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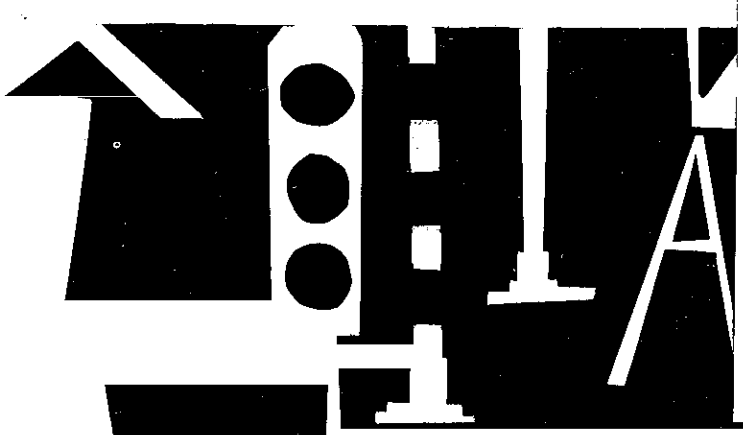
a final report on a cooperative appraisal of devices to guide traffic through construction

67-55



A study made by the
California Division of Highways
in cooperation with the
U. S. Dept. of Transportation
Federal Highway Administration
Bureau of Public Roads
April 1967

STATE OF CALIFORNIA
TRANSPORTATION AGENCY
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

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State of California
Highway Transportation Agency
Department of Public Works
Division of Highways

May 1967

Project: Calif. 13-610670
U.S.B.P.R. HPR-1(4),
XI-2-8

Mr. J. C. Womack
State Highway Engineer
Department of Public Works
Sacramento, California

Dear Sir:

Submitted for your consideration is:

A FINAL REPORT

ON

A COOPERATIVE APPRAISAL

OF

DEVICES TO GUIDE TRAFFIC

THROUGH CONSTRUCTION

Study made under direction of Construction Department.
Report prepared by J. C. Obermuller.

Very truly yours,

J. F. Jorgensen

J. F. Jorgensen
Construction Engineer

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I. SYNOPSIS

The purpose of this study is the evaluation of the physical characteristics of traffic devices, other than signing, available for use in highway construction zones. The study was expanded to include a subjective comparison of the manner in which these devices can be used. The consensus of a review group of highway engineers and others in cooperating agencies is presented, together with a report of the physical characteristics of the devices and materials observed.

This report was prepared under HPR-1(4), XI-2-8 in cooperation with the U. S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

The report is in two parts. The first part presents conclusions and the discussion of the subjective analysis. The second part is the survey of the physical characteristics of the various devices.

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II. CONTRIBUTORS

The value of this project is derived from the collective experience and observations of the men who contributed to the effort. The conclusions have been shaped by the consensus of the group; however, this does not imply concurrence of all individuals with all details presented.

Participants in Review of Traffic Devices
Sacramento - November 2-3, 1966

U.S. Bureau of Public Roads		J. P. Clark
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05	Dick Malone	Roy Alderman
06	Frank Dowling	Paul Webb
07	Norm Brinkmeyer	Gerald Russell
08	Hal Lee	Bob Pond
09	Joe Jarvis	Lee Dodd
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Urban Planning Department	Larry Wieman

Investigation and Report of Part Two
Materials and Research Department

Study made by	Structural Materials Section
Under direction of	E. F. Nordlin
Supervised by	R. N. Field
Report prepared by	R. N. Doty

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PART ONE

III. SCOPE OF STUDY

It is common knowledge that the problem of guiding traffic through highway construction areas is of primary importance in all areas of the country. The Construction Department of the California Division of Highways initiated a request for a special study which culminated in this project.

The concurrence of the U.S. Bureau of Public Roads was requested in February 1964 and their approval of the cooperative project was received in March 1964.

The study is conditioned by three major qualifications. First, there was no attempt to make an exhaustive search of the market to include products of all manufacturers. The material and products mentioned should be considered only as representative of kinds or types. Secondly, the study is referenced to California conditions and practice and the subjective analysis made accordingly. Third, the primary area of consideration was arterial highways with generally high speeds.

The first phase of the study was to make a survey of the physical characteristics of materials and devices commonly being used and available on the market for handling construction traffic. The Materials and Research Department conducted this portion of the study, which is presented in Part Two of this report.

Some of the materials and products are in common use by the contractors, some were introduced by the producing firms' representatives or literature, and some were at least indirectly the result of employees' suggestions.

The cost of this part of the study and the cost of the physical work involved in setting up the evaluation studies described below were financed by the research project funds.

