State Highway Officials to mark numbered United States highways. For other State highways the outline of the State or an identifying symbol, such as the State flower, a keystone or an Indian head, has usually been adopted.

For a résumé of exhaustive tests conducted by the National Bureau of Standards as to the visibility of different color combinations under all conditions, see "Public Roads," Vol. 14, No. 7, September, 1933. These studies were the basis for the colors standardized.

Section 127—Materials

Rust-resisting metal should be used for permanent signs and is recommended for all signs, but wood may be used for large signs and also for temporary and seasonal signs, and heavy cardboard may be used for special occasions or emergencies. For all signs the material specifications (see Appendix B) proposed by the Joint Board on Interstate highways, the U. S. Bureau of Public Roads, the American Association of State Highway Officials, and the National Bureau of Standards should be used.

Non-corrosive bolts, screws and washers should be used for attaching signs to their supports to avoid discoloration.

Section 128—Dimensions

All signs shall be in accordance with the dimensions shown in subsequent sections covering detailed designs. With the exception of route markers and illuminated signs mounted on signal standards, they shall have an outside minimum dimension of at least 24 inches. Where conditions require greater visibility necessitating a larger sign, the outside dimensions shall be in multiples of 6 inches.

The use of smaller signs in cities is undesirable for the following reasons:

1. Driving in cities is even more confusing than in the country, because of increased traffic and frequent intersections.
2. Signs are less visible in cities because of increased competition of other signs and lights.
3. Parked cars and trucks also reduce visibility.

Where space on sidewalks is limited, parking signs may be less than 24 inches.

Section 129—Message—Wording

Where wording is used, the text shall be adequate to convey to the driver a clear concept of the message, but wording beyond this requirement shall not be used except as indicated in Section 132.

The wording and arrangement for each type of sign shall be as specified in subsequent sections.

It is important that the main message be given preference as to location and size and that the secondary message be in similar type in the poorer position.

Section 130—Letters and Figures

Letters and figures used to convey the message shall be of standard proportions and spacing in accordance with one of the alphabets used by the U. S. Bureau of Public Roads (see Appendix D).

Rounded corners of letters and figures are desirable where dies are not involved (see Fig. 130).

Section 131—Message—Symbols

Symbols on the sign shall take the place of a word message on TURN, CURVE, railroad advance warning and caution-type intersection signs and shall supplement the word message on destination signs. Where the rectangular ONE-WAY or DETOUR sign is used, this also shall carry a symbolic arrow.

Symbols can be seen and understood more readily and at greater distances than words and are therefore to be preferred wherever it is possible to use them. Furthermore, in this system the shape of the sign is in itself a symbol of the greatest importance.

Section 132—Legal Authority

When specified by law or regulation, legal authority for a sign shall be expressed in suitable wording at the bottom inside the border in letters not more than 1/2 inch in height.

Section 133—Illumination

All STOP, slow-type and railroad advance warning signs shall be illuminated at night so as to be visible from all distances up to 350 feet.
The outlines and word "STOP" of STOP signs, the outlines of slow-type signs and the outlines and letters "R R" of railroad advance warning signs shall be illuminated.

Less brilliant illumination of the message on slow-type signs is desirable but optional. If a sign is necessary in daylight, it has equal or greater value at night, inasmuch as night driving at high speeds is continually increasing. Illumination of the outline of STOP and slow-type signs will make them visible at ample distance to enable motorists to slow down in time to read and obey the specific message.

Illumination of word messages legible a sufficient distance would hardly be feasible. Illumination of the outlines, besides providing advance warning, should have much educational value in impressing upon motorists the significance of shapes.

In any program of replacement of existing equipment the first replacements with standard signs shall be at the most hazardous locations and at places where the signs are not otherwise adequately illuminated.

While illumination of parking signs is not ordinarily warranted, it is desirable to illuminate certain signal and other movement signs which should be readable at night and sometimes at considerable speed. It is recommended that route markers and destination signs also be illuminated. At least one state has already provided reflecting elements for all signs designating United States highways.

Section 134—Method of Illumination

Illumination of signs shall be white, except the lettering on STOP signs, which shall be red.

The following methods of illumination are listed in the order of preference:

(a) A light, within or behind the sign, or luminous tubes, illuminating the outline of the sign and the main message, whether symbol or word. The light may be flashing or steady, preferably flashing.

(b) An attached or independently mounted flood light focused on the face of the sign.

(c) Reflecting elements set in the face of the sign.

Flashing or steady lights within the sign, flashing or constantly luminous tubes, or flood lights provide the maximum visibility under all conditions. Because of their higher cost and the difficulty of service connections, however, they will probably not be used very frequently in rural areas.

Reflecting buttons outlining the shape of a sign should be placed on the yellow background just inside of the black border.

The importance of the STOP sign is such that it merits a distinctive color of illumination, and red is so generally recognized as a mark of danger requiring a vehicle to stop that it is the obvious choice for the purpose, especially as its visibility is adequate for permitted speeds.
Street lighting is not generally considered adequate illumination for signs because of inflexible location, reduced light due to foliage, and the fact that street lamps are sometimes not operated during all the hours of darkness.

**Section 135—Combination Sign and Signal**

Whenever signals in the form of flashing beacon lights are used in combination with standard signs as part of the design, the color of the flashing light shall conform with the code of color meanings specified in Part III.

Flashing lights are sometimes used in connection with STOP or warning signs to attract greater attention. Since the colors used are the same as those used in traffic control signals their meanings should be similar. The flashing red is to be used for the STOP sign (meaning stop and then proceed when safe) and the flashing yellow (meaning proceed with care) is to be used for the slow-type and caution-type signs.

**Section 136—Sign Mounted on Signal Standard**

A sign mounted on a signal standard should conform in shape to the table in Section 126, and in colors and lettering if it is not to be illuminated from within or behind the sign. If it is to be so illuminated it may be in the form of a box attached to the top or bottom of the signal housing, with the letters illuminated from within. In such cases white letters may be shown against a black background. These signs should be of such dimensions that the letters will be at least three inches high.

**Section 137—Sign Posts and Their Foundations**

Sign posts and their foundations shall be so constructed as to hold the sign rigidly in a proper and permanent position and prevent it from swaying in the wind.

Sign posts for independent mounting should preferably be of metal or concrete, although wood is acceptable if well protected from the weather.

There are numerous adequate designs for posts. Fig. 137 shows several types. All posts should have holes spaced on 6-inch centers except posts for markers, in which it will be more advantageous to have holes spaced on 2-inch centers. Each state and municipality should adopt the material and design dictated by local resources and past practice as the most satisfactory and economical.

Portable or removable mountings are also desirable for MEN WORKING and SCHOOL signs. Such a mounting should be heavy enough not to turn over in the wind, and its base should not be appreciably wider than the sign.
Frequently signs can be correctly placed on existing supports used for other purposes, such as traffic signal standards, street lamps or public utility poles, thereby saving expense and minimizing sidewalk obstruction. Correct location of the sign should not thus be sacrificed, however. Furthermore, signs on or near poles which linemen have to climb are an element of danger to the linemen. This hazard can be largely corrected by the use of easily demounted signs and sign brackets.

Section 138—Marking of Posts

When sign posts supporting signs are marked for the purpose of adding attracting power to the sign, diagonal stripes the same colors as those on the sign shall be used.

Such marking, which should conform to the standards presented in Part II, is also important protection for the sign if it is located close to the pavement or in a wide shoulder.

Section 139—Attachment of Signs

Rust-proof metal shall be used where possible in attaching signs to supports.

Section 140—Detailed Design of STOP Sign

The design and specifications of the standard STOP sign (Fig. 140) shall be as follows:

(a) Shape.—Octagon, with two sides vertical.
(b) Colors.—Yellow background, black or red letters and border; red reflecting buttons for word “STOP,” white for border.
(c) Dimensions.—24 by 24 inches, or larger in multiples of 6 inches.
(d) Main Message.—STOP, located in center.
(e) Secondary Message.—Through Traffic, Bad Corner, Road End, Rail Road, or Draw Bridge, located above and below word “STOP.”
(f) Letters.—“STOP” in 6-inch letters, Series E; secondary message in 3-inch letters, Series B.

The function of the secondary message is to give the reason for the stop and inform approaching motorists of what to expect.

Section 141—Detailed Design of Other Regulatory Signs

The design and specifications of other regulatory signs (Figs. 141a-f) except the ONE-WAY sign shall be as follows:

(a) Shape.—Rectangular with longer dimension vertical.
(b) Color.—White background, black letters and border except on parking signs, red letters and border for prohibited parking, green letters and border for limited parking.
(c) **Message and Dimensions.**—One of the messages in the following table, with corresponding minimum dimensions of letters and sign as indicated:

<table>
<thead>
<tr>
<th>Message</th>
<th>Minimum Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Letters</td>
</tr>
<tr>
<td></td>
<td>Inches</td>
</tr>
<tr>
<td><strong>Speed Regulations</strong></td>
<td></td>
</tr>
<tr>
<td>Begin 25-mile Speed</td>
<td>4</td>
</tr>
<tr>
<td>End 25-mile Speed</td>
<td>4</td>
</tr>
<tr>
<td>Speed Limit—20 Miles</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td><strong>Turning Regulations</strong></td>
<td></td>
</tr>
<tr>
<td>No Turns</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>No Right Turn</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>No Left Turn</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>No “U” Turn</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td><strong>Signal Regulations</strong></td>
<td></td>
</tr>
<tr>
<td>Signals Set for—M.P.H.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Watch Traffic Signals</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Red and Yellow—Pedestrians Only</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Pedestrians Must Obey Signals</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Limit Line</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Alignment Regulations</strong></td>
<td></td>
</tr>
<tr>
<td>Keep Right—Pass in Center Only</td>
<td>3</td>
</tr>
<tr>
<td>Keep in Single Line</td>
<td>4</td>
</tr>
<tr>
<td>Form—Lines</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td>No Passing—Feet</td>
<td>3</td>
</tr>
<tr>
<td>Double Arrow (for “pass right or left”)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Exclusion Regulations</strong></td>
<td></td>
</tr>
<tr>
<td>One Way. Do Not Enter</td>
<td>4</td>
</tr>
<tr>
<td>Vehicles Excluded</td>
<td>4</td>
</tr>
<tr>
<td>Motor Vehicles Excluded</td>
<td>4</td>
</tr>
<tr>
<td>Commercial Vehicles Excluded</td>
<td>3</td>
</tr>
<tr>
<td>Trucks Over—Tons Excluded</td>
<td>3</td>
</tr>
<tr>
<td>Tractors with Lugs Prohibited</td>
<td>3</td>
</tr>
<tr>
<td>No Thoroughfare</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Message</td>
<td>Minimum Dimensions</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td></td>
<td>Letters</td>
</tr>
<tr>
<td></td>
<td>Inches Series</td>
</tr>
<tr>
<td><strong>Parking Prohibitions</strong></td>
<td></td>
</tr>
<tr>
<td>No Parking at Any Time</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 by 18</td>
</tr>
<tr>
<td>No Parking This Side</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 by 18</td>
</tr>
<tr>
<td>No Parking Here To Corner</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 by 18</td>
</tr>
<tr>
<td>No Parking Street Car Stop</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 by 18</td>
</tr>
<tr>
<td>No Parking Safety Zone</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 by 18</td>
</tr>
<tr>
<td>No Parking Theater Exit</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 by 18</td>
</tr>
<tr>
<td>No Parking Passenger Zone</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 by 18</td>
</tr>
<tr>
<td>No Parking Loading Zone</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 by 18</td>
</tr>
<tr>
<td>No Parking Bus Stop</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 by 18</td>
</tr>
<tr>
<td><strong>Parking Restrictions</strong></td>
<td></td>
</tr>
<tr>
<td>Parking——Hour</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2 by 18</td>
</tr>
<tr>
<td>Parking Diagonal</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Parking Parallel</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Parking on Pavement Only</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Live Parking Only</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>12 by 18</td>
</tr>
<tr>
<td><strong>Miscellaneous Regulations</strong></td>
<td></td>
</tr>
<tr>
<td>No Stopping</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>12 by 18</td>
</tr>
<tr>
<td>End of Through Way</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>12 by 18</td>
</tr>
<tr>
<td>No Pedestrian Crossing</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>12 by 18</td>
</tr>
<tr>
<td>No Dumping Allowed</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>12 by 18</td>
</tr>
<tr>
<td>Load Limit——Tons per Axle</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Every regulatory sign must carry its message. Special conditions may necessitate other messages than those above. If so, they should be brief and simple.

Lettering should be proportionate to the size of the sign. The specified dimensions are minimum.

If possible, the principal message should have not more than three words and should be in not smaller than 3-inch letters.

Signs for use on high-speed highways should be considerably enlarged—to the size of billboards if necessary.
Section 142—Detailed Design of ONE-WAY Sign

The design and specifications of the standard ONE-WAY sign (Fig. 142) shall be as follows:

(a) **Shape.**—Arrow (alternate, rectangle with arrow on it).
(b) **Color.**—White arrow, black letters, black background if rectangle is used.
(c) **Dimensions.**—36 inches long by 12 inches high.
(d) **Letters.**—3½ inches, Series C, centered on shaft of arrow.
(e) **Message.**—ONE-WAY.

The sign shall be so attached as to prevent turning to give wrong direction.

This special design is recommended because its symbolic shape has attained very general recognition and use for this specific indication. A similar arrow sign is frequently used for detours.

Section 143—Detailed Design of Slow-Type Sign

The design and specifications of the standard slow-type sign (Fig. 143) shall be as follows:

(a) **Shape.**—Diamond (square with diagonal vertical).
(b) **Colors.**—Yellow background with black letters and border, white reflecting buttons.
(c) **Message and Dimensions.**—One of the messages in the following table with corresponding minimum dimensions of letters and sign as indicated:

<table>
<thead>
<tr>
<th>Message</th>
<th>Minimum Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Letters</strong></td>
</tr>
<tr>
<td>Arrow bent to right</td>
<td>24 by 24</td>
</tr>
<tr>
<td>(symbol for right turn)</td>
<td></td>
</tr>
<tr>
<td>Arrow bent to left</td>
<td>24 by 24</td>
</tr>
<tr>
<td>(symbol for left turn)</td>
<td></td>
</tr>
<tr>
<td>Symbol for T intersection</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Arrow curved to right</td>
<td>24 by 24</td>
</tr>
<tr>
<td>(symbol for right curve)</td>
<td></td>
</tr>
<tr>
<td>Arrow curved to left</td>
<td>24 by 24</td>
</tr>
<tr>
<td>(symbol for left curve)</td>
<td></td>
</tr>
<tr>
<td>Reverse curve (symbol)</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Winding Road</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Hill</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Dip</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Narrow Bridge</td>
<td>24 by 24</td>
</tr>
<tr>
<td>One-Lane Bridge</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Narrow Road</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Draw Bridge</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Low Bridge</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Underpass</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Pavement Ends</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Safety Zone (with arrow)</td>
<td>24 by 24</td>
</tr>
</tbody>
</table>
Every slow-type sign should bear a message indicating the kind of hazard warranting a reduction of speed for a vehicle. The word “slow” on the sign is unnecessary, except in the last sign in the table above, since both the shape and color of the sign give this message. While the messages above are believed to cover all normal requirements and should be used in preference to others conveying the same meaning, it is recognized that special conditions may necessitate other messages, which should be similarly brief and simple.

All messages should be centered on the sign. In the case of the SAFETY ZONE sign, the large arrow or arrows permitting cars to pass on one or both sides should be centered vertically with the words SAFETY and ZONE respectively above and below on two lines.

See Section 114 for the proper application of the BAD CORNER sign as distinguished from other intersection signs.

Section 144—Detailed Design of Caution-Type Sign

The design and specifications of the standard caution-type sign (Fig. 144) shall be as follows:

(a) Shape.—Square with two sides vertical.
(b) Colors.—Yellow background with black letters and border; reflecting buttons white.

(c) Message and Dimensions.—One of the messages in the following table, with corresponding minimum dimensions of letters and sign as indicated:

<table>
<thead>
<tr>
<th>Message</th>
<th>Minimum Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Letters</td>
</tr>
<tr>
<td></td>
<td>Inches</td>
</tr>
<tr>
<td>Bad Corner</td>
<td>4</td>
</tr>
<tr>
<td>Car Line</td>
<td>4</td>
</tr>
<tr>
<td>Tunnel</td>
<td>6</td>
</tr>
<tr>
<td>Viaduct</td>
<td>5</td>
</tr>
<tr>
<td>Stop Sign Ahead</td>
<td>4</td>
</tr>
<tr>
<td>Slow to—Miles</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Diagram of intersection

(see paragraph on page 32)
### Minimum Dimensions

<table>
<thead>
<tr>
<th>Message</th>
<th>Letters</th>
<th>Series</th>
<th>Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough Road</td>
<td>5</td>
<td>C</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Slippery When Wet</td>
<td>5</td>
<td>B</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Rough Shoulder</td>
<td>5</td>
<td>B</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Soft Shoulders</td>
<td>5</td>
<td>A</td>
<td>24 by 24</td>
</tr>
<tr>
<td>School</td>
<td>6</td>
<td>B</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Playground</td>
<td>4</td>
<td>B</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Church</td>
<td>6</td>
<td>B</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Hospital</td>
<td>4</td>
<td>C</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Quiet Zone</td>
<td>5</td>
<td>C</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Cross Walk</td>
<td>4</td>
<td>D</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Cattle Guard—300 Feet</td>
<td>$3\frac{1}{2}$</td>
<td>C</td>
<td>24 by 24</td>
</tr>
<tr>
<td>Bridle Path</td>
<td>4</td>
<td>D</td>
<td>24 by 24</td>
</tr>
</tbody>
</table>

Diagrams of intersections shall indicate accurately the angles of the highways forming the intersection, reading upward with the highway of approach vertical on the sign, and shall differentiate by weight of line between important and lesser highways.

Every caution-type sign should bear a message indicating the kind of hazard. Special conditions may necessitate other messages than those above. If so, they should be brief and simple.

See Section 114 for the proper application of intersection caution-type signs as distinguished from other intersection signs.

### Section 145—Detailed Design of Railroad Advance Warning Sign

The design and specifications of the standard railroad advance warning sign (Fig. 145) shall be as follows:

(a) **Shape.**—Circle.

(b) **Colors.**—Yellow background with black border, symbol and letters (white background in States so requiring by law); reflecting buttons white.

(c) **Dimensions.**—30 inches in diameter.

(d) **Letters.**—6-inch, Series E.

(e) **Message.**—Diagonal cross (symbol for railroad crossing) in 2½ inch lines, and letter R in each side quadrant.

The diagonal cross is substituted for the former standard of a vertical cross to be consistent with the cross-buck sign at the crossing and to avoid conflict with highway intersection signs (see Section 144).

When the vertical cross was standard, a second horizontal bar was sometimes used to indicate more than one railroad track. This tended
toward confusion, as no more than two tracks could be shown, and the only satisfactory place to show the number of tracks is on the RAILROAD CROSSING sign itself (see Section 146).

Section 146—Detailed Design of RAILROAD CROSSING Sign

The RAILROAD CROSSING sign shall be of the cross-buck type and shall conform to the design and specifications adopted by the Association of American Railroads (Fig. 146).

The Association of American Railroads standards call for auxiliary signs mounted on the same support under the following conditions:

When there is more than one track, an inverted T-shaped sign, with a numeral for the number of tracks over the word “Tracks.”

When there is an automatic signal at the crossing, a horizontal rectangle carrying the words “Stop When Swinging” or “Stop on Red Signal,” or a vertical rectangle carrying the single word “Stop,” which is illuminated only when the signal shows that a train is approaching.

Details are shown in Bulletin No. 2, Railroad Highway Grade Crossing Protection, Association of American Railroads.

Section 147—Detailed Design of U S Route Marker

The design and specifications of the standard U S route marker (Fig. 147) shall be as follows:

(a) Shape.—Shield.
(b) Color.—White background with black border and letters.
(c) Dimensions.—16½ by 16 inches.
(d) Letters.—2-inch.
(e) Figures.—5-inch.

The width of letters and figures must be varied to fit the spaces provided, depending on the length of the state name and the number of digits in the route number, but they should be centered on the design in every case.

Section 148—Detailed Design of Auxiliary Signs for Use with Route Markers

The design and specifications of standard auxiliary signs (Figs. 148 a-f) for use with U S route markers shall be as follows:

148a—Directional Letter R or L (to indicate in advance of an intersection that the route deviates to the right or left).

(a) Shape.—Shield similar to route marker.
(b) Color.—White background with black letter and border.
(c) Dimensions.—9 by 8 23/32 inches.
(d) Letter.—5-inch, Series E.
148b—Directional Arrow (to indicate at an intersection that the route deviates to the right or left).

(a) Shape.—Horizontal rectangle.
(b) Color.—White background with black arrow and border.
(c) Dimensions.—Sign 15 by 8 inches; arrow 11 by 4½ inches.

148c—JUNCTION Sign (to give advance indication of points where other routes meet or cross the one marked).

(a) Shape.—Horizontal rectangle.
(b) Color.—White background with black letters and border.
(c) Dimensions.—20 by 8 inches.
(d) Letters.—4-inch, Series B.

148d—DETOUR Sign (to be used in conjunction with route markers to indicate a route temporarily used as a detour).

(a) Shape.—Horizontal rectangle.
(b) Color.—White background with black letters and border.
(c) Dimensions.—20 by 8 inches.
(d) Letters.—4-inch, Series C.

148e—ALTERNATE ROUTE Sign (to be used in conjunction with route markers to indicate alternate route).

(a) Shape.—Horizontal rectangle.
(b) Color.—White background with black letters and border.
(c) Dimensions.—20 by 8 inches.
(d) Letters.—4-inch, Series A.

148f—BY-PASS ROUTE Sign (to be used in conjunction with route markers to indicate by-pass around congested urban area).

(a) Shape.—Horizontal rectangle.
(b) Color.—White background with black letters and border.
(c) Dimensions.—20 by 8 inches.
(d) Letters.—4-inch, Series B.

148g—BUSINESS ROUTE Sign (to be used in conjunction with route markers to indicate route to business part of city).

(a) Shape.—Horizontal rectangle.
(b) Color.—White background with black letters and border.
(c) Dimensions.—20 by 8 inches.
(d) Letters.—2-inch, Series C.

148h—TEMPORARY ROUTE Sign (to be used on road not intended as a permanent part of the route).

(a) Shape.—Horizontal rectangle.
(b) Color.—White background with black letters and border.
(c) Dimensions.—20 by 8 inches.
(d) Letters.—4-inch, Series A.
Section 149—Detailed Design of Main Destination Sign

The design and specifications of the standard main destination sign (Figs. 149 and 149a) shall be as follows:

(a) **Shape.**—Rectangle with larger dimension horizontal.
(b) **Color.**—White background with black letters and border.
(c) **Dimensions.**—At least 15 inches high and long enough to accommodate name and arrow, spaced as provided for in this code.
(d) **Letters.**—5-inch, Series B.
(e) **Symbols.**—Direction arrow opposite each name. (A vertical arrow means straight ahead.)

The specified size may not be practicable in some locations. In such cases a sign should be designed which will adequately meet the conditions but in no case require letters less than 4 inches high.

Section 150—Detailed Design Secondary Destination Sign

The design and specifications for the standard secondary destination sign (Fig. 150) shall be as follows:

(a) **Shape.**—Rectangular slat with longer dimension horizontal.
(b) **Color.**—White background with black letters and numerals.
(c) **Dimensions.**—36 by 6 inches.
(d) **Letters.**—4-inch, Series B.
(e) **Symbols.**—One end and opposite corners painted black to indicate head and tail of a direction arrow.

If the specified length is too short to accommodate the desired place name, the slat may be lengthened, but all slats displayed on the same post shall be of the same length. In no case shall the letters and numerals be less than 4 inches high.

Fig. 150 illustrates the approved design and method of mounting.

Section 151—Detailed Design of Location and Information Sign

The design and specifications of the standard location and information sign (Figs. 151a-151b) shall be as follows:

(a) **Shape.**—Rectangle with longer dimension horizontal.
(b) **Color.**—White background with black letters and border.
(c) **Dimensions.**—18 by 12 inches, or larger multiples of 6 inches.
(d) **Letters.**—4 inch or larger.

An exception to the foregoing is made in the case of the standard “Rest Station” sign. Its design and specifications (Fig. 151c) shall be as follows:

(a) **Shape.**—Clover leaf.
(b) **Color.**—Dark green background with white letters and border.
(c) **Dimensions.**—15½ by 15 3/16 inches.
(d) **Letters.**—Main message 3-inch, Series B; Secondary message 2-inch, Series B.
Article IV—Location and Installation

The location and installation of signs becomes more difficult each year. Higher speeds requiring visibility at greater distances and wider roadways requiring the signs to be placed farther from the center of the roadway call for greater care in locations. The signs should be located with a view to making them seen at all times with a minimum of effort, and to obtaining maximum obedience. They should be located at such points with respect to the hazard or legal requirement they indicate as to permit compliance by operators of motor vehicles with adequate four-wheel brakes operated at reasonable speeds (see table of braking distances, Appendix C).

Section 152—STOP Signs

STOP signs at highway intersections shall be located at the crosswalk line or, in the absence of a crosswalk, not more than 30 feet from the intersected roadway.

STOP signs at railroad grade crossings shall be located 15 to 50 feet from the nearest track.

STOP signs at drawbridges shall be located exactly where it is desired that vehicles stop.

STOP signs at street ends shall be located in the center of the roadway at its end.

When possible, a STOP sign should be placed exactly where vehicles are expected to stop. At an intersection it should be as near thereto as possible without encroaching upon the crosswalk, so that operators can have a clear view of traffic approaching from both directions on the main thoroughfare. If, because of rounded curbs, the sign cannot be placed at this point, it should be placed at the end of the curb return and a stop line or marker installed at the stopping point. If curves in the highway reduce visibility, an advance warning sign reading “Stop Sign Ahead” should be used.

Section 153—ONE-WAY Signs

ONE-WAY signs shall be placed on both corners of the outlet of a one-way street or highway, as well as at midblock entrances thereto, as from alleys and filling stations.

When a two-way street is changed to a one-way movement, the exit shall be protected with a ONE-WAY—DO NOT ENTER sign (Section 141) located on the right hand corner or in the parking lane adjacent to the point.

Section 154—Parking Signs

Parking signs shall be placed at the first and last point where the legal requirement is effective, and at intervals of about 100 feet where the requirement applies continuously for a considerable distance.
Section 155—Other Regulatory Signs

Other regulatory signs shall be located where the legal requirement is effective.

Section 156—Railroad Advance Warning Signs

Railroad advance warning signs shall be located normally about 350 feet from the railroad crossing in rural areas, but not more than 450 feet or less than 200 feet; a minimum of 100 feet in municipalities.

This sign should be placed at such distance that a vehicle moving at the usual speed of traffic at the location can be stopped if necessary before reaching the crossing. This distance will depend on the local conditions, such as grades, curves and visibility. It should be a maximum on a long straight down grade in open country where high speeds prevail, and might be a minimum of 100 feet in congested districts where slow speeds are necessary. If there is a street intersection within 100 feet, an additional sign or signs should be so placed as to warn traffic approaching the crossing from each intersecting street. (See Fig. 156 for typical signs and markings at a railroad grade crossing.)

Section 157—RAILROAD CROSSING Signs

RAILROAD CROSSING signs shall be located 15 feet from the nearest rail of the nearest track.

Section 158—Slow-Type and Caution-Type Signs

Slow-type and caution-type signs shall be located a distance in advance of the hazard equal to the official braking distance for four-wheel-brake vehicles at speeds commonly used by drivers approaching such a point, but in no case less than 100 feet (see Appendix C for table).

Road construction and repair signs, where traffic is warned that use of the highway ahead must be with caution, should be placed 300 to 400 feet ahead of the restricted zone. A DETOUR AHEAD sign should be placed an equal distance in advance of the point of detour. If a restricted zone is of considerable extent, repetition of the warning by judicious use of portable signs along or in the roadway is desirable.

Section 159—Route Markers

Route markers at intersections shall be placed on the far corner beyond the intersection, except those giving advance indication of a turn in the route, which shall be located in the same manner as warning signs.
Route markers set beyond intersections to "pull" traffic through should be located in plain view from the approach to the intersection and not more than 100 feet from it. Route markers set in advance of the intersection to give warning of a turn in the route should be in advance of the intersection a distance equal to the braking distance of two-wheel-brake vehicles at the average speed of approach to the intersection. Care should be taken not to place the sign at such point as to turn traffic into an alley or secondary street in advance of the proper turn. (See Fig. 159 for typical signs and markers at an intersection of two numbered routes.)

The clear marking of routes through towns and cities is much more difficult than rural marking, and great care should be taken to place signs where they will be in plain view at all times regardless of traffic conditions, and at relatively short intervals.

**Section 160—Destination Signs**

Destination signs at intersections should preferably be located on the far side of the intersection.

Where grades are separated and vehicles must turn right around a loop in order to proceed to the left without crossing other traffic streams, a destination sign pointing right shall be conspicuously placed at the beginning of the loop and a confirmatory sign shall be placed pointing in the final direction near the junction of the loop with the second main highway.

Destination signs are particularly necessary when a turn must be made in the opposite direction to that to be expected by the motorist.

**Section 161—Proximity of Signs**

Two signs for different purposes should not be placed closer together than 100 feet if it can reasonably be avoided. Exceptions to this rule are sometimes necessary, particularly where space is limited, but the principle is sound. Two signs close together are difficult for the motorist to read at modern speeds.

Where a warning sign and a route marker are needed at approximately the same location, the warning sign should precede the marker.

**Section 162—Position in Relation to Roadway**

Signs other than temporary signs in the roadway shall be placed on the right side of the roadway and at right angles to it. They shall not be located on the insides of curves, in sags in the profile or behind objects which would obstruct their view.
Fixed signs are placed on the right, where they are not obscured by oncoming traffic. Uniformity in this makes it more likely that the motorist will see the signs, because he knows where to look for them.

Where reflecting elements are used, the sign should be turned slightly toward the roadway, so that the reflecting elements face the point on the roadway where its visibility at night should begin.

Where the width of usable roadway permits, portable signs in the roadway are frequently preferable to roadside signs to indicate road construction or repairs. Similarly ONE-WAY—DO NOT ENTER signs may be more effective when they can be placed in parking space in the roadway.

Section 163—Lateral Distance from Pavement or Roadway

Where a raised curb exists, signs shall be set so that no part of the sign shall be less than twelve inches back of the curb line.

On improved highways where no curb exists, signs shall be erected at the outside edge of the graded shoulder, except that on wide shoulders they shall be not more than ten feet from the edge of the surfacing.

On unimproved or narrow roads no fixed distance can be established. Signs should be located conspicuously. If they cannot be seen sufficiently far in advance they are of no value. They are placed back from the roadway only for their own protection. It is better to place a warning sign too close to the roadway and have it prevent accidents, even though it is knocked down occasionally, than to move it too far back and have it ineffectual.

Section 164—Height

On rural highways, where vehicles do not park in front of the sign within the required visibility, the center of the sign shall be 3-1/2 feet above the crown of the pavement. This also applies to signs on fixed obstructions in the roadway.

In business or residential areas, or wherever a raised curb exists, the center of the sign shall be 8 feet above the pavement.

While the lower mounting is slightly more visible, particularly at night, it is easily obscured by vehicles parked within 100 feet in front of it. Thus if there is any reasonable chance of vehicles parking here, the higher mounting should be used. Reflecting elements have been improved so much during recent years that they are effective at heights from 8 to 10 feet.

Destination signs not otherwise illuminated should be at such height that they can be read at night with the aid of the automobile lights.
Article V—Maintenance

Signs poorly maintained have reduced authority. Following are minimum standards of maintenance.

Section 165—Continuous Maintenance

All traffic signs shall be kept in good order and clearly legible at all times. Signs damaged or destroyed shall be replaced within 24 hours.

Section 166—Schedules for Cleaning and Repainting

Signs shall be cleaned and inspected for repainting at least once a year.

Section 167—Prompt Removal of Obsolete Signs

Signs no longer applicable shall be removed immediately.

This is particularly important with reference to DETOUR and other signs erected in connection with road construction or repairs.
PART II—MARKINGS

Introduction

Markings are closely allied to symbolic signs. They have very definite limitations, especially when applied to pavements and curbs, where they are obliterated entirely by snow, are not clearly visible when wet, and are not very durable if painted. In spite of these limitations, however, they are preferable to signs for certain conditions requiring the transmission of warning or information to the vehicle driver without diverting his attention from the roadway.

The application of markings to traffic control covers a wide range of uses, such as warning of obstructions in the roadway or close to its edges; warning of ditches, culverts or curves which are protected by posts set on the road shoulders; warning of railroad crossings; attracting attention to signs mounted on posts; designation of lanes on the roadway, pedestrian crossings or clearance limits of turning street cars; restrictions as to parking or stopping vehicles, and many similar conditions. Center lines tend to prevent collisions at curves and hill crests. Laning of wide thoroughfares, particularly approaching intersections, may convert chaos into orderly flow. Marking of crosswalks may save many pedestrian lives.

Where markings are used, they should conform to the design, location and maintenance standards presented in this manual.

Classification

Markings for traffic control may be classified as follows:

A. Pavements
   1. Lines
   2. Words
   3. Buttons
   4. Series of arrows

B. Curbs
   1. Solid color
   2. Words and colors
   3. Stripes

C. Objects
   1. Stripes
   2. Solid color

While there is considerable similarity in function and application of markings on pavements and curbs, they have little in common with the marking of objects as warnings of hazards. Consequently these two major classifications of markings will be treated in separate divisions, thus:

Division A—Regulatory and guidance markings on pavements and curbs
Division B—Warning markings on objects of hazard (including curbs when they are hazards)

Standardization

Most markings are individually simple as compared with signs, but they cannot be so completely standardized because of variety of type and application.

The characteristics that have been standardized are location, colors, and design or pattern of marking, including width of lines and dimensions of certain designs.

41
DIVISION A—REGULATORY AND GUIDANCE MARKINGS

Article A-I—Legal Authority

Pavement and curb markings, being almost exclusively within the boundaries of public highways, are seldom placed except by public authority. No other agency should be permitted to place them.

Section 201—Legal Authority

Markings shall be placed only by the authority of a public body or official having jurisdiction for the purpose of regulating, warning or guiding traffic.

The model for legal authority in the Uniform Vehicle Code and Model Traffic Ordinances referred to in Section 101 is equally applicable to markings.

Article A-II—Application and Location

The proper and judicious application and location of pavement and curb markings may be very helpful in safeguarding and expediting traffic. It is highly important, however, that there be both wise selection of points for marking and accurate location of the markings in accordance with the accepted standards.

Section 202—Lines on Pavements

Lines are marked on pavements for regulatory purposes as follows:

(a) Center of roadway in dangerous locations
(b) Traffic lanes
(c) Pavement edges
(d) Turning limits and street car clearances at turns
(e) Boundaries of pedestrian crosswalks
(f) Limit lines at through highways and signalized intersections
(g) Approach to an obstacle or reduced roadway width
(h) Change from two-way to one-way street
(i) Boundaries of safety zones
(j) Parking limits and stalls

Arrows are marked on pavements for directional purposes to indicate the center of a route to be followed.

Section 203—Center Lines

Line markings on pavement shall be placed on the medial line of the roadway in the following locations:

(a) On the approaches to the crest of a hill where the clear view ahead is less than 500 feet.
(b) On all curves having a radius less than 600 feet or where the clear view ahead is less than 500 feet.
(c) On pavements wider than 40 feet.
Center lines should also be marked:
(a) On the approaches to a railroad grade crossing (except of a minor siding or spur) for a distance of 350 feet from the center of the nearest railroad track.
(b) On the approach to a traffic control signal for a distance of not less than 50 feet from the limit line, and as much more as may be necessary to cover the distance within which vehicles are commonly aligned.
(c) On two-lane roadways narrower than 16 feet.
(d) Wherever there is a large volume of traffic.

In some states the practice is to use center lines on two-lane roadways only at points where overtaking and passing is hazardous and unlawful. In others, they are extensively used even on straight level stretches as aids to driving. Wherever the latter practice is followed, **distinctive lines shall be used at the points of hazard.** A double line is suggested for this purpose.

**Section 204—Lane Markings**

Line markings to form lanes are especially desirable:
(a) On roadways wide enough to carry more than two streams of traffic.
(b) Between safety zones and sidewalk curbs where there are two or more lane spaces available.
(c) On the approaches to hill crests and railroad grade crossings and on curves where the roadway is wide enough to accommodate four or more lanes.

Longitudinal lines used to form lanes should be so spaced across the roadway as to allow not less than 10 feet of width for each lane of moving traffic and not less than 7 feet for vehicles parked parallel to the curb.

On highways marked with an odd number of traffic lanes, the middle lane shall be discontinued on hill crests and curves throughout any section of the highway where the clear view ahead is less than 500 feet, on bridges narrower than the adjoining pavements, and at signalized intersections; and the lane lines bounding this middle lane shall converge to a single center line which shall be continued throughout the length of the danger zone.

The foregoing applies particularly to three-lane highways, on which overtaking and passing at such places is extremely dangerous.

In some instances, lane lines are distinguished from center lines by being broken into sections, while center lines in four, six or eight lane roadways should be continuous in all cases.

**Section 205—Street Car Clearance Limits**

Curved lines are frequently used at intersections to indicate the limits of turning movements, the clearance of the overhang of turning street cars, and vehicle lanes outside such clearance lines or around islands.
Section 206—Crosswalks

Crosswalks shall be marked at all intersections where there is material conflict between vehicular and pedestrian movement.

The marking of crosswalk boundaries is most important and should be used extensively wherever there is considerable pedestrian movement. Such lines encourage pedestrians to walk in designated spaces, and are particularly essential at irregular intersections where otherwise the pedestrian cannot determine the proper place to cross. They also indicate to motorists where they must look for pedestrians.

Marked crosswalks should also be provided at other points where there is substantial pedestrian movement, as at long loading islands, schools, churches and in the middle of long blocks in shopping districts.

Section 207—Limit Lines

Limit lines shall be used when it is important that vehicles, in compliance with a STOP sign, traffic control signal or officer’s stop indication, stop behind a point not indicated by a marked crosswalk.

While it is not absolutely necessary to mark the limit line in conjunction with a mandatory sign where the sign can be placed opposite the desired point, it is imperative where the physical layout of the intersection prevents this.

A flexible sign marker or the word STOP marked on the pavement may be a helpful auxiliary in securing proper observance of the stop rule.

The word “STOP” shall never be marked on a pavement or used on a flexible sign marker where a stop is not always required.

Some communities have improperly used this word marking to designate the limit line at traffic control signals.

In some jurisdictions, additional transverse lines are marked on the streets approaching a signalled intersection at a distance in advance of the limit lines to indicate to the motorist the point beyond which he can continue to travel at legal speed and clear the intersection during the period that the warning yellow light is displayed before appearance of the red STOP light.

Section 208—Approach to an Obstruction

Pavement markings shall be used to give warning of the approach to an obstruction unless the obstruction is within an intersection.
The marking of guide lines on the pavement to indicate the safe limits for traffic to clear an obstacle in the roadway is of almost as much value as the marking on the face of the obstacle itself.

Section 209—Boundaries of Safety Zones

The pavement area restricted for use as a safety zone may be marked by lines or buttons in cases where no raised platform has been installed, but their use should be supplementary to the installation of adequate end and side protection of the zone in accordance with the standards presented in Part IV (see Sections 409 and 410).

The use of lines, buttons or lines and buttons without other protection to designate a so-called safety zone is dangerous and is not recommended.

Section 210—Parking Space Limits

The marking of parking space limits tends to prevent dangerous encroachment on fire hydrant zones, bus stops, taxicab stands, loading zones, approaches to corners and clearance spaces for islands. Both pavement and curb markings are used for this purpose.

Parking space limits are indicated on the pavement by lines marked perpendicular to the curb and extending into the roadway the width of a vehicle. In cases where angle parking is permitted, the marking of lines to indicate the limits of stalls enables all operators to park at the same angle with a minimum of waste space.

Section 211—Route Directions

Special directional markings consisting of a series of short arrows in the center of the lane can sometimes be used to route traffic in a manner that could not be indicated by any other means.

Section 212—Approach to Railroad Crossing

Markings to give warning of approach to a railroad crossing are frequently used, especially on rural highways. They consist of several lines and letters arranged in a distinctive design which is never used for any other purpose.

Section 213—Pavement Edges

Line markings on the pavement may be located along the sides of the roadway, especially on bridges, to indicate the limit of safe approach to the edge of the pavement. These are of great benefit at night on dark colored roadways.

Diagonal guide lines should also be used wherever a roadway changes to a narrower width so as to provide sufficient distance to permit traffic to make the transition (see Section 234).
Section 214—Word Markings

Word markings shall not be used for mandatory messages without supporting signs.

Words marked on the pavement or sidewalk curbs are used sometimes to convey brief directional or informative messages supplementary to standard signs. While such word markings present their message without diverting attention from the roadway, a message of more than three words is difficult to apprehend.

Flexible sign markers carrying words may be used instead of words painted on the pavement, but only supplemental to standard signs.

Section 215—Button Markings

Buttons that project several inches above the pavement, whether illuminated or not, shall not be used at any point where they can interfere with traffic.

Buttons may be used to mark non-traffic areas in a wide pavement. In such cases constantly high visibility should be maintained.

Section 216—Curb Markings

Curb markings in color to show parking regulations are of value in showing exactly where parking is restricted, especially where the regulations vary within short distances, but they are not generally effective except as supplementary to standard signs.

Markings on the vertical faces of curbs are effective at the ends of angle or perpendicular parking stalls to indicate parking time-limits and to indicate street names and house numbers. Time-limit markings on curbs where parallel parking is in use have not proved effective.

Article A-III—Design

Section 217—Lines on Pavements

Lines may be marked on pavements by:

(a) Construction joints in the pavement, filled with material of contrasting color.
(b) Construction of the pavement with adjacent strips of different materials showing variation of surface.
(c) Paint or lacquer of contrasting color applied to the surface.
(d) Inserts set into or attached to the body of the pavement.

Section 218—Construction Joints

Many roadways, especially those made of concrete, are built in two or more longitudinal strips wide enough to accommodate a lane of traffic, the joints between the strips being filled with an elastic waterproof compound of a different color than that of the pavement. Such joint lines are very effective in holding traffic in the lanes thus defined.
Transverse lines of this character may also be useful for traffic control purposes, marking limit lines or crosswalks. In the case of pavements laid with transverse joints at regular intervals, however, any joints intended to serve for traffic control purposes must be distinctive in appearance.

Section 219—Contrasting Pavement Materials

Many roadways wider than required for two traffic lanes are built with a single lane of concrete pavement on each side of the roadway and macadam or other material between. The surface of this medial area has a different color and surface texture from the concrete and serves very effectively to hold the opposing streams of traffic apart so that the center is used only for passing.

Section 220—Paint and Lacquer

A common method of marking lines on pavements is by painting, for which purpose special paints and lacquers having durable qualities have been developed (see Appendix E). Disadvantages of this method are that lines subjected to continuous wear from traffic require frequent renewal at considerable expense, even when painting machines are employed, and if they are not renewed as needed they become quite ineffective. An advantage of painted lines is that they can be relocated from time to time if traffic or roadway conditions are altered. They are also very effective while in good condition.

Section 221—Inserts

Inserts are sometimes placed in the pavement to give the appearance of a line. There are several general types:

(a) A narrow strip of contrasting colored concrete set when the pavement is constructed.
(b) Blocks, usually rectangular, set into the pavement.
(c) Disks, usually circular, attached to the pavement.

221a—Rectangular inserts shall be of a permanent color different from that of the pavement, and shall be set so that their upper surfaces are flush with the level of the pavement. They shall be set end to end to form a continuous line, or they may be separated by spaces not greater than the length of a single insert so that the appearance will be that of a broken line.

221b—Round inserts shall show a bright surface contrasting with that of the pavement under the action of traffic, shall be not less than 4 inches in diameter and shall be spaced not more than 16 inches apart center to center on transverse lines nor more than 36 inches apart center to center on longitudinal lines. (They may be set as much closer together as desired.) They shall have a rounded sur-
face so that a smooth contour will be presented to the wheels of vehicles, and they shall not project more than 1/2 inch above the level of the pavement. They shall be permanently fixed in place by anchor bolts or some similar effective device.

Section 222—Widths of Lines on Pavements

Lines marked on pavements shall be not less than 4 nor more than 8 inches wide.

Very wide lines lose their distinctiveness and authority, instead of emphasizing it, as is generally intended.

Section 223—Lengths of Longitudinal Broken Lines

Longitudinal broken lines and the intervening spaces shall be of equal length, within the following limits:

- Center lines and lane markings, 5 to 75 feet
- Street car clearance lines, 2 to 4 feet
- Traffic guide lines, 4 to 10 feet

An arrowhead shall be placed on each section of a traffic guide line.

It is important that the arrows in traffic guide lines be short enough so that the vehicle driver can always see at least two of them. Long directional lines with a single arrowhead at the extreme end which cannot be seen until the end is approached are useless and are likely to be confused with lane markings.

Section 224—Words on Pavements

Words are usually marked on pavements by painting or stenciling, although in some instances round inserts have been used satisfactorily.

The letters should be greatly elongated in the direction of traffic movement because of the small angle at which approaching drivers view the letters (see Fig. 224). If more than one line of words is used, the separating space should be about twice the height of the letters.

Section 225—Colors for Lines or Words on Pavements

On pavements it is difficult to secure a color which will show a strong contrast under all conditions. White, yellow and black are the colors commonly used, depending upon the color of the pavement.

Section 226—Markings to Eliminate Center Lane at Hazardous Points

Markings to eliminate the center lane at hazardous points (see Section 203) shall be made as follows:
(a) A center line shall be marked through the area where the unobstructed view in both directions is less than 500 feet.

(b) The ends of the center line shall be connected with the ends of the lines marking the center lane by straight lines at an angle of 1 in 20 with the center line.

Section 227—Crosswalks

Both boundaries of a marked crosswalk shall be indicated by line markings across the entire roadway.

To facilitate pedestrian cooperation in traffic regulation, pedestrians should know exactly where they are to cross the street, and should feel reasonable security not only against vehicles approaching the intersection, but also against those turning within it. Single line crosswalks fail in this, and are not recommended.

Section 228—Limit Lines

Limit lines, where used, shall be marked across the right half of the roadway at the point behind which vehicles must stop in compliance with a signal or sign (see Fig. 228).

Section 229—Approach to an Obstruction

Pavement markings to give warning of approach to an obstruction shall be in the form of two lines starting 6 inches outside of each corner of the approach end of the obstruction and converging at a point distant ten times the width of the obstruction, from which point a single line shall be extended 100 feet farther from the obstruction (see Figs. 229 and 229a).

Section 230—Pavement Markings for Parking Regulations

Pavement markings to indicate parking regulations, when used, shall be as follows:

(a) For parallel parking a line 6 feet long at right angles to the curb at each end of a prohibited zone indicated by curb markings.

(b) Where angle parking is permitted, a series of lines spaced not less than 7 feet apart, measured at right angles to such lines, and located at the established angle with the curb to form parking stalls.

In the first case the line is used to indicate more clearly the limit beyond which a vehicle must stand to clear the prohibited zone, and should be used only for parking parallel with the curb.

* In the second case the angle of the lines with the curb is usually approximately 45 degrees. This is the most effective angle, considering both ease of access and pavement occupancy. While perpendicular parking does not occupy any more of pavement area and will accommodate more cars for a given length of curb, the difficulties of access are so great and there is so much interference with other
traffic that this method may be employed only on very wide highways with a small volume of traffic. In such cases the stalls should be 8 feet wide (see Fig. 230).

Section 231—Curb Markings for Parking Prohibitions

Curb markings to designate parking prohibitions, when used, shall be a solid color.

Curb markings should be uniformly 6 inches wide on the top surface, the marking of the vertical surface being optional.

On curbs yellow or orange is preferred because dirt does not show as badly as on white. (The American Engineering Council manual recommended a color code for curb markings to distinguish various regulations regarding the stopping and parking of vehicles, but the public has not comprehended the code; hence, only one solid color is recommended to mark curbs where parking is prohibited.) Where curb markings are used to indicate parking prohibitions, their effectiveness has been increased by a line running perpendicularly from the curb 6 feet into the roadway at each end of the curb marking.

Section 232—Route Directions

Where a line of arrows is marked on the pavement to indicate a route direction, such line shall be located in the center of the lane of traffic that is to follow the designated course.

It is important to locate the directional line of arrows in the center of the lane to distinguish it from a lane marking. The combination of two solid lane markings with directional arrows midway between them cannot be mistaken as to its significance.

Direction arrows shall be marked on the approaches to a loading island when vehicular traffic is permitted to pass only to the right of the island.

Section 233—Approach to Railroad Crossing

Where pavement markings are used to indicate a railroad grade crossing, they should consist of a special design in accordance with Fig. 233.

While these markings have value as a means of attracting the attention of a driver to the proximity of a railroad grade crossing because of their distinctive character from all other pavement markings, they are only auxiliary to the standard signs, which must be installed in every case.

Section 234—Pavement Edges

Where a line marking is used to connect the edge of a narrower pavement with that of an adjacent wider section, the length of the diagonal connecting line should be at least four times the offset distance.
Article A-IV—Maintenance

Markings poorly maintained have reduced authority. If painted on the pavement where the flow of traffic wears them out quickly, they should be repainted frequently enough to maintain continuous visibility. Traffic authorities should keep a regular schedule of repainting, based on experience as to the effective life of the marking.

Section 235—Continuous Maintenance

All traffic markings shall be continuously kept in good order and clearly visible.

DIVISION B—WARNING MARKINGS ON HAZARDOUS OBJECTS

Article B-I—Legal Authority

Markings on objects as a warning of their hazardous location are subject to the same jurisdictional restrictions as are those on pavements and curbs for the regulation and direction of traffic, which are presented in Section 201.

Article B-II—Application and Location

The application and location of markings on obstacles should be such that they will be visible to all approaching traffic.

Judgment must be exercised in selecting the objects off the roadway, but it may be noted that, even where they are theoretically a safe distance from the roadway, marking them may prevent serious accident and facilitate night driving.

Section 236—Object Markings

Physical obstructions in or near a roadway which constitute serious hazards to traffic, including installations designed for the control of traffic, shall be adequately marked.

Typical obstructions of this character are bridge supports, monuments, traffic islands, beacon or signal supports, loading islands, "Road Closed" barriers, railroad and drawbridge gates, end posts of narrow bridges, underpass piers and abutments, culvert head walls, guard rails, sign posts, poles, trees and rocks. The marking of trees and rocks, even at some distance from the roadway, aids drivers in keeping to the roadway at night.

Frequently obstructions have been placed in roadways under the mistaken belief that they would serve as aids to the control of traffic. Such installations include signal pedestals in the centers of intersections, sign or signal posts in the center of the roadway at railroad crossings, and mushroom buttons in active traffic areas. These should invariably be removed for safety. Only such immov-
able obstructions as bridge supports and necessary islands may be permitted to remain.

Section 237—Curb Markings on Obstructions

Curb markings shall be placed on all islands located in the line of traffic flow, such markings to be similar to those on other obstructions.

Article B-III—Design

As pointed out in the introduction to Part II, the opportunities for standardization in the design of markings are limited. Object markings can and should be standardized as to colors, angles and width of bands.