It was realized that this physical data would be of a great deal more value in actual use if subject to some kind of an evaluation. This was done by assembling a group consisting of representatives of traffic and construction departments from all districts of the Division of Highways, plus representatives of all interested headquarters functions and guest participants from the State Division of Industrial Safety, the Highway Patrol, and the United States Bureau of Public Roads, and on facilities furnished through the cooperation of the County of Sacramento.

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This was to serve two purposes--as an evaluation panel and as an educational process which would have later benefit to highway operations and provide the basis for amplified instructions concerning handling construction traffic.

The time and expenses of all attendees were absorbed by the participating agencies and were not a charge against the research project.

With the time and resources available it was not possible to make a sophisticated objective study, nor to extend a subjective study to all combinations of devices and circumstances; therefore, it was decided to conduct a demonstration which would provide opportunity for relative comparisons.

The demonstration area was a section of semi-abandoned county highway on the outskirts of Sacramento. This demonstration area was made available through the help and courtesy of the Sacramento County Public Works Department, Traffic Department. The roadway was on tangent alignment, with an asphalt concrete surfacing a bare 20 feet wide, and adjacent bladed earth shoulders. The section of road terminated in a cul-de-sac at the foot of a freeway embankment.

The basic layout of the demonstration was a typical situation of diverting traffic from an existing roadway. An adjacent open field provided an exit for the demonstration runs.

Using this basic situation, different materials and devices were used to produce eight different combinations. These were planned to progress from the simplest to the most complex so that comparative effectiveness could be observed. The participants were grouped by carloads of about four men each during the demonstration. The participants made observation runs on each of these eight setups during the afternoon and returned to repeat the process at night.

A description and photo of each setup for the daytime demonstrations are given in the illustrations. The nighttime demonstration essentially was a reverse run of the daytime sequences except for the introduction of reflective pavement markers and lights.

At night, following removal of the barricades (same remaining setup as daytime Run #3), a flashing "header" light was added at the beginning of curve and a series of steady-burn low intensity lights at intervals around the curve near edge of traffic lane.

Next, the flashing light was removed and a set of sequentially flashing lights were substituted at the same point (beginning of curve).