Section 238—Markings on Obstructions

Obstructions in the roadway shall be marked with not less than five stripes of two sharply contrasting colors visible to approaching traffic at a distance equal to the official braking distance for four-wheel-brake vehicles at speeds commonly used at that point. The stripes shall slope downward in the direction of travel of the observing traffic, at an angle of 45 degrees with the horizontal. The markings shall be painted on the object itself or on an independent surface mounted directly in front of the object.

This design (Fig. 229) attracts attention. The slope of the stripes downward tends to focus traffic into the safe roadway.

Markings of this kind are usually painted on the surface of the obstruction. If the surface would not retain paint readily, some other material, usually wood, should be painted with the marking and attached to the obstruction.

In some places a checkerboard made of squares of contrasting colors has been used, but experience has proved that such markings are not as clearly distinguished from surrounding objects as stripes, and are more expensive, hence they are not recommended.

Section 239—Markings on Adjacent Objects

Objects so close to the roadway as to constitute a definite hazard may be marked with the striped design. Guard rails, trees, rocks and other objects not likely to be hit unless the vehicle leaves the roadway are usually painted solid white.

Section 240—Dimensions of Stripes on Objects

The alternate stripe markings on objects shall be not less than 4 inches wide and shall be as much wider as may be necessary to make a good appearance in proportion to the
A curb at the end of an island or the post supporting a sign would not require stripes of more than the 4-inch minimum width, while a large surface, such as the abutment wall flanking an underpass, might require marking stripes 8, 10 or even 12 inches wide, depending upon its area. The wider stripes are easier and less expensive to mark.

Section 241—Colors for Object Markings

On objects black and white have been used most, but the trend is toward black and yellow. Both combinations have given satisfactory service, and, since their only function is to attract the attention of the driver in ample time for him to avoid the hazard of the obstruction, either may be used, although black and white tends to lose effectiveness when snow is on the ground. Solid white is generally used on guard rails, rocks and trees.

Section 242—Illumination

Wherever an obstruction exists in the direct line of traffic flow in a roadway, the obstruction and marking thereon shall, if possible, be illuminated by a flood light so located as to make it clearly visible to approaching traffic. As a supplementary measure of precaution, it is also advisable to mount on the obstruction at a height of 3½ feet above the pavement an appropriate standard sign containing reflecting elements.

A marking having value in the daytime has equal or greater value at night if the condition warranting it also exists at night. The increase in the volume of night traffic and the increased speeds employed emphasize the need for adequate illumination at night of the markings on all obstructions in the roadway and the greatest possible visibility of pavement markings which give warning of hazards of operation. Flood lighting has been found to be more effective than flashing slow-type signals.

Section 243—Approach to Obstructions

In addition to the markings on the face of an obstruction in the roadway, warning of approach to the hazard shall be given by line markings on the pavement as stated in Section 229.

Article B-IV—Maintenance

It is as important to keep markings on obstacles clearly visible as in the case of pavement and curb markings, but since they are not subject to traffic wear, they do not need to be renewed so frequently. The instruction contained in Section 235 should be observed.
PART III—SIGNS

Introduction

Highway traffic signals include all power-operated devices using light, by which traffic is warned or is directed to take some specific action. Thus they are distinguished from illuminated or reflecting signs.

Classification

Signals are classified as follows:

A. TRAFFIC CONTROL (Stop and Go)  B. FLASHING

1. Fixed time
   (a) Independent
   (b) Simultaneous system
   (c) Alternate system
   (d) Progressive system
2. Traffic actuated
3. Manually operated semaphores*

The basic functions and design of the two principal groups of signals are quite different, and for convenience are treated in separate divisions of this Part.

Standardization

All types of signals can be substantially standardized as to design, location and operation, and it is of primary importance that there be national standardization of such features as affect the public participation in traffic movement. Such standards are herein presented.

Train approach signals are of great importance at railroad crossings. Their design and operation have been standardized by the Association of American Railroads, and only the outstanding features of these standards are recorded in Division B.

Value of Signals

Signals, particularly traffic control signals, involve public expense and alter the natural flow of traffic. Hence they should never be installed except on the basis of thorough factual studies of traffic, accidents and physical conditions.

On such basis, traffic control signals have the following advantages:

(a) They provide for orderly movement of traffic at busy intersections.
(b) They remove the discretion of the operator.
(c) Compared to manual control they represent a considerable economy.
(d) They reduce certain types of accidents at intersections.
(e) Along an artery they can be coordinated to provide for continuous (or nearly continuous) movement at a definite speed.

* Manually operated semaphores must be recognized as traffic control signals. As those in present use are fairly uniform and readily understood, however, and their use is diminishing, they will not be further treated in this manual.
(f) They can be used to prevent speeding on through STOP highways or other main arteries.

(g) They can be used to interrupt heavy traffic at intervals to permit other traffic, pedestrian or vehicular, to cross.

Unfortunately, the recognized effectiveness of properly utilized traffic control signals has led to their installation at a large number of locations where there is no legitimate warrant for their use. Such installations are largely the result of a general but incorrect belief that traffic control signals are an infallible cure for all traffic difficulties. In other cases, warranted traffic control signals have been poorly designed, ineffectively installed, improperly timed and operated and poorly maintained.

Undesirable results from unwarranted or poorly designed signal installations include unnecessary delays, use of other routes to avoid objectionable signals, disobedience to signal indications, and in many cases an increase in accidents. Three independent analyses have shown that, contrary to popular belief, unwisely installed and/or operated traffic control signals increase accidents at 30 to 35 percent of intersections thus signalized, while at an additional 10 to 15 percent, accidents remain unchanged in number.

Much of what is above stated for traffic control signals also applies to flashing signals, whose utility for traffic regulation is increasingly being realized. They will satisfactorily handle many intersection conditions with less delay and with greater reductions in accidents than would have been achieved by advisable use of traffic control signals. They too can be misused, with resulting lack of obedience, unnecessary delays and increased accidents. Careful analysis of facts should likewise be the basis for their installation and use.

DIVISION A—TRAFFIC CONTROL SIGNALS

The classification of traffic control signals indicates two main types, as follows:

(a) Fixed-time signals, which are operated by mechanism on a predetermined time schedule that may, however, be varied in certain ways.

(b) Traffic-actuated signals, which are actuated by approaching traffic by means of mechanical or electrical devices.

Traffic-actuated control may be

(a) Full traffic-actuated, in which there are traffic detectors on all entering streets, or

(b) Semi-actuated, in which only the minor street or streets have detectors, and the GO indication shows automatically and continuously on the main highway except when traffic on a cross street demands the right of way and is accorded it at certain minimum intervals.

Fixed-time signals were in widespread use several years before the first traffic-actuated signals were installed, and still greatly outnumber them. For these reasons fixed-time signals are treated first in
this manual, and details common to both types are discussed under fixed-time signals. Nevertheless, each type has advantages over the other under certain conditions, as will be shown herein.

Traffic-actuated control, to be satisfactory, requires both sensitivity of mechanism to record accurately and respond properly to the “demands” for right of way, and ruggedness to enable it to function under unfavorable weather and other conditions. Traffic authorities contemplating purchase of traffic-actuated equipment should carefully consider its ability to meet these requirements, and the statements in this manual that traffic-actuated control will accomplish certain things assume that the equipment has been wisely selected.

**Article A-I—Legal Authority**

Signal indications would be non-enforceable if placed by other than public authority. Unofficial signals should be legally prohibited, and the erection of unofficial signs or other devices which hide from view or interfere with the effectiveness of any official signal should be prohibited. It is also imperative for safety that signal meanings be strictly observed. Suitable legislative models covering these points are presented in the Uniform Vehicle Code and the Model Traffic Ordinances, as already referred to in Section 101. This control usually gives authority to a certain public body or official to require standardization in the general design, installation, operation and observance of signals. Such broad control when properly used involves numerous advantages and is heartily recommended.

**Article A-II—Application**

Experience has indicated that traffic control signals should be installed only when certain conditions exist. There should be an economic justification for the installation and operation of every signal. Such justification is based upon the value of:

(a) Reduction in delays due to unnecessary periods of waiting and inability to proceed continuously at reasonable speed.
(b) Reduced or prevented accidents.
(c) Improvement in orderly and convenient movement of traffic.

The minimum “warrants” listed in Section 301 are intended to provide such economic justification for fixed-time control.

Pleas are frequently made for the installation of signals at locations which admittedly carry only light traffic and have few accidents. In certain cases, where a new artery has been opened, new paving installed, or some other new condition has arisen, the intersection may warrant immediate attention. Otherwise primary consideration should be given to the locations which have already proved themselves to be unusually hazardous.

The amount of traffic approaching a signalized intersection varies from minute to minute. Not only does the total volume vary, but also the percentage of the cycle necessary for the opposing GO in-
tervals varies. Within reasonable limits, the less traffic, the shorter the GO interval should be. Maximum efficiency in traffic control operation would require intervals of varying length dependent upon the time required for approaching traffic and variances in the percentage of the cycle allocated to the different entering highways. Fixed-time control will not provide these changes except to a limited extent as additional features are provided which vary the cycle length during different times of day, in accordance with a program developed from observed traffic volumes and proportions, and except that certain equipment is now available which will also provide a limited number of changes in the percentage of the cycle allocated to the different GO intervals.

The ideal condition would be for signal indications to change in exact accord with traffic demands from minute to minute. To approach this ideal more nearly, types of control equipment have been developed by which traffic desiring to use the intersection roadway actuates the control mechanism. The resulting method of control is known as traffic-actuated control.

A number of the conditions which should exist to warrant fixed-time control need not be fulfilled for good traffic-actuated control. Reasons are:

(a) Traffic-actuated control when properly designed and operated results almost always in less delay than is involved in fixed-time control.

(b) It generally proves more effective in reducing or preventing accidents because:

1) Violations of the signal, which frequently cause accidents, are less likely because of reduced waiting periods.

2) Traffic-actuated signals can be operated continuously, since the delays inherent in general fixed-time control during light traffic are largely eliminated. Hence, such protection against accidents as is afforded by traffic control operation can be continuously provided.

(c) Traffic-actuated control can be more responsive to traffic demands than fixed-time control, and hence under most conditions more orderly and convenient movement of traffic results. There is less tendency to avoid intersections having traffic-actuated control. This results in more logical routing of traffic and fewer demands for signals.

Therefore, there should be full consideration of the desirability of traffic-actuated control before any decision is reached as to which of the two types of control should be utilized. While traffic-actuated control is generally more expensive than fixed-time control (except possibly the best types of flexible progressive control), analysis will often show that the additional cost is warranted.

**Section 301—Conditions Warranting Installation of Fixed-Time Signals**

Fixed-time traffic control signals shall be installed and operated only where and when one or more of the following warrants, as defined in Sections 302-308, exist:

(a) Minimum vehicular volume

(b) Heavy left turn
(c) Minimum pedestrian volume
(d) Coordinated movement
(e) Through highway
(f) Accident hazard
(g) Combination of warrants; other factors

The various conditions to fulfill these warrants should be established by suitable counts and studies. Such studies should be carried out by a competent traffic engineer.

Section 302—Minimum Vehicular Volume Warrant for Fixed-Time Signals

The minimum vehicular volume warranting the installation and operation of a fixed-time traffic control signal is as follows for the usual intersection:

(a) Total vehicular volume entering the intersection from all directions must average at least 1,000 vehicles per hour for 8 hours, and
(b) Total vehicular volume entering the intersection from the minor street or streets must average at least 250 vehicles per hour for 8 hours, and must be a sufficient percentage of the total from all directions to require the GO indication for at least 25 percent of the time.

This warrant means approximately 17 vehicles per minute entering the intersection from all directions. Most vehicle volume warrants adopted to date require this many vehicles or more.

Where the cross traffic is less than 250 vehicles per hour, alternating of control indications, involving financial outlay and delays to the major street traffic, is not justified. Where it exceeds this amount but does not reach the percentage minimum indicated in paragraph (b) above, traffic-actuated signals are likely to be more effective.

Vehicle volume warrants for intersections of roadways having several moving lanes on one or more streets or highways should be higher than those given. Obviously, considerably more traffic per minute can pass through an intersection in a given time in two or three lanes than in one lane. On multiple lane roadways, due consideration should be given to the number of moving lanes.

When the total vehicular volume entering an intersection having fixed-time signals falls below 500 vehicles per hour for a period of two or more consecutive hours, the fixed-time signals shall be operated as caution or stop signals, or a combination thereof.

The leeway between warrant volume and the reduced volume requiring change from "stop and go" to "caution" or "stop" operation recognizes the impracticability of changing the method of operation many times during the day.

Equipment is available involving a time clock by which a number of changes in cycle length, in the proportioning of intervals, and to and from flashing operation, can be made. Its use is recommended, especially at the more important intersections.
An actual count of vehicles is essential to determine the total vehicular flow through an intersection. In general such counts may satisfactorily be recorded by 15-minute periods, although it is desirable to know of fluctuations during 5-minute periods in the busiest traffic hour. It is suggested that the count classify the vehicles by types and by whether they go straight through, turn right or turn left. The count should be of sufficient duration to establish whether or not a traffic control signal is warranted, and, if so, during what hours it should be operated as a "stop and go" signal. If consideration is being given to operating a signal on "stop and go" control from 7:00 a.m. to 11:00 p.m., the count should cover that period.

A traffic count should be made to establish the need for a traffic signal. The count should be made under the direction of a competent traffic engineer.

Section 303—Heavy Left Turn Warrant for Fixed-Time Signals.

The minimum left turning volume and volumes of other traffic warranting fixed-time signal installation and operation are as follows:

(a) Total vehicular volume entering the intersection from all directions must average at least 1,000 vehicles per hour for 8 hours, and

(b) Vehicular volume making a left turn from one or more directions during a GO interval must involve at least an average of 5 vehicles per minute for the heaviest traffic hour and cross through an opposing stream of at least equal volume.

Occasionally where there is insufficient volume on the cross street to warrant traffic control operation, one or more left turns are so heavy and intersect with such heavy traffic coming from the opposite direction that traffic control operation may be warranted, with one or more separate left turn intervals.

The method of determining the vehicle flow and the form therefore described under Section 302 are suitable for gathering the information necessary to decide whether or not this warrant is satisfied.

Section 304—Minimum Pedestrian Volume Warrant for Fixed-Time Signals

The minimum pedestrian and vehicular volumes warranting fixed-time signal installation and operation are as follows:

(a) Pedestrian volume crossing the major street must average at least 300 persons per hour for at least 6 hours per day,

(b) Vehicular traffic entering the intersection from the major street must average at least 750 vehicles per hour for the same 6 hours, and

(c) Vehicular speeds during the 6 hours must frequently exceed 15 miles per hour.

When for two or more consecutive hours the vehicular traffic drops below 375 vehicles per hour on the major street, or the pedestrian volume crossing the major street drops below 150 persons per hour, the signal shall not be operated as a fixed-time signal.
Provision for safe and convenient use of roadways by pedestrians warrants greater attention than it has heretofore received. Nearly two-thirds of all persons killed in traffic accidents are pedestrians. Intersections which meet this warrant justify control where cross vehicular traffic is too light to warrant a signal solely on the vehicular basis.

Traffic control signals may be warranted for pedestrian benefit in certain cases where vehicular volume is somewhat less than 750 vehicles per hour, but where vehicular speeds frequently exceed 25 miles per hour. Such a condition may create a serious traffic hazard. This case would be covered by the accident hazard warrant described in Section 307.

In addition, certain special non-intersection locations may warrant the installation and operation of a traffic control signal for the benefit of pedestrians where heavy volumes of pedestrians must cross roadways at irregular intervals. Such locations are in the vicinity of schools, large meeting halls and parks. Generally, such signals should either be of the pedestrian-actuated type or should be operated manually only during periods when they are needed.

Studies of pedestrian and vehicular movements are essential to determine whether pedestrian conditions justify the installation and operation of a traffic control signal. The method and forms for vehicular traffic counts have been described in Section 302. The pedestrian study should determine by 15-minute intervals the number of pedestrians crossing each roadway in each direction separately. Persons going to or from a street car across one or more moving traffic lanes should be counted. Pedestrian counts should cover at least those hours when it is believed that pedestrian volume crossing the major street may warrant traffic control operation.

Supplementing the pedestrian studies at a given intersection, it is frequently desirable to make studies at other intersection where traffic control signals are in operation, to determine what percentage of pedestrians obey them. Such information may indicate the extent to which pedestrian observance may be expected at any new signal installation. If pedestrian observance is very poor, the justification for a traffic control signal under this warrant without other measures to secure better observance will not materialize.

The determination of speeds of vehicles approaching intersections should be made for a relatively short distance (say 88 feet) ending at the limit line. The short stretch is necessary to determine the speed at the location desired, namely, at the limit line. Such study should be made under the advice of a competent traffic engineer.

Section 305—Coordinated Movement Warrant for Fixed-Time Signals

A fixed-time traffic control signal which would not be justified under any of the preceding warrants may be warranted as a part of a coordinated signal system if a majority of the signalized intersections composing the system comply with one or more of them, and if the proposed signal installation is necessary to maintain compact group movement or desired group speed.

Coordinated control sometimes necessitates traffic signal installations at intersections where they would not otherwise be warranted, for effective regula-
tion of speed and for maintenance of proper grouping of vehicles. By keeping the vehicles in a coordinated system in compact groups and effectively regulating their speed, less delay and greater convenience and safety are accorded both vehicles and pedestrians entering the coordinated roadway at intervening unsignalized intersections.

In general, such “spacing” signals are not warranted unless the unsignalized distance is more than 2,000 feet. If there is a choice between intersections to be protected by such “spacing” signals, there should be a careful analysis as to which intersection most nearly justifies the signal installation under other warrants.

In designing coordinated signal systems, the question of desirability of “spacing” signals will frequently arise. In studying the situation, vehicular volume counts as heretofore described should be made at all intersections where the data may be needed. These should be supplemented by observations of speeds of vehicles and the amounts and kinds of delay encountered in moving along the highway.

Section 306—Through Highway Warrant for Fixed Time Signals

A fixed-time traffic control signal which would not be justified under the preceding warrants may be warranted:

(a) At an intersection on a through highway where the vehicular volume is so nearly continuous that pedestrians and vehicles on the cross street frequently cannot find safe and convenient opportunities to enter or cross the through highway after reasonable waiting periods; or

(b) As part of a speed controlling, coordinated signal system along a through highway on which speeds are so high that pedestrians and vehicles at cross streets have the same difficulty.

Vehicles on through highways tend, if uncontrolled, to travel at excessive and hazardous speeds, despite laws which require such vehicles to yield the right of way to cross traffic under certain conditions. When cross traffic suffers unduly at only a few isolated locations, independent signal installations constitute a suitable correction. In other cases, especially in urban territory where cross streets are closely spaced, delays and hazards to cross traffic may arise at many intersections. In some of these cases, police patrolling may be a suitable remedy, or a speed controlling, progressive signal system may be successful and less expensive.

Such signalization is not warranted if traffic on the through highway is rarely so heavy as to cause unreasonably long waiting periods for cross pedestrian or vehicular traffic. By “unreasonable” is meant a period such as to cause an average driver or pedestrian to try to cross through the existing traffic when it is hazardous to do so. This period may vary under different conditions from 45 seconds to 2 minutes.

In certain cases the principle of this warrant may be applied to a major thoroughfare which is not a through highway.

If a coordinated signal system is the remedy decided upon, signal installations should be spaced not more than 2,000 feet apart. There should be careful analysis of the conditions at each intersection to determine which cross streets are the most appropriate for signalization.

The facts necessary for decisions under this warrant should be secured through vehicular traffic counts, speed and delay studies, and in some cases pedestrian
traffic counts. Each of these studies is mentioned above. In addition, the factor of accidents also enters this warrant. Suggestions for the analysis of accidents are described under Section 307.

Section 307—Accident Hazard Warrant for Fixed-Time Signals

A fixed-time traffic control signal which would not be justified under any of the preceding warrants may be warranted where:

(a) Five or more reported accidents of types susceptible of correction by a traffic control signal have occurred within a 12-month period, each accident involving personal injury or property damage to an apparent extent of $50 or more; and
(b) Adequate trial of less restrictive remedies with satisfactory observance and enforcement has failed to reduce the accident toll.

Any fixed-time traffic control signal installed because of accident hazards should be operated on the shortest possible cycle length which will serve traffic approaching during the heaviest traffic hour.

The installation of a traffic control signal because of a spectacular or much-publicized accident, or because of a small number of accidents, is strongly condemned. The larger the number of accidents before signalization, the greater is the likelihood of the accidents being reduced by the signal.

Thorough analysis of the accident experience is important. Accident history can usually be obtained from police accident records or from accident reports made by vehicle operators involved. Without thorough analysis of such records for the intersection in question, it is impossible to determine upon the most suitable remedial measures.

Experience has proved that the following four types of analysis are very helpful in determining what should be done:

(a) A summarized statistical table for all recorded accidents at the intersection.
(b) Analysis of physical characteristics at and near the intersection.
(c) Analysis of traffic flow characteristics secured by methods and forms described above.
(d) Analysis of a collision diagram.

A study of these analyses will generally reveal a number of significant facts. For example, the types of accidents have a very important bearing on the appropriateness of signalization. A traffic control signal, when obeyed, can be expected to eliminate or reduce materially the number and seriousness of the following types of accidents:

(a) Those involving collisions between vehicles on intersecting streets which will move on separate GO intervals.
(b) Those involving pedestrians and vehicles which will move during different GO intervals—PROVIDED PEDESTRIANS OBEY THE SIGNALS.
(c) Those between straight moving and left turning vehicles where these are to move on separate GO intervals.
(d) Those involving excessive speed in cases where coordination restricts speed to a reasonable rate.
On the other hand, traffic control signals cannot be expected to reduce the following types of accidents:

(a) Rear-end collisions, which often increase after signalization.
(b) Collisions between vehicles proceeding in the same or opposite directions, one of which makes a turn across the path of the other.
(c) Accidents involving pedestrians and turning vehicles, both moving on the same GO interval.
(d) Other types of pedestrian accidents, IF PEDESTRIANS DO NOT OBEY THE SIGNALS.

If none of the warrants except the hazard warrant is fulfilled, the initial presumption should be against signalization. It is preferable to institute (with proper education and enforcement) other remedial measures which delay and inconvenience traffic less and cost less, such as caution, slow, stated speed and STOP signs or signals; lan-
ing or otherwise organizing traffic movements; safety zones; and traffic islands. If analysis indicates that one or a combination of these other remedial measures is adapted to conditions, it should be given a fair trial of at least six months (preferably a year). Following the trial period, a restudy should be made, and if satisfactory results have not been achieved, such additional steps should be taken as are indicated by the study.

Section 308—Combination of Warrants for Fixed-Time Signals—Other Factors

Signals may occasionally be justified where no one warrant is satisfied but two or more are nearly satisfied, particularly if there are present other important factors, such as:

(a) A sudden change from rural conditions, where relatively high speeds are safe, to those of an urban business district;
(b) Extreme width of roadway which pedestrians must cross;
(c) Predominance of especially handicapped pedestrians, such as small children, or blind, aged or crippled adults, who need to cross the roadway;
(d) Points where large numbers of pedestrians must cross a fast-moving stream of vehicles; or
(e) An intersection on or at the bottom of a long or steep grade.

In case (e) there should always be a traffic control signal at the top of the grade coordinated with the signal or signals below so that a vehicle permitted to enter the descending grade will be able to proceed at the indicated speed without stopping on or at the foot of the grade. This plan greatly reduces the hazard from vehicles unable to stop on slippery hills.

These exceptional cases should be decided on the basis of thorough analysis of facts—never on the basis of petitions or complaints.

Section 309—Selection of Type of Fixed-Time Control Mechanism

Where any such warrant is satisfied, described in Sections 302-308, it is necessary to select the type of fixed-time control mechanism to
be used. These include the following, advantages and limitations of which are set forth in Sections 310-313:

(a) Non-synchronous fixed-time controller for isolated intersections.
(b) Program type of fixed-time controller for isolated intersections.
(c) Synchronous type of fixed-time controller for isolated intersections.
(d) Controllers providing for coordination.

Section 310—Selection of Non-Synchronous Fixed-Time Controller for Isolated Intersections

This type of controller is the least desirable. Controllers of this type already purchased should be shifted to relatively unimportant isolated intersections warranting signalization where:

(a) There is little likelihood that the signal installation will be coordinated with any other; and
(b) The fixed lengths of cycle and intervals will be tolerable during all hours of traffic control (STOP and GO) operation.

Section 311—Selection of Program Type of Fixed-Time Controller for Isolated Intersections

This type of controller provides for a limited number of changes in cycle length and in the proportions allotted to various GO intervals. Such controllers may be used at isolated intersections where:

(a) There is little likelihood that the signal installation will be coordinated with any other;
(b) There are marked variations for considerable periods in traffic demands, as, for example, where the major traffic stream enters on different GO intervals in the morning and evening peak periods; and
(c) With this program in effect, delays are not unreasonable.

Section 312—Selection of Synchronous Type of Fixed-Time Traffic Controller for Isolated Intersections

This type of controller involves the use of a synchronous motor. The design should provide the various items of flexibility described in Section 335. Such controllers should be used at isolated intersections where

(a) The installation is likely to be coordinated with one or more other signal installations, but where interconnection with a master controller is determined to be unjustified economically; and
(b) The fixed lengths of cycle and intervals will be tolerable during all hours of traffic control operation.

This type of controller is almost always preferable at intersections for which the non-synchronous type is suitable.