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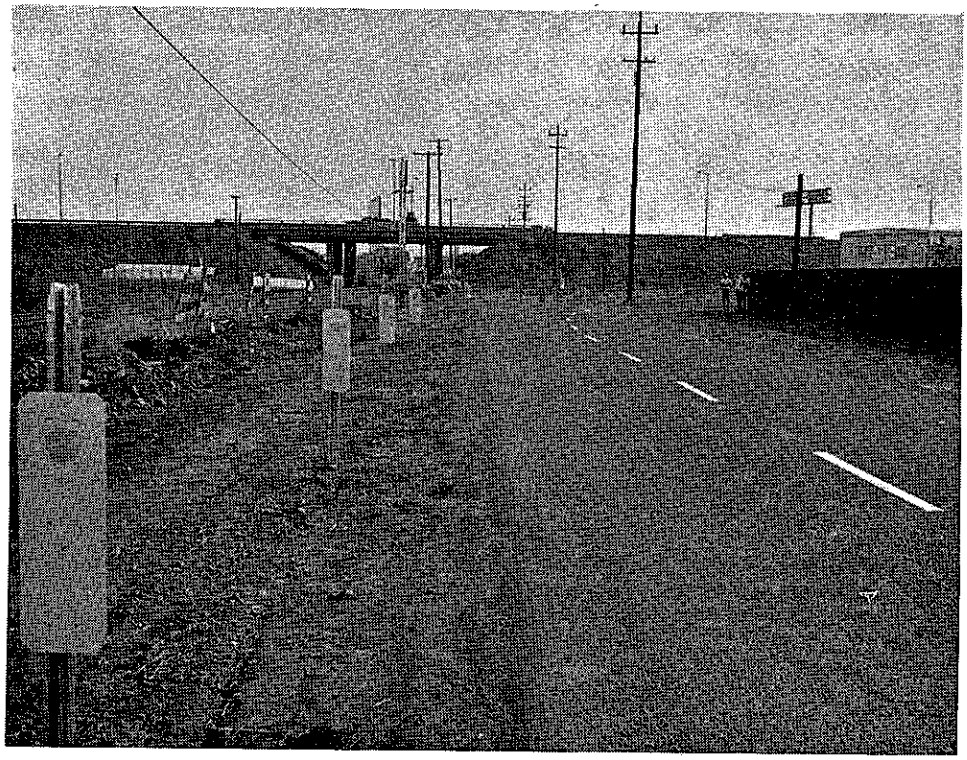
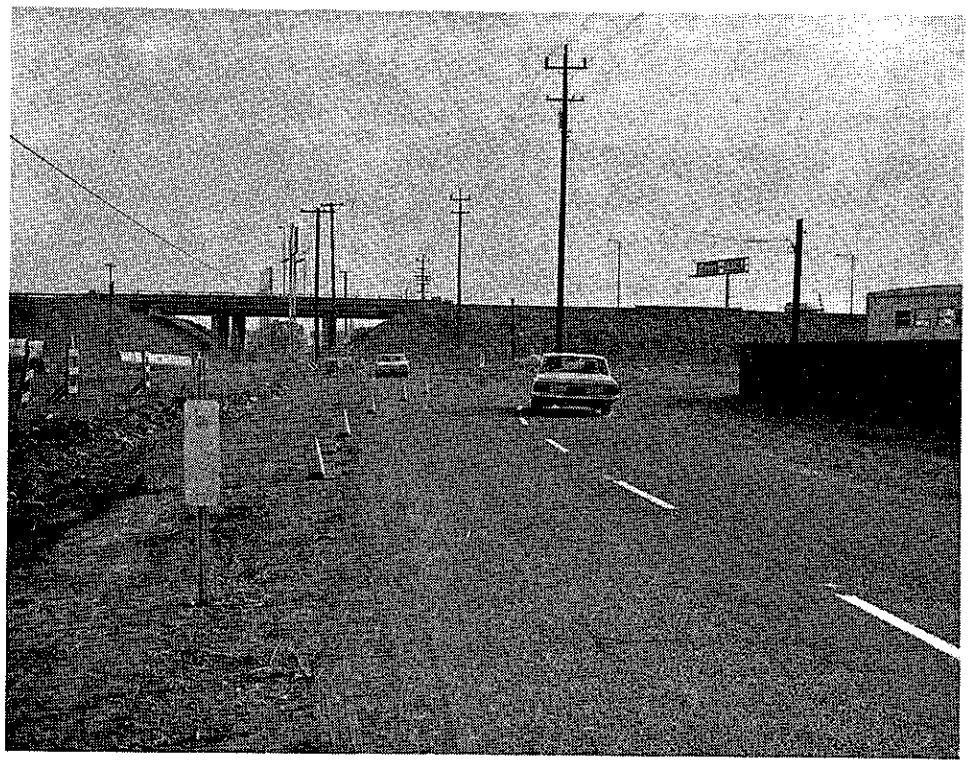


Run #1 The demonstration roadway was considered to be a two lane, one direction road with traffic in both lanes traveling away from camera. Initial setup consisted of a Class I closure barricade and a standard lane stripe diverting traffic off the roadway to the right in the picture. The devices in front of the parked pickup in the distance are individual samples of various devices which could be viewed by the participants as their car returned from the end of cul-de-sac at foot of embankment.



Run #2 Traffic cones added at left edge of left traffic lane.

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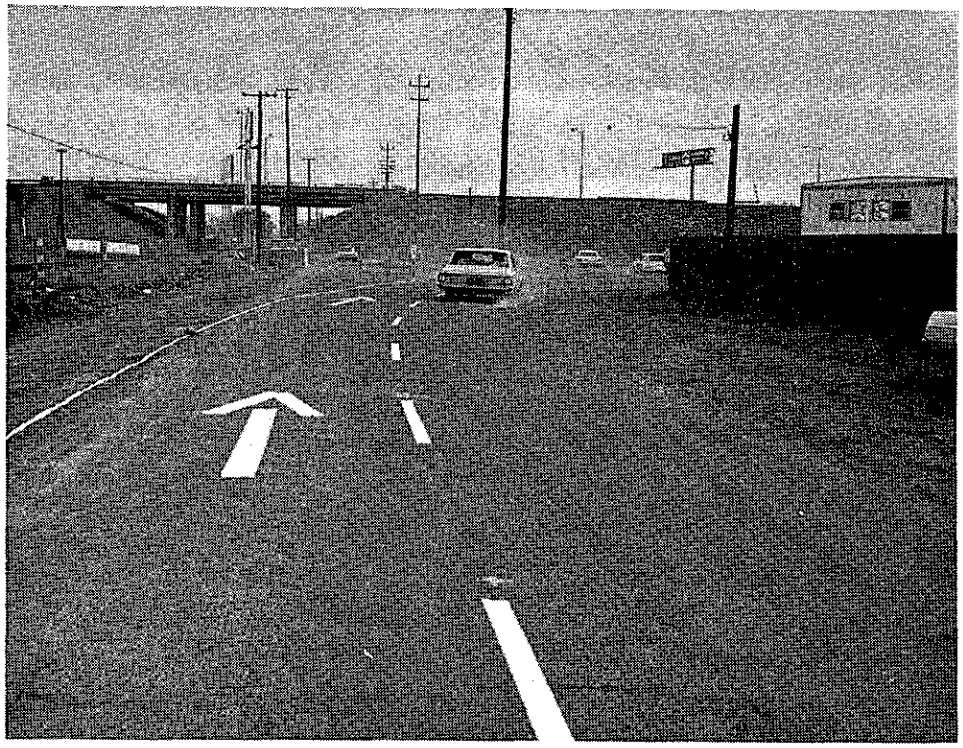

Run #3 The cones were removed and left edge stripe and pavement arrows in left traffic lane were added.

Run #4 A series of 4' wide Cl. I barricades with standard delineator paddles were added in echelon near left edge of left traffic lane.

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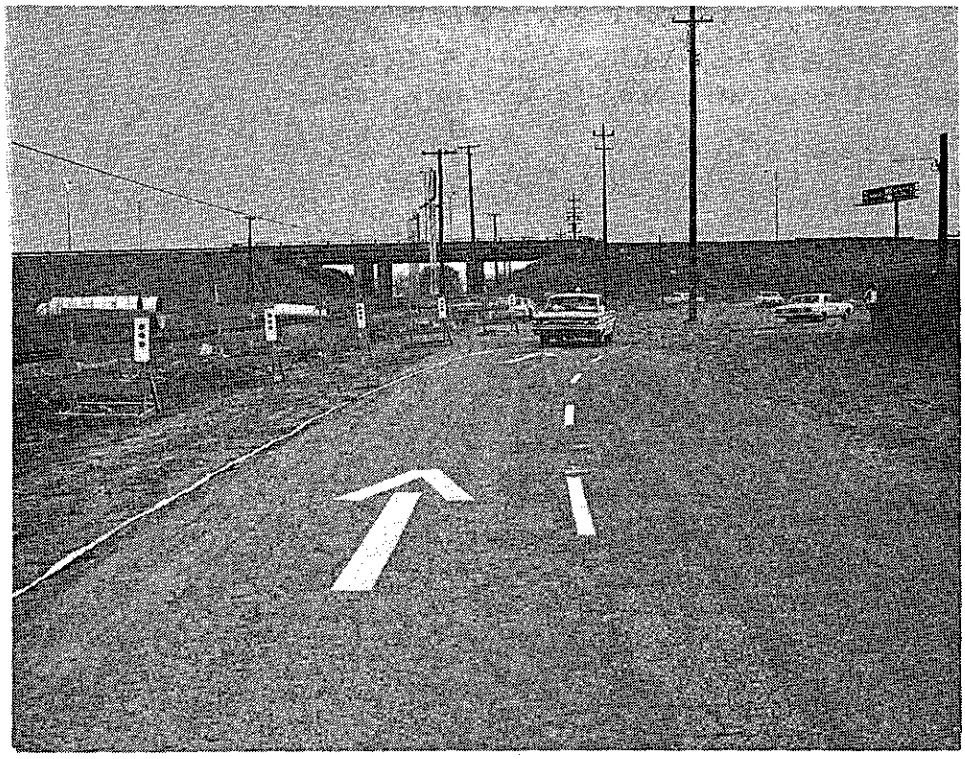
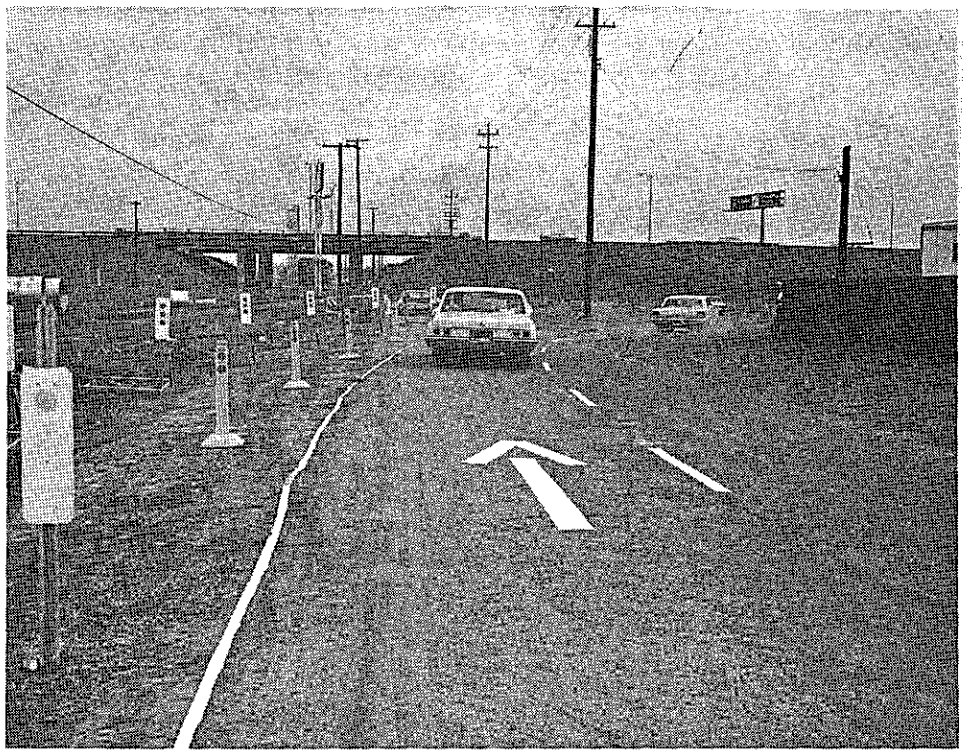