Section 313—Selection of Controllers Providing for Coordination

Two types of control are available for coordination. One of these involves non-interconnected motors, the other a master controller interconnected to local controllers at each signal installation in the
system. Sections 371-376 discuss the various degrees of flexibility attainable by these two types, and the selection should be based upon:

(a) The volumes of traffic involved;
(b) Variances in traffic volume during the hours of intended STOP and GO control;
(c) Variances between traffic in the two directions on the highways involved; and
(d) An analysis of the differences of cost involved.

In general, the non-interconnected synchronous motor plan should not be used for very heavy traffic because of its limitations as to flexibility and because of the absence of assurance that the desired coordination will continue indefinitely. If funds do not immediately permit interconnection and the use of a master controller, it is possible to install synchronous motor controllers of a type which can later be utilized in a very flexible type of system. Under such conditions, the use of synchronous controllers of this type is recommended.

Section 314—Conditions Warranting Installation of Traffic-Actuated Signals

The three elements determining the economic justification for traffic control signals—reduced delays, reduced accidents and improvement in the orderly and convenient movement of traffic—apply with equal force to fixed-time and traffic-actuated control. The latter, however, is almost always more effective in all of these respects than fixed-time control (see introduction to Article A-II). Hence, the various warrants listed for fixed-time control can largely be relaxed or modified for traffic-actuated control. The points listed in the following warrants, presented in the same order as for fixed-time control, relate in general to full traffic-actuated control. Semi-actuated control has a considerably more limited application (see Section 322).

Section 315—Vehicular Volume Warrant for Full Traffic-Actuated Signals

The minimum vehicular volume of 1,000 per hour for eight hours with at least 250 vehicles entering from the minor street or streets is a sound general minimum for either fixed-time or traffic-actuated signalization. If a signal is installed for lesser volumes, traffic-actuated control should be used. Some of the conditions which, combined with somewhat lesser volumes, may justify traffic-actuated control, are referred to in Section 321.

Since full traffic-actuated control adjusts itself to varying traffic volume and involves relatively little vehicular delay during light traffic, it is not necessary to change to flashing operation at any time. Moreover, total traffic volumes and the proportions of vehicular traffic entering during different intervals vary considerably from minute to minute, and fixed-time control cannot constantly take account of
these changes. Properly designed and installed traffic-actuated control does.

Such variances are more marked at some intersections than at others. The heavier the traffic, the greater the necessity of utilizing every second to a maximum efficiency. Hence, traffic-actuated control is especially warranted at very heavy traffic intersections, and where the major traffic enters on different intervals during the morning and evening peak periods.

The more intervals there are per cycle, the less the traffic capacity of the intersection. Fixed-time settings, which cannot vary with changing volumes during the different intervals, are much less efficient than traffic-actuated control at intersections where there are more than two GO intervals per cycle.

Traffic-actuated control will generally give better results for any isolated intersection to be signalized on the vehicular volume basis.

Section 316—Heavy Left Turn Warrant for Full Traffic-Actuated Signals

The minimum left turning volume and the volumes of other traffic set forth in Section 303 constitute a sound measure for any type of signalization, but if signals are installed with lesser volumes, traffic-actuated control should be used, with separate actuation for left turns which are to move on a separate interval or intervals.

Such traffic-actuated control will not result in left turn intervals when no vehicles “demand” such an interval. Also, within certain limits the lengths of such intervals will be proportionate to the number of vehicles turning left. Hence, traffic-actuated control will generally reduce delays materially when used under this warrant.

Traffic-actuated control is much to be preferred over fixed-time control wherever this warrant alone is the basis for signalization.

Section 317—Pedestrian Volume Warrant for Traffic-Actuated Signals

The minimum pedestrian and vehicular volumes warranting fixed-time control indicated in Section 304 constitute sound general minima for either fixed-time or traffic-actuated signalization. If a signal is installed for lesser volumes, traffic-actuated control with pedestrian push-buttons should be used.

With the best types of pedestrian-actuated control, pedestrians need not wait for a fixed interval to expire if traffic becomes light on the street they wish to cross. Neither can continuously heavy vehicular traffic on the street to be crossed hold the GO indication longer than a selected maximum vehicle interval against waiting pedestrians who have registered a desire to cross. On the other hand, a few pedestrians cannot interrupt a heavy stream on the street to be crossed until a selected interval has expired.
Traffic-actuated control is superior to fixed-time control for all conditions under the pedestrian volume warrant for fixed-time control, and it is not necessary to change to flashing operation during light traffic for reasons cited in Section 315. It is important, however, to consider the possibility of providing satisfactory pedestrian clearance periods under traffic-actuated control.

Section 318—Progressive Movement Warrant for Traffic-Actuated Signals

Traffic-actuated control is ordinarily not desirable in combination with a progressive signal system. One of the principal advantages of a progressive system is the control of speed. This is achieved by maintaining a constant relationship between the times when the green light appears on the same highway at adjacent intersections, and by maintaining an approximate equality of GO intervals on the said highway.

Traffic-actuated control when used in combination with a progressive signal system alters the entire pattern governing traffic movement. If it does not affect the starting time of the GO interval, it does frequently prolong that interval and thus diminishes or eliminates speed control. Furthermore, by lengthening the GO interval, traffic-actuated control may so increase the number of vehicles passing through the intersection on one green interval as to overload a short block or cause serious delays at a succeeding signalized intersection where the GO interval is inadequate to handle the increased vehicular load.

Despite these practical objections, there may occasionally be conditions which warrant traffic-actuated control in combination with a progressive system. For example, an intersection may be so close to another or so spaced in relation to adjacent intersections that the best possible progressive timing arrangement involves considerable displacement or reduction in the progressive GO band. A certain multiple intersection or one with complicated movements, or a close group of such intersections, may warrant a combination of traffic-actuated with progressive control. The disadvantages of such a combination should always be carefully weighed in considering such special cases.

Section 319—Through Highway Warrant for Traffic-Actuated Signals

Traffic-actuated control will prove more efficient than fixed-time control for the conditions described in paragraph (a) of Section 306, because traffic on the through highway will not be interrupted unless pedestrian or vehicular traffic is waiting on the side street and has demanded a GO interval. On the contrary, traffic-actuated control under the condition described in paragraph (b) of Section 306 will not regularly provide the desired speed control.
Traffic-actuated control shall not be used along through highways as part of a speed controlling coordinated system.

Section 320—Accident Hazard Warrant for Traffic-Actuated Signals

The basic requirements set forth in Section 307 constitute a sound measure for any type of signalization, but traffic-actuated control should be used for signals installed under any lesser requirements, and is preferable to fixed-time control for any intersection at which the accident hazard warrants a traffic control signal, for reasons set forth in the introduction to Article A-II.

Section 321—Combination of Warrants for Traffic-Actuated Signals—Other Factors

Traffic-actuated control is generally to be preferred over fixed-time control for such cases as can be justified for signalization under this classification (see Section 308).

Section 322—Full Traffic-Actuated Control

The advantages heretofore listed for traffic-actuated control apply primarily to full traffic-actuated control. Since semi-actuated control does not measure the demands of certain traffic streams, it cannot be as responsive to all traffic demands. Therefore, full traffic-actuated control should be selected for all cases where failure to take account of certain traffic demands will seriously affect the efficiency of control.

Full traffic-actuated control (and to a much lesser extent semi-actuated control) has the following advantages at independent or isolated signal installations:

(a) It reduces delays considerably. The more responsive equipment reduces it very nearly to a minimum. This reduction of delays expedites traffic and relieves congestion.

(b) Motorists and pedestrians are more likely to respect and obey the signals, because traffic is dispatched with reduced delays.

(c) The safety element of continuous STOP and GO operation can be retained since the unreasonable delays encountered at fixed-time signal installations during light traffic hours are largely eliminated. Such delays are the main reason for discontinuing STOP and GO operation of fixed-time signals.

(d) Traffic-actuated control minimizes the tendency of traffic to avoid signalized intersections. This results in more logical routing of traffic and fewer demands for signals.

Application of this method of control can be made at points where pedestrians cross a heavy traffic stream by providing push buttons for actuation by pedestrians.

Full traffic-actuated control is well adapted for any independent or isolated signal, and is especially effective at multiple intersections, at intersections with traffic requirements which vary considerably during different times of day, and where special conflicting
movements should be handled separately, particularly if they vary in time requirements at different hours.

The heavier the traffic having varying time requirements, the greater will be the reduction in delays by use of traffic-actuated control.

Full traffic-actuated control is more responsive to traffic demands and is generally much more flexible than other mechanical control.

Section 323—Semi-Actuated Control

Semi-actuated control has certain appropriate applications. These include:

(a) School crossings or other locations where intermittent pedestrian crossings should be provided and resultant delays can be tolerated. Since no impulses are received from the vehicular traffic on the main thoroughfare, the first pedestrian demand received after this traffic has had at least a selected minimum GO interval will secure the pedestrian crossing indication.

Disadvantages of such installations are that, on the one hand, a single pedestrian can interrupt a compact group of vehicles on the main thoroughfare, while on the other hand if a pedestrian crossing interval has just been completed, it will be impossible for any number of pedestrians, no matter how little vehicular traffic is at the instant using the main thoroughfare, to secure another crossing interval until a complete GO interval of selected length has passed for the main street vehicular traffic.

(b) Intersections on through highways or main arteries where speed control is not a factor, but where pedestrians and/or vehicles on the cross street frequently cannot find safe and convenient opportunities to enter or cross the through highway after reasonable waiting periods. Semi-actuated control is especially adapted under this warrant where cross street demands are generally light, infrequent and irregular.

(c) Intersections where there is light traffic on the cross street and where a fixed-time cycle cannot be kept short and the intervals proportioned fairly.

Section 324—Special Pedestrian Signals

There is a growing demand for special pedestrian signals for two different purposes:

(a) To provide a separate interval for pedestrian movement in all directions, all vehicular movement being stopped.

(b) In connection with the standard cycle, to tell the pedestrian when he may safely start to cross so as to complete the crossing before the traffic starts on the other street.

The addition of a separate pedestrian interval slows up the entire cycle and is therefore justified only in exceptional cases where there are many vehicular turns combined with heavy pedestrian traffic or where vehicular movement through which the pedestrian must cross is continuous, as in some traffic circles. Where required in such locations the special pedestrian interval is sometimes indicated by showing the red and yellow signal lights simultaneously, the significance of this special indication being established by statute or ordinance. It is recommended, however, that red be shown in all directions to
stop vehicular movement and that a special WALK signal be provided for pedestrians.

Such pedestrian signals generally show the word WALK illuminated on a dark background. The best practice requires that when this signal is dark a similar WAIT signal should be displayed to advise pedestrians not to cross. These may be carried on the same post as the vehicle signals or on a separate post, and in either case at a height of about six feet.

For the second purpose mentioned above a special pedestrian WALK signal is also recommended where justified by larger traffic volume and high speed. Ordinarily this will first appear simultaneously with the appearance of the green vehicular signal in the same direction and will disappear a sufficient number of seconds before the disappearance of the green so pedestrians who start on the WALK signal can clear the intersection before the green signal is given to vehicles in the other direction. In special cases the WALK signal may be arranged to appear during any desired portion of the green interval. Such special signals are considered preferable for this purpose to the use of green and yellow in combination.

Section 325—Traffic Control Signals in Lieu of Train Approach Signals at Railroad Grade Crossings

Traffic control signals shall not generally be used as alternatives to train approach signals except where streets intersect at or close to the railroad crossing, and then only where observance is enforced by police authority. When used, both sides of the track shall be adequately protected by signal faces.

The signals should show red in all directions when a train is approaching, either by connection to a track circuit or by manual control.

Section 389 on train approach signals sets forth the desirability at certain grade crossings of manually controlled signals or automatic signals that will take some account of the speed of the approaching train. The same principle applies to traffic control signals at railroad grade crossings.

Section 326—Traffic Control Signals Near Railroad Grade Crossings

Except under the conditions set forth in Section 325, traffic control signals should not if avoidable be installed at a street or highway intersection within 150 feet of a railroad grade crossing.

Traffic control signals too close to railroad grade crossings are likely to be misinterpreted by certain drivers approaching from either direction as governing the periods when it is safe to cross the railroad tracks. If the grade crossing is also protected by standard train approach signals, there may be considerable confusion between the two types of signal apparatus so close together.
If exceptional conditions warrant such an installation, extreme care should be taken in the design and operation to avoid the possibility of forcing vehicular traffic to stop on the railroad tracks.

**Article A-III—Design**

Traffic control equipment should be purchased with the future in mind. Flexibility which may not immediately be deemed necessary will usually be found desirable within the life of the equipment. Standardization in those design factors which affect traffic to be controlled is especially important. Equipment which will give long effective life may more closely approach economy even if the first cost is moderate, provided that of equipment of inferior quality.

**Section 327—Number of Lenses per Signal Face**

Each signal face shall have three lenses. It may have additional lenses as indicated herein.

The three-lens type of signal face is adopted as standard because of its very general predominance and because of the important functions of the yellow light, which cannot be satisfactorily taken care of with a signal face having only two lenses. These functions are:

(a) The yellow interval warns approaching traffic and provides necessary time for vehicles in the intersection to clear it.
(b) When the signal is not being operated as a STOP and GO device, the flashing yellow is valuable as a caution signal.

Special arrow indications are permissible for one or more of the following individual movements: Right turn, left turn, straight through.

The foregoing does not preclude the use of special WALK and WAIT lenses as referred to in Section 324.

**Section 328—Color and Position of Lenses**

The three prescribed lenses shall be of the following colors only and shall be arranged vertically in the signal face in the following positions:

Red—At the top
Yellow—Below the red
Green—Below the yellow

When special arrows are used they shall be green. They shall be either below the three prescribed lenses or to the right of them, and shall be in the following vertical order, beginning at the top: Straight through arrow, right-turn arrow, left-turn arrow.

The vertical arrangement of lenses is selected as standard because of its general use, and because a horizontal position is not so well adapted to general signalization problems. Special conditions may
sometimes warrant a horizontal arrangement, however, in which case the red should be located at the left, the yellow next, the green next and special arrows at the extreme right.

Uniformity in position of lenses is of distinct value to all drivers, and of special importance to color-blind persons.

The colors red, yellow and green should conform to the American Standard Colors for Traffic Signals as approved by The American Standards Association (see Appendix F).

Section 329—Shapes and Dimensions of Lenses

The three normal traffic control lenses referred to in Sections 327 and 328 shall be circular, with a visible diameter of not less than eight inches.

A green arrow lens shall show an arrow so designed that its shape will be distinctly visible at a distance of 200 feet. A straight through arrow shall be pointed vertically upward.

Figure 329 illustrates an effective arrow design. It is very important that approaching drivers recognize the green arrow shape at a sufficient distance to govern their actions accordingly. Many arrow lenses now in use fail to meet this requirement.

Horizontal arrows indicate the direction of turn permitted. A vertical arrow pointed upward indicates movement straight through the intersection.

Section 330—Illumination of Lens

Each lens shall be illuminated independently of any other lens, by a clear lamp of not less than 40-watt capacity, especially designed for traffic signals.

Independent illumination of each lens is essential to permit uniform position of lenses, to give satisfactory brilliance and provide the necessary flexibility in signal indications. Special lamps with sturdy filaments and other appropriate characteristics have been designed to meet traffic signal requirements. A 60-watt lamp has been most generally used, but special 40-watt traffic signal lamps are now available. They permit economy in current consumption and will give reasonable satisfaction if the lenses and reflectors are kept thoroughly cleaned and no darkened reflectors are used.

Lamps should be suitable for the voltage range where they are to be used. A lamp which carries more than its rated voltage will have less than the expected 1,500-hour life, while a lamp carrying considerably less than its rated voltage will give subnormal brilliancy.

Section 331—Visibility of Lens

Each lens, reflector and visor shall be of such design as to render the lens, when illuminated, clearly visible to the traffic controlled by that signal face at all distances from 10
to 300 feet, under all light and atmospheric conditions except dense fog. The design shall be such as to prevent, to the maximum degree practicable, any signal face from being seen from a direction to which its indications do not apply.

Section 332—Lettering on Lenses

Except on special pedestrian signals, lettering shall not be used on signal lenses.

The practice of embossing “GO” on green lenses, “CAUTION” on yellow lenses and “STOP” on red lenses reduces the effectiveness of the lens. With the spread of uniform meanings and positions, any warrant for such lettering is constantly decreasing.

When pedestrian lenses are used, they should carry letters at least 3 inches high and so designed and spaced as to give a maximum of legibility. Fig. 332 illustrates a reasonably effective design. In order to avoid possible confusion to vehicle drivers, letters should appear white on a black background. Some consideration is now being given to enlarging the space (especially horizontally) available for the message.

Section 333—Auxiliary Illuminated Signs

Signal heads and auxiliary mounting equipment should be designed so that auxiliary signs can be attached and illuminated either above or below or on either side of any signal face.

Section 334—Operating Power for Controllers

The operating power for all controllers should be ample to provide accurate operation for outside temperatures between 20 degrees below zero and 120 degrees fahrenheit, and for the lowest voltage which will be encountered.

Cases are known where the increased viscosity of lubricants in the winter introduced a sufficiently unusual load to prevent satisfactory operation of controllers. Sometimes the voltage at the end of a long line is appreciably reduced. Controllers should be designed to give satisfactory operation under all such conditions with a reasonable margin of excess power above that required for their peak of work.

Section 335—Immunity to Vibrations

Controller design should be such that its operation will be unaffected by vibrations or other jarring of the control box.

Experience has shown that certain types of design dependent upon very delicate or sensitive adjustments of relays or other parts are unsatisfactory in service.

Section 336—Flexibility of Controllers

Fixed-time controllers of all types should be so designed that a timing schedule for any normal traffic conditions can be easily set
up. It should be possible to fix any established setting firmly in place.

The flexibility of controllers for use at the normal intersection of two streets should make it possible:

(a) To set up at least six separate intervals or periods, even though only four intervals are to be used for the present (see Section 366).
(b) To vary the length of the total cycle between 30 and 70 seconds by steps not to exceed two seconds for cycle lengths between 30 and 50 seconds, and five seconds for cycle lengths between 50 and 70 seconds.
(c) To vary the length of intervals or periods independently by small steps to cover virtually any set of timing requirements.

With respect to item (b), it may be necessary, at complex intersections where three-way movements are required, to increase the total length of cycle.

With respect to item (c), the following ranges are in use in some specifications:

(1) Green interval on main street, from 25 to 65 percent of the total cycle.
(2) Pedestrian clearance period after green on the main street, from 0 to 25 percent of the total cycle.
(3) Yellow interval for movement on the main street, from 0 to 10 percent, and yellow interval for movement on the cross street from 0 to 15 percent of the total cycle.
(4) Pedestrian clearance period after the green interval on the cross street, from 0 to 30 percent of the total cycle.

(Some satisfactory controllers provide a minimum interval of 2 percent.)

One of the major difficulties, especially with older controllers, has been impossibility of adjusting intervals satisfactorily to accord with traffic requirements. This difficulty has been encountered in one or more of the following ways:

(a) At the time of original installation.
(b) Because of changes in traffic conditions at the intersection.
(c) When it has been desired to add new intervals or a pedestrian clearance period.
(d) When it has been desired to relocate the controller at another intersection.

Provision of adequate flexibility at the time of purchase may increase the purchase price somewhat, but this has generally been found to be a good investment.

Section 337—Additional Flexibility for Controllers Used in Flexible Progressive Systems

Controllers used in flexible progressive systems should be so designed that at each intersection the green light on the main street can be made to appear at any desired instant during the cycle. This should be made possible by a simple and readily accessible device which can be fastened securely in any desired position, permitting change in the setting quickly, easily and by small steps.

Section 338—Automatic Maintenance of Coordination

In flexible progressive systems having a master controller and a cable connecting it to a controller at each signal installation in the
system, the design should be such that once in each cycle there will be an automatic check as to whether any local controllers are "out of step," and re-coordination within the next two cycles will be accomplished (provided the controller is not in need of repair or readjustment).

Section 339—Provision for Manual Operation

The provision of apparatus to permit manual operation of signal installations in flexible progressive systems is not in general recommended. At heavy intersections operating under independent control, manual operation of signals at certain times may be warranted by varying traffic requirements.

Experience has proved that if manual control is possible at intersections in flexible progressive systems, there is too great a tendency on the part of the police to operate certain intersections manually. This destroys coordination at those intersections, with disadvantages generally more important than the possible improvement in proportioning intervals achieved by manual control. The presumption should be against manual control until the inability of automatic control to meet the situation at the particular intersection is demonstrated.

Section 340—Weather Proofing

Control box housings shall be constructed and gasketed to prevent entrance of moisture and dust to the operating parts of the controller. All pipe connections shall be water tight and dust tight.

A "breathing hole" of approximately \(\frac{3}{2}\)-inch diameter, located in the bottom of the outer housing, may be desirable to prevent excessive heat and as a precaution against condensation of moisture.

Section 341—Elimination of Radio Interference

Controllers should be designed, or supplemented by apparatus, to prevent an objectionable degree of radio interference.

Radio interference caused by the making or breaking of electrical contacts, or by electrical deficiencies, will cause sharp protests from nearby residents having sensitive radios. It is reasonable to require the manufacturer to guarantee the elimination of objectionable radio interference.

Article A-IV—Location

Signal indications must be unmistakable in their application. The following dangers as to location should be avoided:

(a) Installing traffic control signals along an artery several intersections apart, and expecting traffic, especially cross traffic, at intervening unsignalized intersections to be governed by such signals.

(b) Failing to provide at least one effective signal indication for each direction of travel, where a number of streets come together, at approximately, but not exactly, the same point.

(c) Failing to provide signals readily visible to pedestrians.

(d) Failing to provide signals readily visible from all traffic lanes in wide roadways.
If an intersection or area warrants traffic control signals, a completely satisfactory type of control should be selected. The increased accident hazard, confusion and inconvenience of an inadequate type of control will far outweigh small differences in expense.

Section 342—Signal Installation to Control Its Own Intersection Only

A signal installation shall control traffic only at the intersection where the installation is located.

The unfair and hazardous plan of depending on signals at a few intersections to control traffic at several intermediate intersections requires operation of the signals as a simultaneous system, which is usually inefficient. Drivers on unsignalized cross streets must often enter the crosswalk in order to see a signal on the artery. Strangers are likely to enter unsignalized intersections unknowingly, which is obviously very hazardous.

Section 343—Location of Signal Faces at the Intersection

Signal faces shall normally be located to give approaching vehicular traffic a control indication from the far right corner of the intersection (see Figs. 343 and 343a).

There is considerable difference of opinion, among those who favor corner location of signals, as to whether the signals should be located on the far or near corners.

Advantages of the far right corner location include the following: The signal is on the right side of the roadway where motorists look for signs and warning devices. It is sufficiently removed from the line of vehicles on the near side of the intersection so that it can be seen conveniently by waiting drivers. It can generally be mounted at an effective low height, not suffering the serious limitation of signals over the roadway of having to be mounted at greater height than that permitted for any vehicle.

Advantages of the near right corner location include the following: The signal is located at the point where the stop is to be made. The near side location fits nearly all intersections, however irregular, while the far side plan, at certain irregular or offset intersections, involves supplemental near side signals.

In view of the admitted advantages of each location over the other, and the division of expert opinion as to the relative importance of these advantages, the Committee has carefully examined existing practice and finds that both the number of present installations and the trend point to the far side location as the standard for the future. The Committee, therefore, bases its adoption of that standard largely on this canvass of present practice.

Center suspension of signals continues to be extensively used in rural areas. Advantages are that the first cost is less, and that the
signals can be seen at a greater distance, if overhanging trees would obscure roadside signals. Disadvantages are the departure from standard location, the difficulty of drivers of stopped vehicles seeing signal changes because of their height, and increased cost of bulb and cleaning service.

Believing that here again, with both center and corner location for rural areas possessing advantages, prevailing practice and trend should largely govern, the Committee is convinced by its inquiries that although center suspension still predominate in rural areas, the trend even there is toward corner locations. Therefore no exception for rural areas is made in the recommended standard normal location, but where visibility with the normal four-corner post type mounting would be unsatisfactory, mast-arm suspension (see Section 349) is recommended.

Pedestals in the roadway to carry certain signals are driving hazards and are not recommended.

Section 344—Location in Relation to Curb and Property Lines

One signal face for each direction of approaching vehicles shall be located as near as practicable to the curb line of the street whose traffic it controls. It should be about three feet beyond the far crosswalk line of the intersecting street, or the point where a crosswalk would normally be located (see Fig. 343).

In order to present to the driver a maximum of effectiveness, a post or pole bracket-mounted signal face should be kept close to the curb line. However, for the protection of the equipment from injury by passing vehicles, it is not desirable that any part of the signal head extend within six inches of the curb line.

A signal or its support should not obstruct the crosswalk, hence the supporting post should be erected about three feet outside of the crosswalk line.

Section 345—Location in Relation to a Partially Improved Roadway

Where only part of the established roadway is improved for vehicle travel, the signal face shall be not more than 10 feet to the right of the improved area.

Mainly along rural highways cases arise where only a part of the roadway is improved for vehicle use. So long as the signal face is not more than 10 feet to the right of the edge of the improved portion, it should be satisfactorily visible, since approaching vehicles on city streets, with parking at the curb, are generally about 10 feet from a signal located at the curb. The average vehicle operator gives his major attention straight ahead, and an object more than 10 feet off to the side is not likely to receive proper attention.
This rule has important bearing on the type of mounting, for if the 10-foot distance permits the installation of a post, a low mounting height can be used and maintenance simplified. If, on the other hand, the unimproved portion of the roadway is so wide that a bracket-mounted signal face or center suspension must be used, costs are increased, mounting height must be greater and maintenance is more difficult.

Section 346—Number of Signal Faces per Corner

There shall be at least one signal face for the control of traffic on each street entering the intersection.

There shall be a signal face directly in front of each approved line of pedestrian crossing, if,

(a) The number of pedestrians is appreciable.
(b) The hazard to even a few pedestrians is considerable.