Run #5 Same as Run #4, except barricades were moved to a normal shoulder width offset from edge of traffic lane.



Run #6 Post type portable delineators were added to the above.

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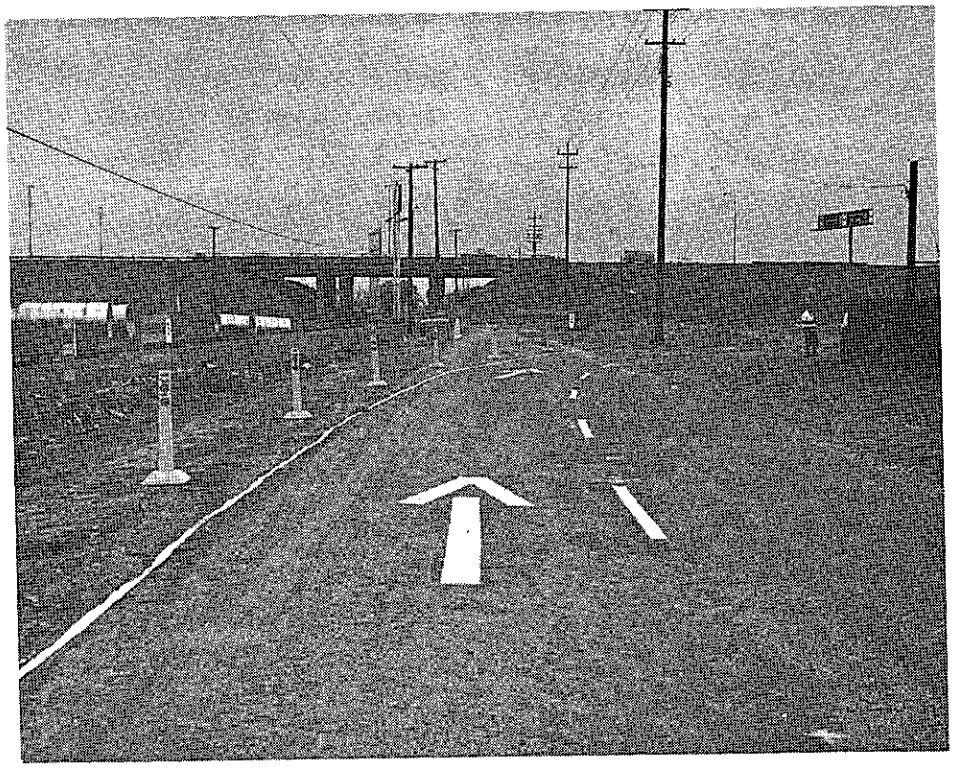
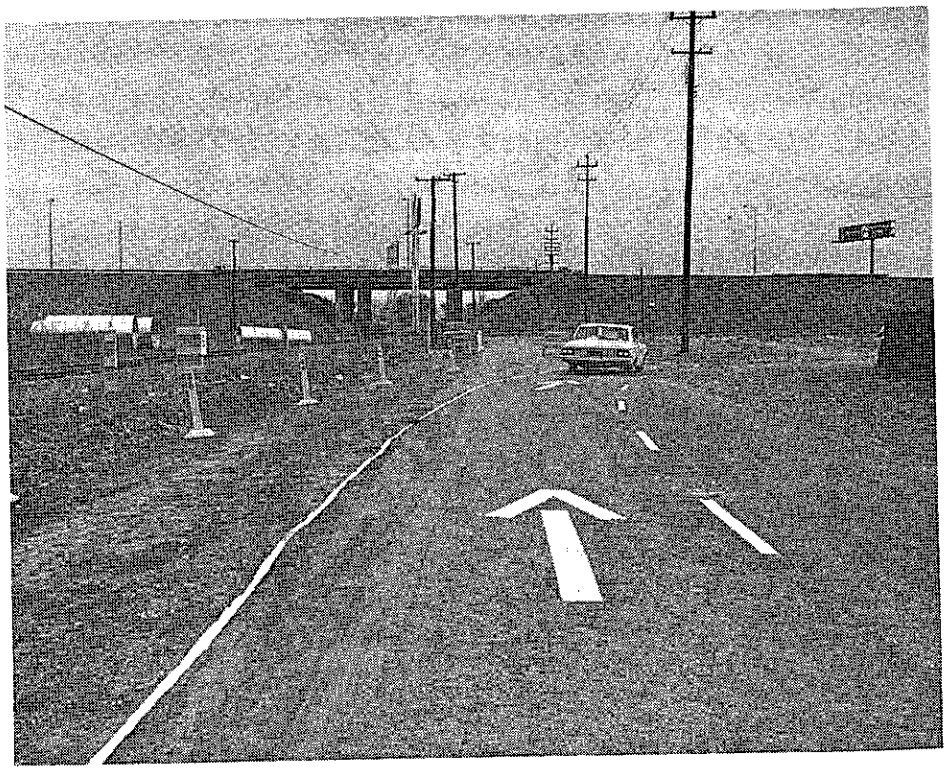


Run #7 The barricades were removed from the setup for #6, leaving the post type delineators near edge of the traffic lane.



Run #8 The delineators were moved to a normal shoulder width offset from edge of the traffic lane.

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Last, all lights were removed and reflectorized pavement markers were placed on the lane line, one between each segment of stripe. (Same as daytime Run #3, with reflectorized pavement markers added.)

The field demonstration was followed by a half-day discussion. The participants had been grouped by carloads and were asked to first report their group impressions of each situation. This was followed by a general discussion and rebuttal among all participants. The reported conclusions are derived from the consensus or range of opinions developed in the discussion and from the written closure comments on the notes sent out for review.

There has been an attempt to analyze factors entering into the conclusions and to project them into useful generalizations that apply to normal highway work.

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IV. CONCLUSIONS

1. The basic problem in handling construction traffic is twofold--to provide a trafficway that is physically adequate and to communicate with the driver so he will properly direct his vehicle. (The subject matter of this study is primarily in the latter area, except signing was not included.)

2. The safest and most convenient construction trafficway is one that has been designed to provide a facility which is geometrically equal to or better than the approach roadway in order to present the motorist with a condition of sufficient continuity of function and appearance that he will react properly, naturally and without confusion.

3. If the above objectives can be attained, the construction trafficway can be treated as a continuation of the approach roadway using standard signing, delineation, etc., and it need not be designated as a "DETOUR." (Because of this, the designation "trafficway" is used in the report rather than the more commonly applied but not necessarily technically correct term "detour.")

4. The continuity of pavement texture and color through the transition from approach roadway to construction trafficway should be maintained. In many cases this necessitates the obliteration of covering up of the prolongation of the approach roadway beyond the transition and starting the transition surfacing back on the approach roadway, even at the expense of later having to remove it. The color differential (but not the texture) between two dissimilar types of pavement can be reduced temporarily by spray painting, such as with a light shot of asphalt.

5. The most important element of a trafficway is the delineation of the traffic lane itself. It is necessary to provide both an all-weather lane line and an outside marking, but of the two, the lane line is the most vital.

6. Simplicity is the keynote to effectiveness. A profusion of signs, barricades, delineators, lights, etc., compete with the primary delineation (the lane line and pavement edge) and confuse the motorist by providing too great a mass of information to assimilate.

7. Safety is the absence of collision, either with moving or fixed objects. Therefore, "safety" devices should not be placed any closer to the edge of the traffic lane than is necessary to define the limits of the safely traversable area. Similarly, all devices should be so designed and constructed to offer the least possibility of damage if struck.

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V. DISCUSSION

A clear understanding of the limitations and qualifications of this demonstration is required in order to properly appraise the results. It was realized by all the participants that the dimensions of the roadway and the geometrics of the diversion and the speed of the observers' automobiles did not correspond with ordinary "live" situations. However, these factors were reasonably "in scale" and formed a representative, recognizable situation. Therefore, it is believed that it would serve beneficially as a prototype for a subjective comparison. These subjective comparisons could be extrapolated by the experience of the trained observer.