Any roadway having more than two moving lanes in each direction shall have an auxiliary signal face on the left-hand side of the highway, preferably on the far left corner of the intersection. This signal face is in addition to the normal far right corner face.

Each direction of vehicular traffic, and of appreciable or hazardous pedestrian traffic, warrants a signal face virtually in front of it as it approaches and crosses the intersection. These conditions can be provided only by a separate signal face for each stream to be controlled.

There is considerable difference in practice as regards the number of signal faces per corner, where corner mounted signals are used. In general, one far side signal face per corner is sufficient in rural territory where there are no pedestrians.

Two signal faces per corner give complete and satisfactory indications for the average intersection when the far right corner location is used and the signal faces at each corner are at 90 degrees and point toward the intersection. To provide equally satisfactory pedestrian indications when the near corner location is used requires three signal faces per corner. Past failures to provide a signal face directly in front of each direction of pedestrian crossing are believed to constitute an important factor in non-observance of traffic control signals by pedestrians.

Three faces per corner give additional indications and may be warranted under certain conditions, as in a business district where elevated structures or other obstructions may hide a signal face. When three faces are necessary, the face toward the nearest building or lot line is omitted.

Four faces per corner give a maximum number of indications, but are seldom economically justifiable.

A recent analysis indicates a distinct trend toward two faces per corner.

Section 347—Auxiliary Signal Face Locations

Proper visibility and effectiveness require auxiliary signal faces in the following locations (see Figs. 347a, 347b and 347c).
347a—Long Intersection.—Where the signal face is more than 100 feet from the limit line of the traffic which it controls, an auxiliary near side, right-hand signal face shall be provided.

347b—Irregular Intersection—When the physical shape of the intersection is such that the far corner signal face would not be in the direct view of approaching traffic, an auxiliary signal face shall be installed at a suitable location so as to give satisfactory visibility to approaching drivers.

347c—Obstructed View—Where physical conditions prevent a vehicle driver from having a continuous view of the signal face for a distance of 200 feet in advance of the limit line, an auxiliary signal location shall be used which will provide this visibility. If physical conditions make it impossible to provide any location at the intersection which can be seen for 200 feet, a slow signal, or a sign effective at night reading “Traffic Signal Ahead,” shall be erected in a suitable position to warn approaching traffic.

The auxiliary signal face should be located as nearly as possible to where it would appear to the driver at a simple right-angle intersection.

Such special conditions constitute only a small percentage of signal installations.

Section 348—Height of Signal Faces

The bottom of the housing of a signal face shall be not less than 8 feet nor more than 10 feet above the sidewalk or, if none, above the pavement grade of the center of the highways, except that where it is necessary to install a signal face under which vehicles must pass, the height to the bottom of the housing shall be a minimum of 14 feet, 6 inches above the roadway surface.

Maximum visibility is the guiding principle in deciding signal height. Signal faces should be high enough not to be obstructed unnecessarily by passing vehicles and pedestrians. On the other hand, especially in urban territory, the increasing attention which is being given to pedestrians requires that, unless there are special pedestrian signals, the signal faces be reasonably low to be within easy range of the average pedestrian’s eye. Grades on approaching streets may be important factors in determining the most effective height.

Clearance required for signal housings mounted over the roadway is in accordance with general highway requirements for overhead structures.
Article A-V—Installation

This article embraces signal-head mountings and other design and construction features incidental to providing signals conforming to the requirements in Articles A-III and A-IV.

Section 349—Types of Mounting for Signal Head

Types of signal-head mountings include the following:

(a) Alongside the roadway
   (1) Posts 8 or 10 feet high
   (2) Short brackets attached to poles (at same height)

(b) Over or in the roadway
   (1) Long brackets or mast arms attached to poles off the roadway
   (2) Cable suspension
   (3) Posts or pedestals on islands

Group (a) has many advantages, including simplicity of design, ease of access and maintenance, and better conformity as to height to the needs of traffic. Of the two types in this group, post mountings are preferable. Where an existing pole is at the position desired for the signal faces, however, it is generally used. New poles may be installed to provide necessary support and clearances for overhead cable.

Mast arm and cable suspension involve considerable lateral strain. Cable suspension interferes with fire fighting and requires overhead maintenance equipment. Both types involve considerable difficulties in cleaning and maintenance, besides placing the signals too high for best visibility to waiting traffic and to operators of vehicles close to the intersection. They are necessary at intersections where traffic in different lanes is to be directed by different signal faces.

Signals on posts or pedestals on islands are justifiable only in certain large and irregular intersections.

Any mounting should be substantially constructed, with a strong foundation, preferably concrete, and should be able to withstand all weather conditions.

Section 350—Installation of Underground Conduit and Cable

Underground cable, though considerably more expensive, is generally desirable, especially for urban intersections. In certain zones it may be legally required.

Before installing any underground cable, governmental units and utilities should be consulted which may have underground structures at the location or which may later place them there. Much trouble and possible damages may thus be avoided. Furthermore, such organizations can give valuable advice as to how such work should be done.

A large proportion of the cost of underground installations can be avoided if the traffic control conduit is installed (even if in advance of need) when
the intersection or other location is torn up for some other purpose, such as for paving, repairing or utility underground installations.

Section 351—Selection of Cable

The cable is an important element in the successful and economical operation of a signal system.

351a. Quality. Experience has proved the desirability of using cable of high quality for all but purely temporary installations.

Some good traffic signal cable specifications (for use on 110-120 volt service) call for a 600-volt cable with at least 3/64 inch of 30 percent para rubber insulation and good quality cloth braid covering on each conductor and with a cable covering suitable for the intended use of the cable. No. 12 or No. 14 B. & S. gauge wire is often used at intersections. The size of conductor required for a master control cable in a coordinated system should be computed.

351b. Color Code. A standard color code should be adopted for traffic control cables. Such a code provides the function to be performed by conductors with various colors and combinations of colors in their braid covering. The color code selected for any jurisdiction would naturally vary according to the features provided in the operation of the traffic control signal or signal system.

The advantages of a standard color code are considerable. Any person familiar with the color code can install, test or replace controllers quickly because the function accompanying each color scheme is known. Color coding generally eliminates the need of tagging the leads. One of the difficulties with tags or numbered bands is that they are likely to come off.

351c. Spares. It is generally sound economy to provide several spare conductors in each local interconnecting and master control cable.

From time to time, for one reason or another, conductors in a cable may develop defects and be no longer suitable for use. In such cases, the provision of spare conductors eliminates the cost of locating the trouble and making repairs, or of installing new cable. Spare conductors also permit adding new features, such as a pedestrian clearance period, or an illuminated sign.

Section 352—Insulation

Adequate insulation shall be provided throughout the entire installation, conforming to fire underwriters' specifications.

Section 353—Cable Positions and Clearances

Positions for traffic control cables shall be such as not to interfere with utility structures and wires or with positions reserved for them. Suitable clearances agreed upon by all interested parties shall be provided in all such cases.

In most communities the utility companies and appropriate governmental agencies have agreed upon certain positions on poles and certain positions underground for various structures, conduits and wires. Much trouble can be avoided if those in charge of traffic
signal installation will work out location problems with such other affected groups. Where a pole is used for several groups and types of cable it is important to maintain satisfactory clearances, both horizontal and vertical.

Section 354—Messenger Wires

All overhead cable shall be supported with a suitable aerial messenger wire whenever there is a span of more than 30 feet.

The use of aerial messenger wire in such cases removes the strain from signal cables, thereby reducing the likelihood of cable trouble. Unsupported cable is quite likely to develop trouble at the ends of cable spans.

It is generally good economy to provide high grade aerial messenger wire, such as that with a copper covering welded to the steel by the molten welding process. The size and strength of messenger wire is dependent on the load to be carried. A 5/16-inch wire with an ultimate strength of not less than 6,200 pounds is usually satisfactory for a 12-conductor signal cable.

Section 355—Rust-Proofed Hardware

Satisfactorily rust-proofed hardware should be used in all places open to the weather.

Hot-dipped galvanized hardware meeting the N.E.L.A. specifications gives satisfactory performance. Other equally satisfactory rust-proofing methods are now available.

Section 356—Prevention of Explosives

Suitable steps shall be taken to prevent explosion where underground wiring is used.

Gases from underground conduits and structures are likely to enter the traffic signal conduit and accumulate in the control box. The making and breaking of contacts in the controller have ignited explosive mixtures of gases. One satisfactory method of preventing this hazard is to seal the conduit with hot wax just below the control box.

Section 357—Wiring and Fuses

All wiring in the signal installation, with adequate provision for fuses, shall be installed in accordance with the current standards and requirements of the Board of Fire Underwriters.

Section 358—Shielding of Signals

Each signal face shall, if possible, be so shielded by a visor or screen that an approaching driver can see only the signal face or faces intended for his observance.
Confusion results if signals are so located that operators see two signal faces giving different indications. Irregular street design frequently necessitates so placing signals that there is a comparatively small angle between their beams. Such cases require especial care in shielding so that the driver will be sure which signal he is to obey.

Shielding also tends to prevent "jumping" the lights by drivers who see the yellow light indication on the cross street.

Section 359—Pointing of Signal Faces

Each signal face shall be so adjusted vertically and horizontally that its beams will be of maximum effectiveness to the approaching traffic for which it is intended.

In general, signals should be pointed so as to have a maximum effectiveness in the usual position of approaching drivers at a distance from the limit line equal to the average distance they would move while reacting to the stop indication and stopping their vehicles. Factors such as curves or grades may make it advisable to change the pointing somewhat.

For an average urban intersection where the normal speed of the approaching vehicle is 25 miles per hour, the point of maximum effectiveness would be at the height of a driver's eyes, about 6 feet to the right of the center line of the pavement and about 75 feet back from the limit line.

Frequently poles on which signal faces are installed are not exactly vertical. Brackets or other mounting fixtures should be so designed that it will be possible to adjust the signal face both vertically and horizontally through a considerable angle.

Article A-VI—Operation

The primary utility of traffic control signals is found in their operation in accordance with actual traffic requirements. Inconvenience, disobedience and hazard follow unnecessary, arbitrary or inaccurate operation.

Article A-II is intended to assure the installation of appropriate types of traffic signals, and only at locations where they will be beneficial. The operating standards contained herein provide for a reasonable efficiency in the operation of signals at warranted locations.

Section 360—Continuous Operation of Fixed-Time Signals

Traffic control signals shall be operated at all times either as STOP and GO devices, or:

(a) As a slow signal (flashing yellow) provided normal safe approach speeds on all approaches exceed 8 miles per hour;

(b) As a combination of slow signal (flashing yellow) and STOP signal (flashing red), in which cases the caution signal shall show in all directions for which the normal safe approach speed exceeds 6 to
8 miles per hour and the STOP signal shall show in all directions for which the normal safe approach speed is less than 6 to 8 miles per hour.

(c) In the case of a “through street,” as a slow signal (flashing yellow) on the through street and as a STOP signal (flashing red) on other approaches.

Signals requiring a showing of red only occasionally, as at drawbridges, fire stations, school crossings and other points, shall show steady green or a flashing indication at all other times.

It is desirable that an operator approaching a traffic control signal should presume that it is functioning unless he is given a specific indication to the contrary. Hence it is required that all signals in use be “live.” When not operating as a STOP and GO device the signal should be used as a flashing device. Flashing operation has a dual value; it indicates clearly to the operator that (a) the signal is not operating on STOP and GO, and (b) that the intersection carries under normal conditions a comparatively heavy traffic flow.

During seasonal shutdowns when it is not desirable to operate signals in any of the manners described above, they should be turned, hooded or taken down so that operators will be under no misapprehension that a bulb may be burned out.

Methods of computing normal safe approach speeds can be secured by reference to printed material on this subject available through the American Automobile Association, Pennsylvania Avenue at 17th Street, Washington, D. C., or the National Safety Council, 20 North Wacker Drive, Chicago.

Section 361—Limitation of Operation as a Fixed-Time Traffic Control Signal

All fixed-time traffic control signals, other than progressive systems of three or more intersections, should be changed from traffic control STOP and GO to flashing operation when for any period exceeding two hours traffic conditions fall below the volume requirements set forth in Section 302, except that if the accident warrant is satisfied the signal may be operated during such light traffic hours on a cycle of not more than 30 seconds.

During certain hours the traffic at many signalized intersections is too small in volume to warrant STOP and GO operation. Signals at such locations may have great utility during hours when traffic flow is heavy. The change to flashing operation during light traffic periods not only facilitates the movement of traffic, but also tends to secure observance of the signals when they are operated as STOP and GO devices. In general STOP and GO operation is not warranted during the hours from 11:00 p. m. to 7:00 a. m. Special consideration should be given to warranted hours of operation on Sundays and holidays.

Section 362—Meaning of Color and Arrow Indications

Color and arrow indications in traffic control signals should have the meanings ascribed to them in this section and no other meanings. In no case, however, should a driver be permitted to enter or
proceed through an intersection without due regard to the safety of other persons within the intersection, regardless of signal indications.

Satisfactory results from traffic signal operation require a uniform understanding of their color combinations. Those herein set forth are in basic accord with the Uniform Vehicle Code (Act V, Sections 32 and 33).

This section applies primarily to traffic control signals at intersections, but appropriate interpretation can be readily made for use of signals elsewhere than at intersections, such as drawbridges, school crossings and fire stations.

The meanings of the indications which should be thus prescribed by law are as follows:

362a—Red.—While the red lens is illuminated, no pedestrian or driver of a vehicle facing the signal may enter the intersection, provided, however, that if a green arrow lens is illuminated at the same time, a driver may cautiously enter the intersection to make the movement permitted by the arrow, subject to the superior rights of pedestrians and vehicles proceeding on a regular GO indication.

Confusion and serious hazard result from lack of uniform obedience to red signals. The red light should always indicate that each vehicle shall stop and shall not proceed farther until a GO signal appears, unless specifically authorized by one of the auxiliary indications above described.

Permitting vehicle operators to make right or left turns during the showing of the red light with no modifying arrow is bad practice. It weakens the single meaning of the red indication. The practice cannot be permitted at all intersections, and, therefore, cannot be followed uniformly. It adds to pedestrian hazards and inconvenience in crossing streets. It creates hazards and delays vehicle movement if the discharge capacity of the outlet highway is inadequate for both the regular through movement and the irregularly permitted turn.

The appropriateness of right and left turns proceeding during the stop period is exceptional and, therefore, should require a specific modifying indication, as is provided by the right or left turning arrow lens. When such turning arrows are shown during the interval when through movement is stopped, they should always be illuminated in conjunction with the red signal which they modify. If shown alone there is always doubt as to whether other movements are forbidden during the indicated interval. Furthermore, drivers approaching an arrow signal may mistake it for the customary GO signal. This is especially likely with strangers and with a poorly designed arrow indication.
362b—Green.—While the green lens is illuminated, pedestrians and vehicles facing the signal may proceed straight through or vehicles may turn to the right or left, subject to the safety of those who were in the intersection or on the crosswalks at the time the lens was illuminated, and subject to the exceptional rights of emergency vehicles. Drivers of vehicles making a right or left turn shall yield the right of way to pedestrians crossing (or who have started to cross) on a green indication.

362c—Yellow.—When the yellow lens is illuminated alone, any driver of a vehicle approaching the intersection or a marked limit line who can stop with safety before reaching the limit line must do so. Any driver whose vehicle is so close to the intersection that a stop cannot safely be made back of the limit line shall proceed cautiously through the intersection.

The yellow lens is required in standard signal apparatus for the reasons indicated in Section 327. Confusion has frequently arisen from the misuse of this lens. When the length of the yellow vehicle clearance interval is correct, and the standard meaning above described is generally observed, necessary functions of warning and clearing the intersection are performed by this interval.

362d—Green Arrows.—When a special straight through, right turn or left turn green arrow is incorporated in a signal face, vehicles in their proper lanes may proceed or turn in the direction permitted by the arrow when illuminated, subject to the superior right of pedestrians and vehicles proceeding straight through.

It is apparent that the utility of these special green arrow indications is dependent upon there being a lane available for the movement so indicated. Such lanes should be clearly marked on the roadway surface.

Traffic shall be permitted at all times to proceed straight ahead or turn in either direction on a circular green indication. Wherever it is intended to permit traffic on a certain thoroughfare in a given interval to make certain movements and prohibit it from making others, the regular circular red lens facing that traffic shall be illuminated together with a separate green arrow for each permitted movement.

(The foregoing is not intended to prevent prohibition of turns at all times or during certain periods of the day by the erection of signs as provided in Section 109a.)

In Massachusetts and elsewhere the plan has been tried of prohibiting certain movements, such as a left turn, on the regular cir-
cular green indication by signs stating that those movements were allowed only on special green arrow indications. The plan has not been satisfactory, however, because drivers failed to understand it and proceeded to make the prohibited turn on the regular circular indication.

362e—Flash Red (Stop Signal).—When the red lens is illuminated by rapid intermittent flashes, drivers shall stop before entering the intersection, and not proceed until it is safe to do so.

Where a flashing red STOP signal is used, no STOP sign should be used.

362f—Flash Yellow (Slow Signal).—When the yellow lens is illuminated with rapid intermittent flashes, drivers may proceed through the intersection only with caution.

The use of steady yellow as a slow signal is not recommended.

Section 363—Removal of Confusing Colored Lights

The Uniform Vehicle Code, Act V, Section 34, prohibits the display of any unauthorized sign, signal, marking or device which interferes with the effectiveness of any official traffic control device. The enactment of this provision is particularly important as applied to all lights of such a color and location as to be confused with traffic control signals. Any steps necessary to eliminate this serious hazard are warranted.

Section 364—Unexpected Conflicts During GO Interval

No movement which may involve an unexpected crossing of pathways of moving traffic should be permitted during any GO interval, except under unusual conditions, when:

(a) The movement involves only slight hazard,
(b) Serious traffic delays are materially reduced by permitting the movement, and
(c) Traffic subjected to the unexpected conflict is effectively warned thereof.

While the conflicts created by usual turning movements during the ordinary GO interval are well known and persons may properly be expected to avoid accidents therefrom, they should not be called upon to guard against unusual and hence unexpected movements. If conditions at a signalized intersection warrant specialized control, the public is entitled to special warning. This may be given by an illuminated sign or under certain conditions by the use of a flashing yellow slow signal instead of a green GO signal.

The tendency to install signals permitting such unexpected conflicting movements without effective warnings to the public has been growing, but is strongly condemned.
Section 365—Length of Cycle

The cycle shall be as short as will accommodate the necessary movements.

Considerable dissatisfaction with traffic control signals may be attributed to improper timing. Therefore, this subject warrants the thorough consideration of those who have charge of signal timing.

Short cycles encourage observance of the signals by pedestrians and vehicle drivers. Unfortunately no entirely satisfactory formulas are as yet available for an exact determination of proper cycle length. For city conditions a cycle length of from 30 to 50 seconds is generally found to be satisfactory for the usual intersection. For rural intersections it may be desirable to use somewhat longer cycles, giving the extra time to the main highway. Signal timing should be established on the basis of study of traffic requirements by a competent traffic engineer.*

Changes in cycle length for different traffic conditions during the day, while requiring special apparatus, are generally desirable.

Section 366—Rotation of Intervals

Each interval provided for traffic movement should generally be given once and only once during each cycle, provided, however, that with traffic-actuated control by pedestrians or vehicles, intervals not regularly utilized may be initiated only when the demand exists. Extraordinary conditions may warrant the duplication or omission of an interval in any one cycle.

Nothing herein should be interpreted as preventing continuous movement of one line of traffic during several intervals.

A typical illustration of the sequence of intervals in simple cycles is as follows:

<table>
<thead>
<tr>
<th>Internal number</th>
<th>Main Street</th>
<th>Cross Street</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Green</td>
<td>Red</td>
</tr>
<tr>
<td>2</td>
<td>Yellow</td>
<td>Red</td>
</tr>
<tr>
<td>3</td>
<td>Red</td>
<td>Green</td>
</tr>
<tr>
<td>4</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>and repeat</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Simple Cycle With Pedestrian Clearance Period

<table>
<thead>
<tr>
<th>Interval Number</th>
<th>Main Street</th>
<th>Cross Street</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vehicles</td>
<td>Pedestrians</td>
</tr>
<tr>
<td>1</td>
<td>Green</td>
<td>Walk</td>
</tr>
<tr>
<td>2</td>
<td>Green</td>
<td>(Wait)</td>
</tr>
<tr>
<td>3</td>
<td>Yellow</td>
<td>(Wait)</td>
</tr>
<tr>
<td>4</td>
<td>Red</td>
<td>(Wait)</td>
</tr>
<tr>
<td>5</td>
<td>Red</td>
<td>(Wait)</td>
</tr>
<tr>
<td>6</td>
<td>Red</td>
<td>(Wait)</td>
</tr>
<tr>
<td>and repeat</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The above cycles are presented as they would be viewed by an automobile driver. Controllers designed to provide for more intervals can repeat the same color combination in consecutive intervals as may be needed.

*The National Safety Council has published a report on this subject entitled "Timing Stop and Go Signals," Public Safety Memo No. 84. A report on the subject is also being prepared by the American Automobile Association.
Section 367—Fixed-Time Intervals Proportioned to Traffic Requirements

Cycles should be divided into intervals proportionate to the time required by the traffic which will enter the intersection during the signal intervals. Where the time requirements of the different movements vary widely in proportion during different times of the day, provision should be made for changing the percentage of total cycle allowed for each interval to accord reasonably well with the traffic time requirements. Where the percentages of the total cycle required by different traffic movements do not vary materially during the day, the percentages allowed the different intervals should be those which most accurately accord with the requirements of the heaviest traffic hour.

Since traffic moves in lanes, the more lanes in use, the shorter the time required for a given volume to pass through an intersection, assuming that the intersection has adequate discharge capacity. Intervals should not, therefore, be proportioned purely on the basis of relative volume entering in the different directions unless there are the same number of moving lanes on each entering street.

Furthermore, streets carrying considerable proportions of slow moving vehicles or street cars and buses which must load and unload at intersections will require more time to discharge a given volume than streets where the traffic is made up largely of passenger automobiles.

In general, traffic tends to spread into available lanes so that each lane requires approximately the same time to discharge its load. Under certain conditions this may not be true, and a given lane may generally require a greater amount of time. This becomes the critical lane and should be the one considered in proportioning intervals.

Usually the volume of traffic per lane entering the intersection on a GO interval will not be equal from the two directions on the same street. The per-lane volume of traffic entering from the heavier direction, therefore, should generally determine the time required for the interval. Therefore,

(a) If during the heaviest traffic hour the headways of vehicles per critical lane per hour are equal for the two heavier directions at right angles, the ratio of GO intervals should equal the ratio of those volumes per critical lane; but

(b) If during the heaviest traffic hour the headways vary for the two heavier directions at right angles, the ratio of GO intervals should equal the ratio of the volumes per critical lane divided by the ratio of their respective headways per critical lane.

Recent experiments show that excellent efficiency can be attained under certain off-peak conditions with 15-second intervals closely approaching the performance of traffic actuation, but, in general, no vehicle GO interval should be less than ten seconds, or less than sufficient to permit pedestrians to cross to a point of safety unless an exclusive pedestrian interval is used. If a pedestrian clearance interval is used in conjunction with the normal cycle, the total GO interval should be long enough to allow not less than five seconds during which it is indicated that pedestrians may start to cross,
and enough longer to permit the waiting pedestrian groups to enter the roadway.

Section 368—Limitation of Number of Intervals and Special Indications per Cycle

No interval or special indication should be used in a signal cycle unless its desirability has been definitely established.

In considering the intervals to be used, the presumption should be strongly against the use of an exclusive pedestrian interval recurring once each cycle, or of a special green arrow indication, especially a left turn indication.

Section 369—Vehicle Clearance Interval

A yellow vehicle clearance interval shall be used following each green interval. In no case shall a yellow interval be displayed in conjunction with the change from red to green.

In general, the vehicle clearance interval should be not less than three seconds, nor more than is reasonably necessary to clear the intersection of traffic. At intersections where speeds are 35 miles per hour or more the clearance interval should be at least five seconds.

While intervals longer than five seconds may occasionally be necessary at very wide intersections, they cause impatience among drivers and result in starting before the green light appears.

Theoretically, the display of yellow after red has the utility of advising the waiting motorist to prepare to start. In practice, it has frequently induced waiting drivers to start before the green light appears.

The use of the yellow clearance interval as a period during which pedestrians are supposed to walk is disapproved. The function of the yellow interval should be exclusively that of intersection clearance and of warning to approaching drivers.

Section 370—Coordination of Fixed-Time Signals

In general, all fixed-time traffic control signals within 2,000 feet of one another and controlling the same roadway should be operated in coordination. Even at greater distances coordination may be desirable under certain conditions.

Great inconvenience and delay result from the independent operation of closely adjacent signal installations operating on fixed-time control. Most of this delay can be eliminated by carefully planned coordination. However, under certain adverse conditions which seriously affect the efficiency of coordinated control, greater efficiency may be possible with traffic-actuated control operated either independently or in combination with coordinated control (see Section 376). More factual data are needed on this matter.

Section 371—Types of Coordination

The most useful classification of traffic control signal systems is based on their method of coordination. Since the primary purpose of this coordination is to organize and facilitate traffic flow, it is
essential to indicate what vehicular traffic will do under the various systems. On this basis of classification there are three general types of coordination of fixed-time signals. These are defined and described in Sections 372-374, as: (a) Simultaneous system; (b) alternate system, and (c) flexible progressive system.

**Section 372—Simultaneous System**

A simultaneous system is one in which all signals always give the same indication to a given highway at the same time. All intervals change at the same instant and like intervals are identical at all signal installations.

The simultaneous system is simple and requires but one controller. In customary operation, however, it has the following disadvantages:

(a) The simultaneous stopping of all traffic along the highway prevents continuous movement of vehicles and results in low over-all speed.
(b) Speeding is encouraged in order to pass as many controlled intersections as possible before a change of signals.
(c) Cycle length and interval proportioning must be based on the heaviest traffic requirements encountered. Since the timing at all intersections must be the same, considerable inefficiencies are introduced at most signal installations.
(d) The simultaneous starting of many street cars creates a sharp peak in power load.

**Section 373—Alternate System**

An alternate system is one in which adjacent signals or groups of signals show opposite indications to a given highway at the same time. All signals change their indications at the same time, but instead of all signal faces governing one highway changing from red to green, the first, third and fifth signal faces or groups thus change, while at the same time the second, fourth and sixth signal faces or groups change from green to red.

Under conditions for which this system is satisfactory, it has the following advantages:

(a) Continuous movement is possible for the vehicles at the front of a group along a given highway for blocks of equal length at approximately a predetermined speed.
(b) Speeding is discouraged because a vehicle is forced to make frequent stops if it exceeds the speed for which the system is arranged.

It has the following disadvantages:

(a) It requires equal GO intervals for both main and cross street traffic, which is inefficient at most intersections.
(b) It is not well adapted to a street having blocks of unequal length.
(c) If the signals are alternated by groups, the flow capacity is materially reduced during heavy traffic, the latter part of the moving group being delayed between intersections when the color indication changes. If the cross streets are equally spaced, grouping by two intersections reduces capacity about one-half, while grouping by three intersections reduces capacity to about one-third.

Changing a simultaneous system to an alternate system may be regarded as a step in the direction of progressive control.
Section 374—Flexible Progressive System*

A flexible progressive system is one using a common cycle length throughout, in which the individual signal faces controlling traffic on a given highway show GO indications independently in accordance with a timing schedule designed to permit (as nearly as possible) continuous operation of undelayed groups of vehicles along the highway at a planned rate of speed, and in which the intervals at any signal installation may be independently adjusted to the traffic requirements at that intersection.

In general the flexible progressive system when efficiently designed and operated has the following advantages:

(a) Continuous movement of full undelayed groups of traffic at approximately a predetermined speed is possible on both the main and cross streets in the system.
(b) Intervals at each intersection may be proportioned for maximum efficiency considering traffic requirements at that intersection.
(c) speeding is discouraged because a vehicle must make frequent stops if it exceeds the speed determined for the system.
(d) Differences in block length can be handled better than with other fixed-time systems.

Section 375—Degrees of Flexibility of Flexible Progressive System

There are many degrees of flexibility provided by systems bearing this name. The least expensive method of providing such a system is by the use of unconnected synchronous motors receiving energy from a common or electrically synchronized source. The second general method involves the use of a master controller which “supervises” secondary controllers at each signalized intersection.

With the first method, a common cycle length and proper coordination between controllers will exist as long as no trouble occurs, but if one or more controllers get out of step, re-coordination must be established by adjusting with stop watches the lags of timers which are out of step.

With the second method, the master controller primarily insures that the secondary controllers keep in step. The introduction of numerous additional features of flexibility is also made possible. For example, most equipment of this type permits changing the length of the cycle for the system at different times of day. It is also possible to institute flashing operations from the central control board at any desired time of day. Some types of equipment provide for several different timing schedules, such as one to favor heavy inbound

* The definitions on page 9 include a separate definition for “progressive system.” The term involves the principle of continuous movement of the traffic in waves or platoons. The alternate system (and in rare instances the simultaneous system) accomplishes this to a certain degree and was formerly sometimes called a “limited progressive” system. The flexible progressive system was first regarded as a further refinement of the same principle, but all of its features are now deemed essential if a more expensive installation than a simultaneous or alternate system is warranted. Therefore, traffic engineers seldom consider any other type of “progressive” system. The definition of “progressive system” is retained to recognize the basic wave principle.
flow in the morning, another for average conditions, and a third to favor heavy outbound flow in the late afternoon, thus utilizing the street capacity to a greater extent.

While equipment permitting greater flexibility costs more, conditions are frequently such in urban territory that the most flexible system constitutes an economy.

Section 376—Conditions Affecting Efficiency of Signal System

Certain conditions seriously reduce the efficiency of signal systems, even of the most flexible progressive systems. Among these are:

(a) Very short street blocks, especially where reasonably high speeds are possible. (This particular condition does not affect the simultaneous system.)
(b) Narrow streets where parking and loading interfere with free movement.
(c) Traffic composed of units of widely differing speeds, such as street cars, buses, trucks, horsedrawn vehicles and passenger automobiles, especially on narrow streets.
(d) Certain types of complicated intersections, such as those requiring three GO intervals per cycle.
(e) Heavy volumes of vehicles turning into the artery, especially if the block into which they turn is short.

Nevertheless, the flexible progressive system secures the best results possible by fixed-time control from such street and traffic handicaps as cannot be removed or relieved.

If conditions are unfavorable to flexible progressive control, independent traffic-actuated operation may prove more efficient.

More factual evidence is necessary before definite recommendations are warranted as to the appropriate scope, advantages and limitations of traffic-actuated control in coordinated signal systems or in lieu of such systems.

It is possible to design signal controls so that signals will operate under isolated traffic-actuated control during light traffic hours, but when traffic on the main street reaches a predetermined density, the progressive master controller will become effective and cross flow can not interfere with the progressive band of travel. When the traffic on the main street falls below a predetermined density, the system automatically returns to traffic-actuated control. While the signals are in separate traffic-actuated operation, there is no systematic movement in progressive bands.

Section 377—Selection of Type of Coordination

The type of coordination chosen should be that which careful studies indicate will produce the best traffic results.

377a. Flexible Progressive System. In general, the flexible progressive system is best adapted to the efficient movement of traffic, and has the possibility of advantageous use of traffic-actuated control in conjunction with it at critical intersections.

377b. Alternate System. The alternate system may prove satisfactory where blocks are of practically even length and where the equal GO intervals in all directions reasonably accord with traffic requirements at each major intersection. The lack of flexibility of this system not only restricts its utility but also prevents desirable readjustments to accord with changes in traffic conditions.
377c. Simultaneous System. Intersections not more than 300 feet apart often constitute a serious coordination problem. At normal traffic speeds the time required to move from one intersection to the next is so short that a very short cycle would be required for a flexible progressive or alternate system of control. If only two such intersections are to be coordinated, the best plan is generally to operate them as a simultaneous system, giving an ample GO interval on the main street for a major portion of the traffic to clear through both intersections. If two such close intersections are encountered in a larger group to be coordinated, the best plan is to select the flexible progressive system and to adjust the lags at both of the close intersections so as to interfere the least with the continuous movement of traffic. Frequently this will result in virtually simultaneous operation of these two signal installations. Except for this limited application and perhaps other rare exceptions, the use of the simultaneous system is not recommended.

Section 378—Speeds for Progressive Systems

The speed or speeds for which a flexible progressive system is designed should accord reasonably with what speed tests show would be the speed of movement of vehicles if cross traffic delays were eliminated. After drivers have become accustomed to a progressive system, it may be possible to increase the speed with safety.

Excessive speeds should be avoided, especially in busy urban districts. Except in business districts, progressive systems along arteries are generally timed for speeds ranging from 20 to 30 miles an hour—the majority at 22 to 25 miles per hour. In general, the more heavily used the artery, the narrower the roadway, the more built-up and busy the district, the shorter the blocks controlled, the more mixed the types of traffic, or the more pedestrians and cross street traffic there are, the slower should be the design speeds.

Local authorities should be careful to avoid design speeds which will conflict with state laws governing speeds.

Section 379—Signs Indicating Timed Speed

"Timed speed" or "best speed" signs (see Part I, Section 141) should always be erected to guide drivers operating under an alternate or flexible progressive system. Such signs should be located close to the signal indication by which the driver is guided. They may be erected at every signalized intersection or, if the blocks are short, at every other intersection.

Section 380—Special Features of Traffic-Actuated Control

It is possible to secure full traffic-actuated equipment with a number of features which result in additional reductions of delays and increased efficiency in dispatching traffic. Not only are intervals
initiated by impulses from individual vehicles or pedestrians, but the
length of each GO interval is affected by the number of such im-
ulses received and by the number of seconds between these impulses.
As approaching traffic “thins out,” the number of seconds between
successives impulses increases. When a certain spacing in seconds has
been reached, waiting traffic on the cross highway receives its GO sig-
nal. However, the equipment prevents one street from holding traffic
for unduly long intervals against traffic waiting on the other street,
even though dense traffic may continue to approach the intersection.

When a waiting group of vehicles receives its GO indication, a certain period
is required to get the vehicles in motion, after which they flow through the
intersection at a reasonably uniform rate. It is possible to secure apparatus
which provides for such a “starting” period.

Exclusive pedestrian intervals can be provided with at least one
type of traffic-actuated control. Recently success has been secured
in providing pedestrian clearance periods.

Article A-VII—Maintenance

Much of the authority of signals is dependent upon their com-
pelling effectiveness. Signals with impaired efficiency cannot be
expected to command desired respect. Proper maintenance is, there-
fore, of primary importance. If it is important that street lights be
regularly and effectively maintained, how much more desirable is
proper maintenance for traffic signals, which have so large an effect
on traffic accidents. Good maintenance also increases the effective
life of traffic equipment.

Maintenance should be an important consideration in the design
and purchase of traffic signal equipment. If low first cost is accom-
panied by high maintenance costs or by serious losses of efficiency,
it is poor economy.

The standards set forth herein are intended to provide the essential
features for an adequate maintenance program.

Section 381—Inspection and Bulb Replacement

Traffic signal installations should be inspected for lamp outages
and satisfactory operation once each day. All burned out bulbs
should be replaced.

Utility companies and municipalities demand daily inspection of street
lights. Surely it is considerably more important that there be daily inspec-
tion of traffic control signals.

Section 382—Cleaning

Signal lenses, reflectors and bulbs should be thoroughly cleaned
at least once every six months. Lenses and reflectors should always
be cleaned when bulbs are replaced, unless the last regular cleaning
has been very recent.
The reduction in brilliancy of a signal indication resulting from even a moderate amount of dust and dirt is generally very much underestimated.

The frequency with which cleaning is required will vary according to the location of the signal. A signal located on a bridge over railroad tracks may require cleaning once a month.

Section 383—Maintenance of Controllers

Every controller shall be kept in effective operation in strict accordance with its predetermined timing schedule. For this purpose the following are minimum standards:

383a—Lubrication.—Controllers shall be carefully lubricated in accordance with a lubrication chart furnished by the manufacturer at least as frequently as is specified by the manufacturer and more frequently if experience proves it necessary.

Different controllers require lubrication at widely different intervals. The more complex the control mechanism, the larger the number of moving parts, and the more work they do, the more exacting will be the lubrication requirements.

The manufacturer should furnish a simple lubrication chart showing clearly the points requiring lubrication and the kind or kinds of lubricant to be used. No other lubricant should be used unless its appropriateness has been established.

383b. Timing. The correctness of timed operation of the controller should be carefully checked at least once each six months.

The checking as to timing can be done effectively in connection with cleaning, lubrication or overhauling. The length of each interval should be recorded for at least two complete cycles. These should then be checked against the timing schedule, which should be located in the control box housing.

The necessity for checking timing arises from the possibility of mechanical or electrical misadjustments and because of unauthorized changes in timing.

383c. Overhauling. Every controller should be removed from service and overhauled at least once every twelve months.

The overhauling should consist of a thorough cleaning, checking for correctness of operation, a careful inspection for worn parts or parts out of position, any necessary adjustments, replacement of necessary parts, and lubrication. The controller should then be placed on test in the shop for at least two days, during which period several observations should be made as to whether its operation is in strict accordance with the timing schedule, and otherwise satisfactory.

Section 384—Painting

Signal heads, brackets, poles, posts, control boxes, housings and conduits above ground should be repainted at least every two years, and as much oftener as may be necessary to prevent corrosion and to maintain the good appearance of the equipment.
The frequency with which repainting is needed will vary with the paint, the condition of the surface to which it is applied, chemicals in the atmosphere and other conditions.

**Section 385—Record Keeping**

Thorough maintenance records should be kept and analyzed at regular intervals to determine further policies as to equipment purchases and maintenance program.

Good maintenance records are valuable in a number of ways:

(a) Careful analysis will assist in determining whether or not the maintenance program in use is satisfactory.

(b) Analysis of costs will aid in deciding upon types of equipment to be purchased and improvements in maintenance methods.

(c) Maintenance records will frequently be subpoenaed by courts in connection with accident cases.

Maintenance records should indicate the necessary time required and costs of cleaning, lubrication, retiming, overhauling, bulb replacement, painting, et cetera, for each signal installation and for each specific controller.

**DIVISION B—FLASHING SIGNALS**

Division B embraces all traffic signals other than traffic control (STOP and GO) signals. These include STOP, slow and train-approach signals. With the exception of the train-approach wigwag signal all are flashing, and the latter is classed as flashing since it produces a similar effect.

**Article B-I—Legal Authority**

Flashing signals should be placed along the highway only by the properly constituted authorities having jurisdiction, and since they are included with traffic control signals in this respect by definition, the same legislative models of law apply as are referred to in Article A-I.

**Article B-II—Application**

**Section 386—Conditions Warranting STOP and Slow Signals**

STOP and slow signals shall be used as parts of a fixed-time traffic control signal installation not continuously operated as STOP and GO signals, under the conditions set forth in Section 360.

STOP signals are also desirable instead of or in conjunction with STOP signs at especially hazardous intersections.

Slow signals should be used to mark permanent obstructions in the line of travel on the roadway, such as safety zones, posts, bridge structures and abutments. They may also be used to attract atten-
tion to slow-type signs marking exceptionally hazardous road conditions, such as the end of a road, a sharp turn or a steep grade, but they fail to impress unless confined to points of extreme danger.

Section 387—Conditions Warranting Train Approach Signals

Train approach signals shall be installed at railroad grade crossings to warn highway traffic of any approaching train where the volume of flow on either the railroad or the highway is considerable, or where physical obstructions to clear vision exist on the highway approaches.

Such signals shall be used for no other purpose.

Train approach signals have been standardized in all particulars of application, design and location by the Association of American Railroads as shown in its Bulletin No. 2 on Railroad Highway Grade Crossing Protection (see Section 389).

Article B-III—Design and Operation

Section 388—STOP and Slow Signals

Signal heads for STOP and slow signals, while they may vary in minor details of shape and dimensions, shall include the following essentials:

(a) Each lens shall have a visible diameter of not less than 5 inches.
(b) The illuminating element, lens, reflector and visor shall be of such design as to render the lens, when illuminated, clearly visible to traffic facing the signal at all distances from 10 to 300 feet under all light and atmospheric conditions except dense fog.
(c) The light shall flash continuously at a rate not less than 50 nor more than 70 times per minute. The illuminated period shall be at least as long as the dark period.
(d) The colors of the lenses shall be red for STOP and yellow for slow.
(e) When a flashing signal is used in combination with a standard sign, it shall be incorporated in the design of the sign above the symbol or word message which the sign indicates. An alternative to this is flashing illumination of the symbol or word message itself.

Flashing signals properly designed are sufficiently brilliant to give clear indications during daylight as well as dark hours, for which reason continuous operation is desirable.

Beacons showing steady lights are not recommended, because they lack attracting power and are likely to be confused with other lights.

Section 389—Train Approach Signals

The Association of American Railroads has approved two types of signals to give warning to the user of a highway of the approach of a train at a railroad crossing:
(a) Flashing light type—with two red lights mounted horizontally and flashing alternately.

(b) Wigwag type—with a swinging target and red light.

The standards adopted by the Association of American Railroads also include the following requirements:

Train approach signals shall be mounted on the same post that carries the standard railroad crossing sign and shall not be used at any other place or for any other purpose.

Signal indications shall begin not less than 20 seconds before the arrival of the fastest train over the crossing.

The ideal control would be such that, regardless of the above mentioned conditions, the signal indications would begin not less than nor much more than 20 seconds before the arrival of the train at the crossing. This would spare motor traffic the annoyance of waiting unduly long for slow moving freight trains, and reduce the number of accidents caused by racing for the crossing. Ideally also, no signal indication would be given by a train standing at a station or about to stop before reaching the crossing, or by switching operations in the vicinity except when they passed over the crossing.

This ideal can be attained only by manual control, and this is recommended at urban crossings where the conditions are as described above. Refinements in automatic control which take some account of speed of approaching trains have been applied at a few crossings. They add greatly to the expense and accomplish their purpose only in part.

The length of stroke of the swinging light in the wigwag type measured horizontally between extreme positions, and the distance between centers of lights in the flashing type, shall be 30 inches.

The number of complete swings of the wigwag type and the number of flashes of each light in the flashing type shall be not less than 30 nor more than 45 per minute.

When lights are operated at normal voltage, they shall be clearly visible on a tangent at a distance of 300 feet on a clear day with a bright sun at or near the zenith.

Lenses and roundels shall be not less than $5\frac{3}{8}$ nor more than $8\frac{3}{8}$ inches in diameter, and shall be hooded to prevent phantom lights.

Article B-IV—Location

Section 390—Location with Respect to Roadway and Hazard

The purpose of a signal other than a traffic control signal should largely govern its location with respect to the roadway and the hazard warranting the signal. Following are the suitable locations:

STOP or slow signals

Same as STOP and slow-type signs or suspended over the center of an intersection
Train approach signals

At the right side of the roadway not more than 15 feet from the nearest railroad track

There should be a train approach signal each side of the track or tracks, at the right side of the roadway. The location of train approach signals in the center of the roadway is not recommended, even in wide roadways.

**Section 391—Height of Signals**

The height of signals in this group should be as follows:

(a) On obstructions, 4 feet above pavement
(b) On safety zones, 4 feet and 12 feet above pavement
(c) At the roadside, 8 feet above pavement
(d) At railroad crossings, not less than 7 nor more than 9 feet
(e) Suspended over roadway, not less than 14½ feet

**Article B-V—Maintenance**

**Section 392—Standards for Maintenance**

The same considerations govern the maintenance of flashing signals that apply to traffic control signals, so that the standards established in Division A should be applied.
PART IV—ISLANDS

Introduction

Vehicular traffic may be excluded by law or by physical construction from certain roadway areas, either to provide segregation of pedestrians and vehicular traffic or to control conflicting streams of traffic. The term "islands" includes all such areas.

Classification

Islands may be classified functionally and physically as follows:

A. SAFETY ZONES
   1. Loading islands
      (a) Permanent
      (b) Removable
      (c) Preliminary
   2. Pedestrian islands

B. TRAFFIC ISLANDS
   1. Divisional
   2. Channelizing
   3. Rotary

Safety zones include all areas in roadways set aside for persons on foot. Traffic islands include all areas created for the diversion or segregation of vehicular traffic. The basic functions and design of the two groups are quite different, and for convenience are treated in separate divisions of this Part.

Standardization

Islands are not adapted to detailed standardization. This manual sets forth certain basic requirements that should be met in the design and construction of islands, certain minimum dimensions that should be observed, and certain defects of design that should be avoided.

DIVISION A—SAFETY ZONES

Article A-I—Legal Authority

The only questions of legal authority involved in the establishment of islands are the authority to place them in roadways where they might obstruct vehicular traffic, and the authority to exclude that traffic from them.

A model of legal authority for the establishment of safety zones is presented in the Model Traffic Ordinances, Part II, Section 14, and authority for the exclusion of vehicular traffic from such zones is provided in Article XI, Section 83, of Act V, Uniform Vehicle Code.

Article A-II—Application

Of the conditions which should be considered in determining whether or not a safety zone is warranted, the following are of major importance.

(a) Accident frequency
(b) Density of vehicular traffic
(c) Density of pedestrian traffic
(d) Speed of vehicular traffic
(e) Width of roadway
(f) Complexity of intersection
Section 401—Functions of Safety Zones

Safety zones are used principally in cities to afford protection to pedestrians at street car loading points or where they are unable to cross wide roadways safely without stopping. They may fill several useful functions:

(a) Provide opportunity for street car passengers to await, enter or leave street cars in safety.
(b) Serve as loading points for buses on streets where there is both street car and bus traffic.
(c) Expedite vehicular traffic by permitting it to continue in motion while street cars or buses are stopped for loading.
(d) Provide protection for pedestrians crossing the roadway.
(e) Expedite vehicular traffic by serving as divisional islands to separate opposing streams and hold vehicles in lanes.

Section 402—Loading Islands

Loading islands are warranted and should be established at street car stops under any of the following conditions:

(a) Where both vehicular and pedestrian traffic are sufficiently heavy to require physical separation.
(b) Where the speed of vehicular traffic along the roadway is so high that physical protection is required for even a limited number of pedestrians.
(c) Where accident experience indicates the need.

Loading islands should be used by buses as well as street cars on streets where both types of vehicles are operated, but if a separate loading place is used by buses, it should be located on the corner away from the loading island, to avoid congestion in the traffic lane beside it.

Section 403—Types of Loading Islands

403a. The Permanent type of loading island should always be used if possible in order to afford maximum protection to pedestrians.

403b. The Removable type of loading island may be used instead of the permanent type at points where permanent structures cannot be permitted because unobstructed use of the roadway may be required at times.

403c. A Preliminary type of loading island may be used where apparent need for it is indicated by conditions or suggested by public requests, but where it is considered advisable to make actual tests of the need before constructing a permanent island, or where insufficient funds are available for permanent construction. Preliminary installations should be replaced as soon as possible with a type which provides some measure of physical end protection.

Section 404—Pedestrian Islands

Pedestrian islands shall be used in urban areas on exceptionally wide roadways or in large or irregularly shaped intersections where there is a considerable amount of pedes-
tarian traffic and where heavy volumes of vehicular traffic make it difficult and dangerous for pedestrians to cross. No island shall be placed where there is less than 20 feet between it and the adjacent sidewalk or another island.

Pedestrian islands should not be located in roadways carrying fast-moving vehicles unless they can be so placed, usually in the center of the roadway between the opposing streams of traffic, as not to create hazards to the vehicles. At any other point on such roadways where there is any considerable pedestrian movement across the roadway it should be protected by other means, such as a pedestrian actuated traffic signal or a pedestrian subway.

In urban areas, however, where the vehicular traffic is relatively slow-moving, pedestrians in any considerable number should not be required, particularly at uncontrolled intersections, to find their way through more than four lines of traffic without the refuge of a center island, or through more than three lines in one direction without an intermediate island. Such islands may also be desirable at signalled intersections to reduce the clearance periods and expedite traffic.

Section 405—Direction of Flow at Islands

Whenever islands are established in roadway areas, the local traffic authority shall specify, in each case, whether vehicles may pass on both sides of the island or are restricted to passing only toward the right, and standard signs designating such regulations shall be placed properly to inform the vehicle driver (see Fig. 143h).

Article A-III—Design

Section 406—Elements of Design

Loading islands shall be designed first to afford as great protection as necessary to the car rider or pedestrian and second to create as little hazard as possible to passing vehicles.

The following are the principal elements in the design and construction of safety zones:

(a) Platform or pavement marking designating the restricted area
(b) Protection of area on the end toward approaching vehicles
(c) Protection of area along the side toward the curb
(d) Illumination of end protection and area

At present there is practically no standardization in the design and construction of islands of any type, even in the case of loading islands, which are best adapted to the establishment of standards. Consequently the principal elements listed above may be found in various combinations in existing equipment.
Section 407—Designation of Area by Platform

The area of a safety zone is frequently designated by the construction of a platform raised above the pavement level to approximately the same height as the adjacent sidewalks. Such platforms are generally made in permanent form of concrete or similar material, with curbing conforming to local standards and with the surface properly graded for drainage.

In some instances, for economy or convenience, platforms or loading islands are made of wood in less permanent form. Frequently they are so constructed as to be removable entirely when the full area of the roadway is required for other uses. In such cases the safety of the restricted area is directly dependent on the effectiveness of the end protection and on the degree of permanence of the construction.

When wooden platforms are used, they shall be built in the most substantial manner possible, the height shall be the same as that specified for the permanent type, and the outside edges shall be faced smoothly, similar to the curbing.

Section 408—Designation of Area by Pavement Markings

Pavement markings to designate a safety zone, where a platform is not used, shall be as permanent as possible, but shall not be considered as sufficient in themselves to protect pedestrians. When located in the line of traffic they shall always be supplemented by adequate devices for end and side protection (see Section 411).

The so-called safety zone made by simple pavement markings with or without buttons but without other protection is dangerous and is not recommended.

Section 409—End Protection of Loading Islands

All loading islands shall have adequate physical protection at the end toward approaching traffic to withstand the impact of colliding vehicles.

The only satisfactory end protection for permanent construction is a sloping abutment designed to stop colliding vehicles and minimize the damage thereto. Vertical abutments are not recommended.

Vertical posts (three or more) solidly set in the pavement in a curve so as to deflect colliding vehicles, or removable posts firmly set in deep sockets in the ground in a curve, so installed that they can be removed and the foundation holes covered, are permissible for temporary or removable zones, but they cannot be regarded as adequate protection against serious hazards to vehicles colliding with them.

The safety of an area set aside for pedestrians is more dependent upon the adequacy of the protection at the end toward approaching traffic than upon any other feature of the design. Hence no loading island can be classified as
permanent unless it is provided with a substantial buttress at the end sufficiently strong to withstand the impact of any vehicle which might accidentally collide with it.

It is unlikely that conditions indicating the use of a removable loading island will occur in locations described in item (b), Section 402, but if they do the end protection should be designed to provide the maximum possible safety to pedestrians.

There are many existing installations where no end protection is provided except the raised curb of the platform, or the installation of an ordinary lighting pole, or the placement of one or more signs mounted on movable posts having heavy pedestal bases. None of these types can be considered to provide adequate end protection, and they should be used, if at all, only for zones of the preliminary type where even the slightest protection may be better than none at all.