It was not intended to make absolute value judgments of specific individual devices, especially those modifications represented by different manufacturers, and none are inferred.

One written review comment by a participant summarizes the overall reaction as follows: (with some parenthetical editing).

"In this State the term 'detour' is applicable in very few cases. In general, I feel that the design of the (construction trafficway) should be equal to the approach highway and that signing and delineation should be a continuation of the existing (system). The use of (warning signs) and devices should follow (the general policy) that whenever the driver can determine conditions for himself, any warning sign or device is redundant and weakens those signs and devices in general. If the driver can see the road and follow the delineation easily, I do not believe that the 'detour' sign and the large number of (other signs and devices) are necessary. They are probably more distracting than helpful.

"In summary I would say that any (construction trafficway) should be designed and constructed so that the motorist is not even aware of the change.... If this can be done, then <u>no</u> (special) warning signs or devices are needed."

The research which led to the subjective study described herein helped enunciate this expression. It is considered to be a good one. The results of the study already have had some influence on construction traffic handling on projects administered by the California Division of Highways. It is expected to influence future instructions and operating procedures.

This discussion and the data given in Part Two is offered for the information of all who help determine how to handle construction traffic.

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Pavement Markings

1. Lane line markings are indispensable. Visibility under adverse conditions; i.e., darkness and wet weather, is even more important on construction trafficways than on the approach highway. Raised reflective markers at appropriate intervals along the lane line are excellent for this purpose and should be a must. For temporary situations, where the markers must later be removed, butyl rubber adhesive is an effective and economical way to fix the markers to the surface, subject to qualifications mentioned in Part Two of the report.

2. When traffic paint is used for the body of the lane stripe in temporary situations requiring later removal, the removal is bothersome, time consuming, costly and even more important, sometimes leaves a texture differential that can give a false signal in darkness or rain. An adhesive-backed foil material with painted and beaded surface is effective and economical to use for the body of lane line marking, except under adverse weather conditions as mentioned in Part Two.

3. Edge stripe or the wider channelization stripe is required in most construction situations in addition to the lane line. These stripes may be needed on the left or on the right or on both sides. These stripes may be made of the same material as the lane stripe, but there should be careful distinction made by difference of width and continuity so that it will not be confused with a lane line.

4. Pavement arrows are another effective pavement marking. The arrows should be placed in the center of each traffic lane wherever it is necessary to reinforce a message of directional change, and at points of confusion or conflict of direction of traffic movement. They should be used always when it is necessary to remind the driver of the direction of travel, as when two-way traffic is carried on one roadway of a divided facility.

Delineators

5. A delineator is any visible device which helps the driver fix the position of the traffic lane. By day, the effectiveness of the delineator is determined by position, spacing, form, texture, size and color. By night, the effectiveness is determined by position, spacing and reflectivity.

6. Delineating devices which could become projectiles when struck by vehicles or which would appreciably damage a vehicle when struck should not be used. Metal posts mounted in concrete-filled round buckets are a prime example.

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7. Traffic cones have a good shape for visibility and are relatively nonhazardous but can be displaced very easily. If used for other than temporary daytime work they must be fastened to the surface by a positive means such as explosively driven studs. A cone 27" to 36" high is judged desirable when used for delineation. If in use overnight, a reflector unit must be fastened to the top of the cone.

8. The tubular post type of flexible material has less target value because of the narrow projection. For nighttime they must have a reflector button fastened on the top. Reflectorization by bands of reflective sheeting or paint is not as effective as reflector buttons, especially after a period of use and abuse.

9. A type of semi-flexible plastic delineator consisting of a rectangular post and reflector button with an integral ballastable base has good visibility and safety factor. Since it depends on weight alone to hold it in place, it cannot be considered satisfactory for a permanent location where there is a high probability it may be hit, such as in a narrow median between opposing lanes.

10. Self-supported guide posts that are dependent upon a PCC slab or block base have not been entirely satisfactory. If the base is big enough to keep the paddle from being blown over, it creates a hazard. Another type of paddle support consisting of a plywood triangle backed up by a wood post and foot has been successful in use and the probable hazard aspect appears somewhere between the flexible and block type of bases.