In general, loading islands without end protection, even if the platform is raised, are dangerous and are not recommended.

The end protection of a loading island should not only safeguard pedestrians occupying the area, but should also minimize the hazard to the occupants of a vehicle which may collide with the buttress. To provide this additional protection, several cities have extended the end buttress into a portion of the long V-shaped area which is avoided by vehicles diverging to pass either side of a safety zone. This extension is designed on the theory that a moving vehicle which enters the “dead” area in advance of a safety zone will collide with the buttress, and that, therefore, the “dead” area should be occupied by a structure which will deflect vehicles or minimize the effect of a head-on collision. Experience with this type of loading island protection has not been sufficient to warrant the development of standard specifications at this time. In general, these designs contemplate a structure, in advance of the buttress, which is fairly narrow at the extreme end and widens gradually to the full width of the island. This widening of the base of the structure is accomplished by a curve rather than a straight line to assist in the deflection of the vehicles.

In one type of design the approach end of the structure is constructed sufficiently low to permit the axle of a vehicle, striking it head-on, to pass over it. The central strip (or strips) of the structure are sloped upward so that the axle will quickly come into contact therewith and ride up it. The resulting frictional resistance will tend to bring the vehicle to a less abrupt stop. The sides of the structure are usually rounded or sloped from the central friction strip to the pavement to prevent the overturning of a vehicle which strikes the structure head-on, and also to divert without serious damage the wheels of a vehicle coming into a glancing collision with the structure.

Several other designs have been used, ranging from that just described to abutments having only the slightest rounding or slope of contour toward approaching traffic, but the trend is toward the extension of the structure farther into the dead area. This trend seems justified by the reduction in serious injuries and damages which has been demonstrated by tests.

Section 410—Side Protection of Loading Islands

Side protection of loading islands is warranted only where unusually hazardous conditions indicate its need. In some instances where an abutment is placed at the end of the loading space, but no platform is provided, properly designed side protection may be desirable.
When loading islands were first utilized, considerable attention was given to side protection to prevent invasion by vehicles and to discourage pedestrians from leaving loading islands at other than designated crosswalks. Experience has demonstrated that a raised platform in most instances provides adequate protection against vehicle invasion from the side, whereas side posts without raised platforms create a hazard by engaging the wheels of vehicles and causing them to be diverted into other traffic. The use of chains or rails to connect posts along the side of loading islands does not seem to have any greater justification that would a similar device inserted along the curbs of busy thoroughfares.

Where side protection is deemed essential it should be provided by a line of fixed or firmly secured removable posts, not less than 3 feet high and set not more than 8 feet apart. In the absence of a raised platform a substantial sheet of metal, extending at least 12 inches above the pavement, should be placed along the line of posts, on the side of vehicular traffic, to prevent vehicle wheels from striking the posts, and to divert such traffic away from the loading island.

In no instance should posts for side protection be located within a crosswalk.

Section 411—Pedestrian Island Protection

Since pedestrian islands are generally located on the medial line of a highway, where vehicular traffic passes in opposite directions on either side, only a moderate amount of end protection is necessary. When the island is located at a point where traffic passes in the same direction on both sides, it should be provided with the same type of end protection as a permanent loading island. Generally, pedestrian islands are short in length and quite frequently are located in crosswalk areas where no side protection is possible.

Section 412—Illumination of Safety Zones

All safety zones shall be provided with the following means of illumination:

(a) A flood light so arranged that it will effectively illuminate the buttress or other end protection structure of the zone.

(b) Three yellow lights flashing simultaneously showing toward approaching vehicular traffic and mounted on the end of the zone, one at a height of 12 feet and the other two 4 feet above the pavement.

In addition to the foregoing, it is desirable that a flood light be so arranged that it will effectively illuminate the platform or restricted pavement area available for the use of pedestrians. It is desirable to have two independent sources of light supply for the illumination of safety zones.

In the case of permanent loading islands and pedestrian islands, the illuminating equipment is usually placed on the end protection structure. Light equipment for removable loading islands must be arranged so that the area can be cleared entirely when occasion requires the removal of the island. This is usually accomplished by suspending the lights above the area, or by mounting them on supports outside of the roadway.
Where illumination is not available for a preliminary island, portable red lanterns shall be placed on the stanchions marking the end of the island, and the signs marking the island shall be of the reflecting type.

Section 413—Signs at Safety Zones

An appropriate standard sign shall be placed on every safety zone in the line of traffic flow at the end toward approaching traffic. It shall be illuminated adequately, preferably of the reflecting type. The height of the center of the sign shall be not more than 4 1/2 feet above the pavement.

Appropriate signs mounted 8 feet above the pavement shall be placed along the curb of the sidewalk adjacent to all loading islands prohibiting parking opposite the entire length of the island and for such distance beyond the point opposite each end thereof as is necessary to permit easy passing by moving vehicular traffic. (Section 92 (8), Act V, Uniform Vehicle Code.)

Section 414—Markings at Safety Zones

The approach to a safety zone in the line of traffic flow shall be marked on the pavement as provided in Section 229, Part II.

The ends of all islands toward approaching traffic shall be marked according to the standards presented in Section 238, Part II.

The latter applies particularly to buttresses and lighting standards or protection posts on safety zones. Markings are also very effective when placed on the curbing of islands in or adjacent to the line of approaching vehicular traffic.

Section 415—Shape of Safety Zones

Loading islands and pedestrian islands located in straight streets are generally rectangular, frequently with the ends pointed or rounded. Pedestrian islands in wide irregular roadway areas should be of proper shape to fit the general layout.

Section 416—Height of Platform

The platform height of all islands used by pedestrians shall be from 5 to 7 inches and in general shall conform to local standards of curb height for sidewalks. Where additional surfacing is anticipated on the roadway pavement, due allowance shall be made for it.

Section 417—Dimensions of Loading Islands

Loading islands shall be at least 4 feet wide and shall be long enough to provide adequate access to car entrances for
the number of cars ordinarily stopped at the island at one time.

Because of the difference in widths of street cars, no standard distance from the rail can be specified. Platforms should be built to accommodate the narrowest car. If any cars are operated which would overhang the edge of the island, warning to this effect should be given by marking a safe clearance distance.

Section 418—Dimensions of Pedestrian Islands

Pedestrian islands shall be not less than 3½ feet wide and the usable length shall be not less than 5 feet nor less than the width of the approaching crosswalk.

Section 419—Summary Specifications of Loading Islands

419a. The *Permanent* type of loading island should be designed in accord with the following specifications:

(a) Shape
(b) Designation of area
   - Platform
   - Pavement
(c) Dimensions
   - Length
   - Width
   - Height
(d) End protection
(e) Side protection
(f) Markings
(g) Sign
(h) Illumination

<table>
<thead>
<tr>
<th>Shape</th>
<th>Rectangle (V-shaped end preferred)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete or metal</td>
<td></td>
</tr>
<tr>
<td>Fixed posts, with buttons or other markings</td>
<td></td>
</tr>
<tr>
<td>Providing access to all car entrances</td>
<td></td>
</tr>
<tr>
<td>4 feet minimum</td>
<td></td>
</tr>
<tr>
<td>5 to 7 inches, equal to adjacent curbs</td>
<td></td>
</tr>
<tr>
<td>Sloping abutment (V-shape preferred)</td>
<td></td>
</tr>
<tr>
<td>Platform curbing (posts optional)</td>
<td></td>
</tr>
<tr>
<td>Stripes on end and side protection, including edges of platform</td>
<td></td>
</tr>
<tr>
<td>&quot;Safety Zone,&quot; center not more than 4½ feet high (Fig. 143h)</td>
<td></td>
</tr>
<tr>
<td>Three flashing yellow lights, two 4 feet and one 12 feet high; flood light on end protection</td>
<td></td>
</tr>
<tr>
<td>Flood light on island (optional)</td>
<td></td>
</tr>
</tbody>
</table>

419b. The *Removable* type should be designed in accord with the foregoing specifications except in the following items:

(b) Designation of area
(d) End protection
(e) Side protection
(h) Illumination

<table>
<thead>
<tr>
<th>Designation of area</th>
<th>Wood or metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platform</td>
<td>Removable posts in deep sockets</td>
</tr>
<tr>
<td>Pavement</td>
<td>Removable posts</td>
</tr>
<tr>
<td></td>
<td>Same (optional)</td>
</tr>
<tr>
<td></td>
<td>Not operated when island is removed</td>
</tr>
</tbody>
</table>

419c. The *Preliminary* type of loading island should be designed in accord with the foregoing specifications except in the following items:

(b) Designation of area
(d) End protection
(e) Side protection
(h) Illumination

<table>
<thead>
<tr>
<th>Designation of area</th>
<th>Removable posts with heavy bases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removable posts</td>
<td>Removable posts</td>
</tr>
<tr>
<td>Same (chain optional)</td>
<td>Red lanterns on posts when other illumination is not available</td>
</tr>
</tbody>
</table>
Section 420—Summary Specifications of Pedestrian Islands

Pedestrian islands should be designed in accord with the following specifications:

(a) Shape
   Rectangle in straight street; to fit plan in wide road intersection

(b) Designation of area
   Platform
   Concrete or metal
   Pavement
   Posts

(c) Dimension
   Length
   Width
   Height
   5 feet minimum, not less than crosswalk width
   3 1/2 feet or more
   5 to 7 inches, equal to adjacent curb
   Curbing
   End and side protection
   Flood light on area

Article A-IV—Location

Section 421—Loading Islands

Loading islands shall be located at street intersections with the end at the near edge of the crosswalk, unless such location is unavailable because of switches, turning movements or similar conditions. When a loading island is located in the middle of a long city block, a special crosswalk shall be marked giving access to it on the side of the island at one or more selected points.

In no case shall a loading island be established unless there is at least one available traffic lane 9 1/2 feet wide between the curb and the island.

Section 422—Pedestrian Islands

Normally, pedestrian islands shall be centered on the medial line of the roadway and within the lines of the crosswalk.

In the case of eight-lane roadways in urban areas under the conditions described in Section 404, additional islands should be placed at the one-quarter and three-quarter points. Inasmuch as they will be directly in the line of traffic, they will require the same end protection and illumination as loading islands.

DIVISION B—TRAFFIC ISLANDS

Article B-I—Legal Authority

Traffic islands are elements of street and highway design and as such require no other authority.
Article B-II—Application

Of the conditions which should be considered in determining whether or not a traffic island is warranted, the following are of major importance:

(a) Accident frequency
(b) Density of vehicular traffic
(c) Speed of vehicular traffic
(d) Requirements for physical regulation
(e) Width of roadway
(f) Complexity of intersection
(g) Physical obstructions in roadway, such as monuments and supports of overhead structures

Section 423—Types of Traffic Islands

Traffic islands of the divisional and channelizing types, which do not add materially to the total width of roadway, are applicable in highly developed urban areas as well as suburban and rural areas. Because of the space required for adequate rotary movement of traffic, rotary islands, except in the case of circles and small parks laid out with the original street system, have their principal application in suburban and rural districts, where the cost of land is not prohibitive.

Section 424—Divisional Traffic Island

The divisional type of traffic island may be used longitudinally in a roadway to separate different streams of traffic under any of the following conditions:

(a) In a roadway having only two lanes where it is desired to prevent vehicles going in the same direction from passing one another, as, for example, at narrow bridges, viaducts or underpasses or on dangerous curves
(b) In a roadway having four or more lanes where it is desired to separate the streams of traffic flowing in the opposite direction
(c) In a roadway having six or more lanes where it is desired to separate the slow moving local traffic serving the abutting property along the sides from the faster through traffic moving in the same direction nearer the center
(d) In a roadway of any width where it is desired to provide guides to traffic approaching a fixed obstruction, such as a bridge support or a safety zone
(e) In a roadway at the ends of tunnels or bridges or where traffic is regularly stopped for toll or inspection purposes.

As the potential speeds of automobiles have increased and highway surfaces have been improved, the hazards of higher passing speeds have vastly increased. While this condition has been met to some extent by widening the roadway to three, four and even more lanes, the hazard still remains so long as there is common surface in the center of the highway which is accessible to traffic moving in opposite directions. The only adequate means of preventing such hazard is the installation of traffic islands in the form of raised medial strips, which may be of any width from a narrow curbing to a broad parked strip.
Section 425—Channelizing Traffic Island

The channelizing type of traffic island may be used in large or complicated intersections or in the approaches thereto of streets four or more lanes in width to guide vehicles into a proper path of travel through the area.

While the hazard of collision will tend to prevent a motorist from diverging from a straight course on a narrow roadway, there is a tendency on the part of many drivers to wander without good judgment on wide roadways, especially at intersections where there is a broad expanse of pavement. This tendency can be checked by the installation of channelizing islands in areas not used by the normal flow of traffic.

Section 426—Rotary Traffic Island

The rotary type of traffic island may be used where two or more highways carrying heavy traffic intersect and it is desirable to raise the capacity of the intersection as nearly as possible to the combined capacities of the highways without grade separation, by compelling all traffic to flow to the right around the island located in the center.

A long, narrow rotary island may also be effectively placed longitudinally in the center of a major highway across the line of a minor highway in order to compel drivers desiring to cross straight through or turn left at the intersection from the minor highway to weave through the traffic on the major highway instead of crossing it at right angles.

Article B-III—Design

Section 427—Elements of Design

The same elements of design are used for traffic islands as for safety zones, but with different degrees of emphasis because of the varying conditions of location and use. Since they are not intended to protect pedestrians and are frequently located to one side instead of in the direct line of traffic flow, little or no special end and side protection may be required, while permanence of construction is of major importance.

Section 428—Designation of Area

In most cases traffic islands are designated by permanent curbs outlining the area, with suitable filler of pavement, lawn or shrubs, depending upon the location and other conditions. Such curbs are sometimes sloped more than standard curbing to reduce possible damage to colliding vehicle wheels. Where it is important that vehicle operators be able to see beyond the island, shrubbery should not exceed 2 feet in height, so that it will not obstruct the operator's view. No such limitation is necessary in the case of large rotary islands.

Occasionally conditions may warrant the use of mushroom buttons to designate the area of traffic islands, especially of the channelizing type.
Section 429—End and Side Protection for Traffic Islands

Traffic islands generally do not require any end or side protection other than the curbing, except that narrow divisional islands should be provided with slopes or posts on the end toward approaching vehicular traffic to avoid damage to colliding vehicles.

Section 430—Illumination of Traffic Islands

In general, traffic islands can be illuminated adequately by the street lighting system, but if not, especially in rural locations or in the case of narrow islands in the line of traffic flow, the same methods of illumination should be adopted as are specified for safety zones. Where the narrow end of a traffic island faces approaching traffic for the purpose of segregating or channelizing parallel streams of flow, an appropriate illuminated standard sign shall be used to mark its location.

Section 431—Signs at Traffic Islands

Small traffic islands in the line of traffic streams and those not illuminated adequately shall be protected by appropriate illuminated signs.

Section 432—Markings at Traffic Islands

Small traffic islands in the line of traffic streams shall be marked in the manner provided for safety zones in Section 414.

In other cases, it is quite common practice to mark the curbs of traffic islands with solid white color or with standard object marking for the general guidance of drivers.

Section 433—Shape of Traffic Islands

The shape of a traffic island is dependent upon its location and the function it is to perform.

Traffic islands of the divisional type are usually long and relatively narrow rectangles.

Traffic islands used for channelizing purposes are likely to be any shape, although the majority are modifications of triangles.

Traffic islands of the rotary type are usually circles or some modified form that approximates a circle or an ellipse. They may be extended in one direction to such degree that they become rectangles with rounded ends, while occasionally they are quite irregular in shape to fit peculiar conditions.

In any case, they should be of sufficient size and of proper design to permit reasonable speed around them and to make approaching vehicles from the various highways reduce speed sufficiently so that safe convergence will result. The distances between much used entrances and outlets should be sufficient to permit vehicles to weave
through the stream to the desired outlet without interrupting continuous flow of traffic.

In cases where the traffic is much heavier on one highway than on the others, modifications of design are possible, for example:

(a) Elongation of the island into an ellipse with the longer dimension in the direction of the heaviest traveled highway.

(b) Separation of the heavier flow from that of the other highways by circular divisional islands forming two concentric circles of travel, of which the inner one is available only to traffic on the principal highway by properly located openings between the ends of the divisional islands. This method makes signal control necessary at the entrances to the inner circle where the streams of traffic meet practically at right angles.

Section 434—Height of Traffic Islands

The height of the platform for traffic islands is usually the same as that of adjacent curbs, varying from 5 to 7 inches. In some cases of divisional type islands, it may be desirable to make them higher, but care should be taken to avoid any chance for collision with projecting parts of passing vehicles, such as hubs, steps or running boards.

Section 435—Dimensions of Divisional and Channelizing Traffic Islands

Divisional and channelizing traffic islands shall preferably be not less than 2 feet wide, and they shall not extend into any intersection beyond the curb line of the crossway. In general, the widths shall be adjusted to maintain 10-foot lanes for traffic moving in a straight line, 12-foot lanes for traffic moving around curves, and 7-foot lanes for parallel parking.

When medial divisional islands are laid out they should be so planned as to width that if additional traffic lanes are likely to be required in the future, either by street widening or narrowing of the divisional island, or both, there will always remain a medial divisional island at least 2 feet wide, and if pedestrian crossings are required, there will also be opportunity for pedestrian islands at two-lane or three-lane intervals as called for in Section 404.

Consideration should also be given to provision for left-turning vehicles while waiting for an opportunity to cross the opposing stream of traffic.

Section 436—Dimensions of Rotary Traffic Islands

Each rotary traffic island must be designed with particular regard for existing conditions and for the safety of pedestrians, especially as to roadway widths and curb radii. The following are governing considerations:

(a) The central island must be large enough for a vehicle traveling at the most desirable rate of speed to follow the inner curb closely. One hundred
feet is recommended as the minimum radius, although short arcs of 75-foot radius may be permitted joining curves of larger radius. A speed of 20 miles per hour can be maintained without danger or discomfort around a circle of 100-foot radius, but the design should discourage speeds higher than 25 miles per hour.

(b) The central island must be large enough to afford adequate space for interweaving between any two entering streets.

**Section 437—Summary Specifications of Traffic Islands**

437a. The *Divisional* type of traffic island should be designed in accord with the following specifications:

<table>
<thead>
<tr>
<th>(a) Shape</th>
<th>Rectangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b) Designation of area</td>
<td>Concrete curbs with suitable filler</td>
</tr>
<tr>
<td>(c) Dimensions</td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td></td>
</tr>
<tr>
<td>(d) End protection</td>
<td></td>
</tr>
<tr>
<td>(e) Side protection</td>
<td></td>
</tr>
<tr>
<td>(f) Marking</td>
<td></td>
</tr>
<tr>
<td>(g) Sign</td>
<td></td>
</tr>
<tr>
<td>(h) Illumination</td>
<td></td>
</tr>
</tbody>
</table>

437b. The *Channelizing* type of traffic island should be designed in accord with the foregoing specifications except in the following items:

<table>
<thead>
<tr>
<th>(a) Shape</th>
<th>To fit plan of location, usually triangular</th>
</tr>
</thead>
<tbody>
<tr>
<td>(c) Width</td>
<td>Variable, dependent upon conditions</td>
</tr>
<tr>
<td>(d) End protection</td>
<td>Abutment if in line of traffic</td>
</tr>
</tbody>
</table>

437c. The *Rotary* type of traffic island should be designed in accord with the foregoing specifications except in the following items:

<table>
<thead>
<tr>
<th>(a) Shape</th>
<th>To fit plan of location, frequently circular</th>
</tr>
</thead>
<tbody>
<tr>
<td>(c) Dimensions</td>
<td></td>
</tr>
<tr>
<td>100-foot radius or more</td>
<td></td>
</tr>
<tr>
<td>(d) Protection</td>
<td></td>
</tr>
<tr>
<td>Curbing</td>
<td></td>
</tr>
<tr>
<td>(e) Marking</td>
<td></td>
</tr>
<tr>
<td>Stripes on curbing opposite approach streets (optional)</td>
<td></td>
</tr>
<tr>
<td>(f) Sign</td>
<td></td>
</tr>
<tr>
<td>Illuminated ONE-WAY opposite approaches</td>
<td></td>
</tr>
<tr>
<td>(g) Illumination</td>
<td></td>
</tr>
<tr>
<td>Adequate street lighting</td>
<td></td>
</tr>
</tbody>
</table>

**Article B-IV—Location**

**Section 438—Divisional Islands**

Divisional islands separating streams of traffic moving in opposite directions shall be located on the medial line of a roadway (Figs. 438 and 438a).
Divisional islands separating streams of traffic moving in the same direction may be located to suit the conditions, usually with more restriction of space to the slower moving stream.

Section 439—Channelizing Islands

Channelizing islands are of such varying character and shape that no standards of location can be formulated. Usually they are located in areas, as shown by traffic patterns, not used by the normal flow, where they will not interfere with correct movement.

Section 440—Rotary Islands

Rotary islands may be located in the centers of large intersections of two or more major highways (Figs. 440 and 440a).

Section 441—Street Car Tracks in Rotary Islands

In case there is a street car line passing through the intersection, the tracks should be routed through the island or around it in the direction of the vehicular traffic flow.

Sometimes a rotary island has been in use so long as to antedate the advent of motor vehicles. In such cases it is not unusual for a double-track street car line to be installed on one side of the island, with cars operating in both directions, one of which is opposite to the flow of other vehicles. Such a situation is both inconvenient and dangerous and should be corrected.

Section 442—Combinations of Islands

In many cases conditions are such as to warrant the location of several islands in combination, of which the following are common examples:

(a) Two or three divisional islands in a wide highway or boulevard
(b) Channelizing islands in the approaches to a large rotary island
(c) Curved divisional islands around a rotary island to separate the streams of traffic from different entering highways

Section 443—Unwarranted Islands

Not infrequently traffic islands have been placed without due regard for the convenience of the traffic they are intended to facilitate and control, with the result that they hinder free movement, causing confusion and delay rather than expediting traffic.

No traffic island shall be established unless there are at least two available lanes not less than 20 feet wide between the island and the adjacent curb, except in the case of a divisional island on a two or three lane roadway in a dangerous location, such as a narrow bridge or curve.
Fig. 130
ROUNDED LETTERS
Optional where dies are not involved

B C D
G O P
R S U

A 71-a
(See A 71-a Appendix D)
Fig. 141-a
NO LEFT TURN

Fig. 141-b
WATCH TRAFFIC SIGNALS

Fig. 141-c
END 25 MILE SPEED

Fig. 141-d
ONE WAY DO NOT ENTER

Fig. 142
TRACTORS WITH LUGS PROHIBITED

Fig. 142
KEEP RIGHT PASS IN CENTER ONLY

Fig. 142
ONE WAY
FIG.150 - APPROVED DESIGN FOR SLAT GUIDE SIGNS WITH BRACKETS FOR MOUNTING ON POSTS

TYPES OF POSTS, SEE FIG. 136

SLAT SIGN ASSEMBLY

HUNTINGTON 148

SLAT SIGN

NOTES
SLATS INTERCHANGEABLE
FOR SIZES OF LETTERS AND NUMERALS, SEE SHEETS A-35, 36

SECTION OF SLAT

1/2" CARRIAGE BOLT

3/8" #8 BRASS SCREW

16' LENGTH OVER ALL

STEEL PLATE 10 GAUGE

DETAILED OF BRACKET

SECTION A-A

DRILL FOR 3/8" #8 BRASS SCREW
APPENDIX A

Warrant for Use of Hill Sign

A HILL sign should ordinarily be used only on descending grades and under the following conditions:

On a 6 percent grade, more than 2,000 feet long
7 percent grade, more than 1,000 feet long
8 percent grade, more than 750 feet long
9 percent grade, more than 500 feet long
11 percent grade, more than 400 feet long
13 percent grade, more than 300 feet long
15 percent grade, more than 200 feet long
16 percent grade, any length

This sign should be used where the percent or length of grade is less than above indicated, if the grade is also on a sharp curve.
APPENDIX B

Specifications for Uniform Signs and Markers
As Proposed by the
Joint Board on Interstate Highways

DESCRIPTION

This work contemplates the fabrication and finishing of road signs and markers in wood, embossed metal, cast iron, cast steel, cast aluminum or vitrified enamel, as indicated by the purchasers, in accordance with the standard working drawings approved by the Joint Board on Interstate Highways, and with these specifications.

MATERIALS

The material to be used for the sign board in any order shall be designated by the purchaser, and shall conform to the following:

1. Wood used for these signs should be yellow poplar, redwood, white pine, yellow pine, fir or cypress, kiln dried, grading one face clear, other side free from wane, loose knots or large pitch pockets as may be designated and approved by the purchaser.

2. Sheet metal used for embossed signs or for base of vitrified enamel signs shall conform to the following requirements at the option of the purchaser.
   a. The total amount of carbon, phosphorus, sulphur, manganese and silicon shall not exceed 0.7 percent. If the total of these five elements equals or exceeds 0.2 percent, the metal shall contain not less than 0.17 percent of copper, and not more than 0.06 percent of sulphur. If the total of these five elements is less than 0.2 percent, the presence of copper is optional and sulphur shall not exceed 0.04 percent.
   b. Commercial flat black sheets.
   c. Cast iron shall conform to the American Society for Testing Materials Standard Specifications, Serial Designation A 47-24, or A 48-18, and subsequent amendments to date of contract, as may be indicated by the purchaser. Where adequate foundry control methods are enforced, special tests for physical properties of the separate heats used will not be required.
   d. Cast steel shall conform to the American Society for Testing Materials Standard Specifications, Serial Designation A 88-24 (semi-steel), and subsequent amendments to date of contract. Where adequate foundry control methods are enforced, special tests for physical properties of the separate heats used will not be required.
   e. Cast aluminum shall conform to the American Society for Testing Materials Standard Specifications, Serial Designation B 26-21, Alloy E, and subsequent amendments to date of contract.

Paint

(a) Paint for metal signs both for background and design colors shall be of the enamel type of a quality and character to permit of baking, and shall produce a true color tone and a surface smooth, tough and without cracks or other blemishes. The yellow color tone, as indicated by reflected white light, shall show a dominant wave length of not less than 580 nor more than 588 millimicrons, a purity of not less than 80 percent, and an integral reflection of pigment of not less than 35 percent. A liquid color sample conforming to this specification will be furnished by the purchaser if demanded.

(b) Enamels for vitrifying shall be either a colored glass or shall have a glass base or carrier with pigment in suspension, so compounded that upon fusion they will produce glass of the required color.

(c) Paint for wooden signs, both for background and design colors, shall consist of pure linseed oil and best grade pigments together with pure gum turpentine and dryer. It shall produce a true color tone which will not change
under exposure, and a surface smooth, tough and without cracks or other blemishes. The yellow color tone as indicated by reflected white light shall meet the same standards as specified for metal signs.

**Fabrication**

*Variation*

All working drawings show finished signs, and die and pattern makers must provide for allowances required by the processes of manufacture. For wood the overall dimensions are nominal. For sheet metal the overall dimensions of finished signs may vary from drawings by not more than one-sixteenth inch per foot for draw in embossing. For cast iron, cast steel and cast aluminum the overall dimensions of finished signs may vary from drawings by not more than one-eighth inch per foot.

*Wooden Signs*

Signs made of wood shall have tongue and groove glue joint parallel with grain of wood, which grain shall run in the direction of the longer overall dimension of the finished sign; shall be thoroughly glued with a high grade waterproof glue; and shall be reinforced with two battens securely fastened to each separate member of the sign. Sign boards and battens shall be of one inch stock surfaced on all sides. Face of board when finished shall be a smooth plane surface.

*Sheet Metal Signs*

Signs made of sheet metal shall be embossed or have a vitrified finish; and when embossed the details of the design shall be raised from the background of the design not less than one hundred one-thousandths (0.100) nor more than one hundred and twenty-five one-thousands (0.125) of an inch. The finished embossing or vitrifying shall conform to the lines of the working drawings and shall be clear and even in outline and free from cracks or tears. The entire sign shall be free from wind, twist, or buckle, and the background shall be substantially a plane surface. Unless otherwise specified by the purchaser, all signs shall be of eighteen (18) gauge metal, United States standard. If so specified, signs having a dimension of more than twenty-two (22) inches lateral to the finished design shall be of sixteen (16) gauge metal, United States standard.

*Cast Iron or Steel Signs*

Signs of cast iron or steel shall be true to line and finish as specified under material specifications. The background shall be not less than one hundred and sixty one-thousandths (0.160) of an inch in thickness, and the design shall be raised not less than one hundred one-thousandths (0.100) nor more than one hundred and twenty-five one-thousandths (0.125) of an inch. Thickness of background, if to be greater than the minimum specified above, shall be so stated by the purchaser.

*Cast Aluminum Signs*

Signs of cast aluminum shall be true to line and gauge and free from holes and coarse, pitted or porous areas. The background shall be not less than two hundred one-thousandths (0.200) of an inch in thickness, and the design shall be raised not less than one hundred one-thousandths (0.100) nor more than one hundred and twenty-five one-thousandths (0.125) of an inch. The thickness of background, if to be greater than the minimum, shall be so stated by the purchaser.

**Finish—Background Color**

*Wood Signs*

Wooden signs shall have a primer coat, dipped, brushed or sprayed; a second coat dipped, brushed or sprayed; and a finish coat, brushed or sprayed. Each coat shall be thoroughly dry before the succeeding coat is applied. The finish
coat after drying shall produce a semi-gloss finish and shall be free from brush marks, blisters, wrinkles or other blemishes.

**Embosed Metal Signs**

Embosed metal signs shall have one primer coat, dipped or sprayed, and at least one additional coat on the back and two additional coats on the face. The last coat shall be brushed or sprayed, and following the application of the last background coat the sign shall be baked for not less than one and one-half hours at a temperature of 175°F. to 325°F. according to the requirements of the pigment and carrier oils. The baking temperature and rate of increase of temperature shall be so controlled as to produce a tough, flexible coating, not visibly darkened and entirely free from cracks, shrinkage, wrinkles, blisters or other blemishes. Separate baking of each background coat may be given, but is not required.

**Vitrified Enamel Signs**

Vitrified enamel signs shall have a background finish consisting of a “slush,” “grip” or “ground” coat separately fused to the base metal. On this shall be applied the succeeding coats necessary to produce the desired design. All coats shall be so fused as to produce in the finished sign a single integral coat of enamel.

**Cast Iron and Steel Signs**

The background coat of cast iron and steel signs shall be applied in the same manner as specified for embossed metal signs.

**Cast Aluminum Signs**

Signs of cast aluminum may be finished as bright castings without further treatment, or they may have applied a coat of aluminum paint, wherever the color code of the standard designs specifies white. Baking will not be required for aluminum paint, but if the background color is applied with paint of the enamel type, the process shall be the same as specified for embossed metal signs.

**Finish—Design Color**

**Wooden Signs**

The design color on wooden signs shall be applied by hand or process. The design color shall dry to an even, glossy black. The finished design shall be clear cut and sharp, the lines of all letters and details true, regular and free from waviness, unevenness, furry edges or lines and from all cracking, scaling, pitting, blistering or blemishes of any kind.

**Sheet Metal Signs**

The design color on embossed metal signs shall be applied by means of rolls or other suitable device, and the equivalent at least of two wet coats shall be applied. The design color shall then be baked as required for the background color. On vitrified enamel signs the design shall be produced by the successive application of enamels necessary to produce the desired colors, fused as required above. The finished design shall be clear cut and sharp, the lines of all letters and details true, regular and free from waviness, unevenness, furry edges or lines, and from all cracking, scaling, pitting, blistering or blemishes of any kind.

**Cast Iron, Steel and Aluminum Signs**

The design color on cast metal signs may be applied in the manner as specified for embossed metal signs, or may be built up with brushing or spraying lacquers which will bond thoroughly with the metal surface or background coats.
APPENDIX C

Speed and Stopping Distances

Practical Stopping Distances with Four-Wheel Brakes and Most Favorable Type of Road Surface

Prepared by National Bureau of Standards

<table>
<thead>
<tr>
<th>Miles per hour</th>
<th>Feet per second</th>
<th>Reaction distances</th>
<th>Braking distances</th>
<th>Stopping distances</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>14.7</td>
<td>7</td>
<td>7</td>
<td>14</td>
</tr>
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<td>15</td>
<td>22</td>
<td>11</td>
<td>15</td>
<td>26</td>
</tr>
<tr>
<td>20</td>
<td>29.3</td>
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<td>28</td>
<td>42</td>
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<td>25</td>
<td>36.7</td>
<td>18</td>
<td>43</td>
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<td>44</td>
<td>21</td>
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</tr>
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<td>35</td>
<td>51.3</td>
<td>25</td>
<td>84</td>
<td>109</td>
</tr>
<tr>
<td>40</td>
<td>58.7</td>
<td>28</td>
<td>109</td>
<td>137</td>
</tr>
<tr>
<td>45</td>
<td>66</td>
<td>33</td>
<td>135</td>
<td>168</td>
</tr>
<tr>
<td>50</td>
<td>73.4</td>
<td>36</td>
<td>172</td>
<td>208</td>
</tr>
<tr>
<td>55</td>
<td>80.7</td>
<td>39</td>
<td>210</td>
<td>249</td>
</tr>
<tr>
<td>60</td>
<td>88</td>
<td>42</td>
<td>248</td>
<td>290</td>
</tr>
</tbody>
</table>
APPENDIX D

Index to Series of Working Drawings

Full size working drawings of the signs listed below are on file in the Bureau of Public Roads and the several state highway departments. Copies of individual sheets will be furnished to manufacturers and those responsible for the design, erection and maintenance of such signs upon direct application to the Bureau of Public Roads, Washington, D. C.

**Regulatory Series**

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Requires also</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-1</td>
<td>Load Limit 2 Tons per Axle.</td>
<td>A-33</td>
</tr>
<tr>
<td>R-2</td>
<td>No Dumping Allowed.</td>
<td>A-33 and A-46</td>
</tr>
<tr>
<td>R-3</td>
<td>No Parking At Any Time.</td>
<td>A-33 and A-46</td>
</tr>
<tr>
<td>R-4</td>
<td>Speed Limit 20 Miles.</td>
<td>A-19 and A-48</td>
</tr>
<tr>
<td>R-5</td>
<td>Tractor Sign.</td>
<td>A-18</td>
</tr>
<tr>
<td>R-6</td>
<td>Keep Right—Pass in Center Only.</td>
<td>A-18</td>
</tr>
<tr>
<td>R-7</td>
<td>Parking on Pavement Only.</td>
<td>A-17 and A-33</td>
</tr>
<tr>
<td>R-8</td>
<td>No Stopping.</td>
<td>A-17 and A-46</td>
</tr>
<tr>
<td>R-9</td>
<td>Watch Traffic Signals.</td>
<td>A-18</td>
</tr>
<tr>
<td>R-10</td>
<td>End 25 Mile Speed.</td>
<td>A-19 and A-20</td>
</tr>
<tr>
<td>R-10A</td>
<td>Begin 25 Mile Speed.</td>
<td>A-19 and A-20</td>
</tr>
<tr>
<td>R-12</td>
<td>No Left Turn.</td>
<td>A-46 and A-47</td>
</tr>
<tr>
<td>R-13</td>
<td>One-Way. Do Not Enter.</td>
<td>A-19</td>
</tr>
<tr>
<td>R-14</td>
<td>Fresh Oil.</td>
<td>A-37, A-38 and A-39</td>
</tr>
<tr>
<td>R-15</td>
<td>No U Turn.</td>
<td>A-46 and A-47</td>
</tr>
<tr>
<td>R-16</td>
<td>No Parking This Side.</td>
<td>A-33 and A-46</td>
</tr>
<tr>
<td>R-17</td>
<td>Loose Gravel.</td>
<td>A-21, A-22 and A-23</td>
</tr>
<tr>
<td>R-18</td>
<td>Soft Shoulders.</td>
<td>A-5 and A-6</td>
</tr>
<tr>
<td>R-20</td>
<td>Parking Parallel.</td>
<td>A-17</td>
</tr>
<tr>
<td>R-20A</td>
<td>Parking Diagonal.</td>
<td>A-17</td>
</tr>
<tr>
<td>R-23</td>
<td>Church.</td>
<td>A-25, A-26 and A-27</td>
</tr>
<tr>
<td>R-24</td>
<td>Playground.</td>
<td>A-19</td>
</tr>
<tr>
<td>R-25</td>
<td>Quiet Zone.</td>
<td>A-37, A-38 and A-39</td>
</tr>
<tr>
<td>R-26</td>
<td>One-Way Arrow.</td>
<td>A-98</td>
</tr>
<tr>
<td>W-1</td>
<td>Railroad Advance Warning.</td>
<td>A-70</td>
</tr>
<tr>
<td>W-2</td>
<td>Railroad Crossbuck.</td>
<td></td>
</tr>
<tr>
<td>W-3</td>
<td>STOP sign.</td>
<td>A-70 and A-71</td>
</tr>
<tr>
<td>W-3A</td>
<td>STOP sign inset.</td>
<td>A-18</td>
</tr>
</tbody>
</table>

**Warning Series**

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Requires also</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1</td>
<td>Hill.</td>
<td>A-73 and A-74</td>
</tr>
<tr>
<td>C-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-3</td>
<td>Curve (Right).</td>
<td></td>
</tr>
<tr>
<td>C-4</td>
<td>Curve (Left).</td>
<td></td>
</tr>
<tr>
<td>C-5</td>
<td>Reverse Curve (Right).</td>
<td></td>
</tr>
<tr>
<td>C-5A</td>
<td>Reverse Curve (Left).</td>
<td></td>
</tr>
<tr>
<td>C-6</td>
<td>Turn Right.</td>
<td></td>
</tr>
<tr>
<td>C-6A</td>
<td>Turn Left.</td>
<td></td>
</tr>
<tr>
<td>C-7</td>
<td>Two-Way Arrow.</td>
<td></td>
</tr>
<tr>
<td>C-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-9</td>
<td>Hospital.</td>
<td>A-35</td>
</tr>
<tr>
<td>C-10</td>
<td>School.</td>
<td>A-25, A-26 and A-27</td>
</tr>
<tr>
<td>C-11</td>
<td>Narrow Bridge.</td>
<td>A-35</td>
</tr>
<tr>
<td>C-12</td>
<td>Narrow Road.</td>
<td>A-35</td>
</tr>
<tr>
<td>C-13</td>
<td>One Lane Bridge.</td>
<td>A-35</td>
</tr>
</tbody>
</table>
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C-15 Typical Intersection Diagram.
C-16 Typical Intersection Diagram.
C-16A Typical Intersection Diagram.
C-17 STOP Sign Ahead. Requires also A-19.
C-19 Slow to 25 Miles. Requires also A-34 and A-48.
C-20
C-21 Winding Road. Requires also A-47.
C-22 Safety Zone. Requires also A-46.
C-24 Car Line. Requires also A-47.
C-25 Draw Bridge. Requires also A-35.
C-26 Road Closed. Requires also A-35.
C-28 Detour Ahead. Requires also A-35.
C-29 Men Working. Requires also A-35.
C-30 Low Bridge. Requires also A-35.
C-31
C-33
C-34 Bad Corner. Requires also A-47.

Guide Series
M-1 Blank for route marker.
M-2 Blank for turn marker.
M-4 Turn marker design (right). Requires also M-2 and A-66.
M-5* State name insets for Wisconsin, Illinois, Missouri and Ohio. Requires also A-33 and A-45.
M-6 State name insets for Arkansas, Iowa, Minnesota and Indiana. Requires also A-33 and A-45.
M-7 State name insets for Alabama, Arizona, California and Colorado. Requires also A-33 and A-45.
M-9 State name insets for Idaho, Kansas, Kentucky and Louisiana. Requires also A-33, A-45 and A-61.
M-10 State name insets for Maine, Maryland, Massachusetts and Michigan. Requires also A-33 and A-45.
M-11 State name insets for Mississippi, Montana, Nebraska and Nevada. Requires also A-17 and A-33.
M-12 State name insets for New Hampshire, New Jersey, New Mexico and New York. Requires also A-17, A-33 and A-77.
M-13 State name insets for North Carolina, North Dakota, Oklahoma and Oregon. Requires also A-17, A-33 and A-45.
M-14 State name insets for Pennsylvania, Rhode Island, South Carolina and South Dakota. Requires also A-17 and A-33.

* Spacing and width of stroke in state names (M-5 to M-16 inclusive) are adjusted to dimensions of the shield and may be made up in a single die.
Guide Series (continued)
M-19 Single arrow.
M-19A Double arrow.
M-20 Detour. Requires also A-35.
M-21 Alternate. Requires also A-4.
M-22
M-23 Business Route.
M-24
M-25
M-26
M-27
M-28
M-29
M-30
M-32 B By-Pass. Requires also A-19.
M-33 Special shield inset showing 3 numerals and letter.
D-1 Directional sign. Two names.
D-2 County line sign.
D-3 Physical feature.
D-5 Drinking Water. Requires also A-18.
D-6 Blank for rest station.
D-7 Rest station design. Requires also A-17 and A-18.
D-8
D-9
D-10 Tourist Camp. Requires also A-19.
D-11 City Limit.
D-12 Village Limit.
D-13
D-14 Special sign (Constructed by U. S. Department of Agriculture, Bureau of Public Roads).

Alphabet Series
A-1 2-inch Series A, letters and digits.
A-2 3-inch Series A, letters and digits.
A-3 4-inch Series A, letters A to Y.
A-4 4-inch Series A, letter Z and digits 0 to 9.
A-5 5-inch Series A, letters A to T.
A-6 5-inch Series A, letters U to Z and digits 0 to 9.
A-17 2-inch Series B, letters and digits.
A-18 3-inch Series B, letters and digits.
A-19 4-inch Series B, letters A to Y.
A-20 4-inch Series B, letter Z and digits 0 to 9.
A-21 5-inch Series B, letters A to I.
A-22 5-inch Series B, letters J to R.
A-23 5-inch Series B, letters S to Z and digit 0.
A-24 5-inch Series B, digits 1 to 9.
A-25 6-inch Series B, letters A to I.
A-26 6-inch Series B, letters J to R.
A-27 6-inch Series B, letters S to Z and digit 0.
A-28 6-inch Series B, digits 1 to 9.
A-33 2-inch Series C, letters and digits.
A-34 3-inch Series C, letters and digits.
A-35 4-inch Series C, letters A to Y.
INDEX TO WORKING DRAWINGS

Alphabet Series (continued)
A-36  4-inch Series C, letter Z and digits 0 to 9.
A-37  5-inch Series C, letters A to I.
A-38  5-inch Series C, letters J to R.
A-39  5-inch Series C, letters S to Z and digit 0.
A-40  5-inch Series C, digits 1 to 9.
A-41  6-inch Series C, letters A to I.
A-42  6-inch Series C, letters J to R.
A-43  6-inch Series C, letters S to Z and digit 0.
A-44  6-inch Series C, digits 1 to 9.
A-45  2-inch Series D, letters and digits.
A-46  3-inch Series D, letters and digits.
A-47  4-inch Series D, letters A to Y.
A-48  4-inch Series D, letter Z and digits 0 to 9.
A-49  5-inch Series D, letters A to I.
A-50  5-inch Series D, letters J to R.
A-51  5-inch Series D, letters S to Z and digit 0.
A-52  5-inch Series D, digits 1 to 9.
A-53  6-inch Series D, letters A to I.
A-54  6-inch Series D, letters J to R.
A-55  6-inch Series D, letters S to Z and digit 0.
A-56  6-inch Series D, digits 1 to 9.
A-61  2-inch Series E, letters and digits.
A-63  4-inch Series E, letters A to Z.
A-64  4-inch Series E, letter Z and digits 0 to 9.
A-65  5-inch Series E, letters A to I.
A-66  5-inch Series E, letters J to R.
A-67  5-inch Series E, letters S to Z and digit 0.
A-68  5-inch Series E, digits 1 to 9.
A-69  6-inch Series E, letters A to I.
A-70  6-inch Series E, letters J to R.
A-71  6-inch Series E, letters S to Z and digit 0.
A-73  8-inch Series E, letters A to I.
A-74  8-inch Series E, letters J to R.
A-75  8-inch Series E, letters S to Z and digit 0.
A-76  8-inch Series E, digits 1 to 9.
A-77  2-inch Series F, letters and digits.
A-78  3-inch Series F, letters and digits.
A-85  6-inch Series F, letters A to I.
A-86  6-inch Series F, letters J to R.
A-87  6-inch Series F, letters S to Z and digit 0.
A-91  8-inch Series F, letters S to Z and digit 0.
A-92  8-inch Series F, digits 1 to 9.
A-93  8-inch Series C, letters A to I.
A-94  8-inch Series C, letters J to R.
A-95  8-inch Series C, letters S to Z and digit 0.
A-96  8-inch Series C, digits 1 to 9.
A-97  1½-inch Series F, letters and digits.
A-98  3½-inch Series C, letters A to Y.
A-100 3½-inch Series E, letters A to Y.
A-102 1½-inch Series D, letters and digits.
A-103 3½-inch Series B, letters A to Y.
A-104 3½-inch Series B, letter Z and digits 0 to 9.
APPENDIX E

American Association of State Highway Officials Tentative Standard Specifications for White Traffic (Zone) Paint (Ready Mixed)

Revised 1933

SPECIFICATION M-34 FOR BITUMINOUS PAVEMENTS

A. General Requirements

1. The paint shall be well ground, shall not settle badly or cake in the container, shall be readily broken up with a paddle to a smooth, uniform condition, capable of easy application with a brush in the ordinary manner according to the rules of good standard practice.

2. It is required under these specifications that the color after drying shall be a white, furnishing the maximum amount of opacity and visibility. The paint shall dry sufficiently within one-half (½) hour after application so there will be no pick-up under traffic, and thoroughly dry, free from any tackiness, within one (1) hour after application.

B. Properties

3. Composition.

<table>
<thead>
<tr>
<th></th>
<th>Minimum percent</th>
<th>Maximum percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigment</td>
<td>60</td>
<td>65</td>
</tr>
<tr>
<td>Vehicle (containing at least 40 percent of fixing drying oils)</td>
<td>35</td>
<td>40</td>
</tr>
</tbody>
</table>

4. Pigment.

<table>
<thead>
<tr>
<th></th>
<th>Minimum percent</th>
<th>Maximum percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siliceous material</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>Lithopone (light fast)</td>
<td>68</td>
<td>70</td>
</tr>
</tbody>
</table>

5. Vehicle. The vehicle should consist of the best quality of fixed drying oil (properly treated tung or linseed or mixture of these two oils), gum varnish, Japan drier and volatile thinner so proportioned in order to obtain a paint of the required color, durability and drying time. The fixed drying oils shall be of such color and quality as will not darken under service to impair the paint's visibility, and shall furnish the maximum elasticity and durability.

SPECIFICATION M-35 FOR CONCRETE PAVEMENTS

A. General Requirements

1. Paint shall be well mixed in the manufacture by proper grinding of the pigment, incorporating the inerts to meet the requirements hereafter specified. The pigment shall not settle badly or cake in the container, shall not thicken in storing to cause change in consistency, shall be readily broken up with a paddle to a smooth, uniform condition, capable of easy application with a brush of mechanical distributor in the ordinary manner according to the rules of good standard practice.

2. It is required under these specifications that the paint after drying shall have a pebbly or roughened surface and that the color shall be a flat white, furnishing the maximum amount of opacity and required amount of visibility for both night and day conditions of service. The night visibility of the reflected paint as measured by an Illuminometer in photometric apparatus at an angle of incidence of 83° 20' with an angle of reflection of 87° 8', shall be at least ten (10) foot-candles when compared to a ground standard milk glass plate having


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an angle of diffuse reflection of approximately 77 percent and furnishing an Illuminometer reading of three (3) foot-candles.

3. Paints submitted of required composition as hereinafter specified will be rated on the basis of unit price, the best night and day visibility, ease of application, covering and compliance with other requirements of specifications as determined by the Engineer. The paint shall dry sufficiently within one-half (½) hour after application so there will be no pickup under traffic, and thoroughly dry, free from any tackiness, within one (1) hour after application.

B. Properties

4. Composition.

<table>
<thead>
<tr>
<th>Pigment</th>
<th>Minimum percent</th>
<th>Maximum percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle (containing at least 30 percent fixed drying oils)</td>
<td>65</td>
<td>67</td>
</tr>
<tr>
<td>Inerts* (fibrous talc, Asbestine or other siliceous material of a combination thereof)</td>
<td>33</td>
<td>35</td>
</tr>
<tr>
<td>Lithopone (light fast)</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>Zinc Oxide (lead free)</td>
<td>55</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>12</td>
</tr>
</tbody>
</table>

5. Pigment.

6. Vehicle. The vehicle shall consist of the best quality of fixed drying oil, Japan drier and volatile thinner, so proportioned in order to obtain a paint of the required color, durability and drying time. The fixed-drying oils used shall be of such color and quality as will not darken under service to impair the paint's visibility and shall furnish the maximum elasticity and durability.

*The inerts as specified shall have an approximate mechanical analysis (grading) of

<table>
<thead>
<tr>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing 50 mesh sieve</td>
</tr>
<tr>
<td>Passing 100 mesh sieve</td>
</tr>
</tbody>
</table>
APPENDIX F

Quotations from Code on Colors for Traffic Signals Approved as an American Standard

Rule 51. Qualitative definition of colors for luminous signals.

(a) Red. The spectrum of red shall contain both red and orange but not more than a trace of yellow and no green, blue, or violet. The most desirable hue is entirely free from yellow which means that the glass does not transmit the yellow light from a sodium flare.

(b) Yellow. The spectrum of yellow shall contain red, yellow, and green, with but little blue and no violet. The most desirable hue is entirely free from blue and might be designated a light amber.

(c) Green. The spectrum of green shall contain yellow, green, blue, and violet, with only a trace of red and orange. This hue is known as "admiralty green" and has a bluish tint when observed by daylight.

Rule 52. Quantitative definition of colors for luminous signals.

The colors red, yellow, and green shall have the following characteristics:

<table>
<thead>
<tr>
<th>Color</th>
<th>Dominant wave length</th>
<th>Purity</th>
<th>Integral Transmission of glass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Millimicrons</td>
<td>Percent</td>
<td>Percent</td>
</tr>
<tr>
<td>Red</td>
<td>Not less than 624</td>
<td>Not less than 100</td>
<td>Not less than 10</td>
</tr>
<tr>
<td></td>
<td>nor more than 592</td>
<td>Not less than 97</td>
<td>Not less than 24</td>
</tr>
<tr>
<td>Yellow</td>
<td>Not less than 592</td>
<td>Not less than 97</td>
<td>Not less than 24</td>
</tr>
<tr>
<td></td>
<td>nor more than 600</td>
<td>Not less than 97</td>
<td>Not less than 24</td>
</tr>
<tr>
<td>Green</td>
<td>Not less than 496</td>
<td>Not less than 45</td>
<td>Not less than 11</td>
</tr>
<tr>
<td></td>
<td>nor more than 536</td>
<td>Not less than 45</td>
<td>Not less than 11</td>
</tr>
</tbody>
</table>

These values are determined by the transmission of light from a source at the color temperature of 2,360° K (practically that of the acetylene flame or present type of vacuum tungsten lamp at normal voltage) through the respective glasses. They are based upon spectral transmission measurements and upon computations carried out in accordance with the methods and data described in the Colorimetry Report of the Optical Society of America.
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