11. Although this factor has not been studied objectively, it appears the effectiveness of a delineator depends to a certain extent upon how well it ties visually to the roadway surface beneath it. That is, a delineator which shows as an upward continuous projection from the surface, such as a traffic cone, may reference the limits of the trafficway better than a delineator appearing to be suspended in thin air without visible support, such as a delineator paddle on a thin post. This is particularly true if the delineation is being used to mark a limited path of travel through an area which is indistinct or of indefinite extent, typical of many construction situations. This also suggests the example that all other factors being equal, a truncated pyramidal shape with its base on the surface would be more effective than the same shape inverted.

Barricades

12. Barricades are fixed object hazards. Barricades should not be placed unless they are intended to separate the motorists from objects of greater hazard than the barricade or as a positive closure. Ideally, they should be used only for physical closure of a roadway and not to guide traffic or effect direction change.

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13. Barricades should not be used as primary delineation. They should be placed as far back as possible from the primary delineation system. If this is not possible, at least place them clear of the trafficway.

14. Any barricade marking a specific point of hazard in the delineated traversable area of a trafficway should be highly reflectorized or marked with appropriate warning lights.

Lights

15. Flashing lights emphatically should not be used as delineation. Example: Don't use to delineate drop-off along edge of pavement, but can be used if a hole or fixed object encroaches at a particular location.

16. Flashing amber lights used as advance warning should be mounted in a distinctive position clearly separable from the primary delineation and generally higher than normal reflector units.

17. Low intensity battery operated steady burn lighting units are available on the market for use in marking hazards and for use in series for delineation. If there is considerable circuitous curvature and sparse traffic, the steady burn units appear to offer a measure of advanced delineation signal which would not be provided by reflector units. They do not appear to be a particular advantage in a location where there is a fairly steady stream of traffic or on straightaways where headlights normally pick up standard reflector units at a considerable distance. It is believed that more field use and observation is necessary to develop optimum application.

18. Similarly, there are on the market flasher units which are interconnected with built-in controls to create a system of sequential flashing lights. Originally intended for such uses as a progressive-signal in locations such as a curve, limited observation indicates its primary use as an attention-getter. The frequency and cycling should be such that there is an appreciable pause between end of one cycle and beginning of next. This is also a product which requires additional adjustment and observation before a definitive statement could be made.

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PART TWO

VI. FORWARD

It is the intent of this portion of this report to provide interested parties with the names, sources, descriptions, and approximate prices of all the devices considered in this study for use as construction zone traffic control devices. Comments relative to the physical characteristics of the devices are included as are opinions of the probable or actual effectiveness of the devices.

The methods initially proposed for conducting the evaluation of the various materials and devices consisted of the following:

1. In-service tests performed in actual construction zones.
2. Applicable routine physical tests.
3. Special tests when required.

As this study progressed, it became increasingly evident that to prepare a valid evaluation of the effectiveness of most traffic handling devices for construction zones, heavy emphasis must be placed on the continuous observation of these devices while they are in actual use. An extensive and lengthy observation of several of the items listed herein was not warranted due to their limited effectiveness and/or usefulness.

As stated in Part One of this report, the group of devices reported herein was selected as representative of the several types of traffic control devices that are now available. No attempt was made to evaluate all the devices currently on the market. Because the effectiveness of any device is completely dependent on the particular construction situation involved, the comments included herein are general observations, and the suitability of each device must be considered in relation to the proposed application.

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A. Pavement Markers

Stimsonite 88 Pavement Markers

Stimsonite Signal Products

Elastic Stop Nut Corporation of America

Elizabeth, New Jersey

(See Figure 1)

The cost of these reflective pavement markers is $1.10 each and does not include the cost of the epoxy adhesive that is used for permanent attachment to the pavement surface.

These units were developed for use as permanent nighttime lane delineators and are attached to the pavement surface using an epoxy adhesive. As this method of attachment was developed for permanent installation, removal of the markers is very difficult. However, because of the outstanding reflectance of these markers and the variety of colors available, it was felt that they would be useful in construction zone delineation provided some method of attachment could be found that would permit removal without destroying the marker or gouging the pavement. An attempt was made to temporarily attach them to an asphaltic concrete surface with one concrete nail through a hole drilled in the center of the unit. This "centermount" method of attachment to the roadway did not prove to be satisfactory as the markers tended to rotate about the mounting nail with subsequent brittle fracture of the methylmethacrylate surface around the hole and then peeling of the surface from the filler material (see Figure 2). To eliminate the rotation problem, attachment with two nails has been proposed.

In-service tests of these reflective pavement markers in permanent installations have proven that their durability in conditions as found around Sacramento is good. These markers would be of great value in construction zones if an effective semi-permanent method of attachment to the pavement can be developed. A proposed method of temporary attachment with a butyl adhesive is included under "Miscell-- Devices".

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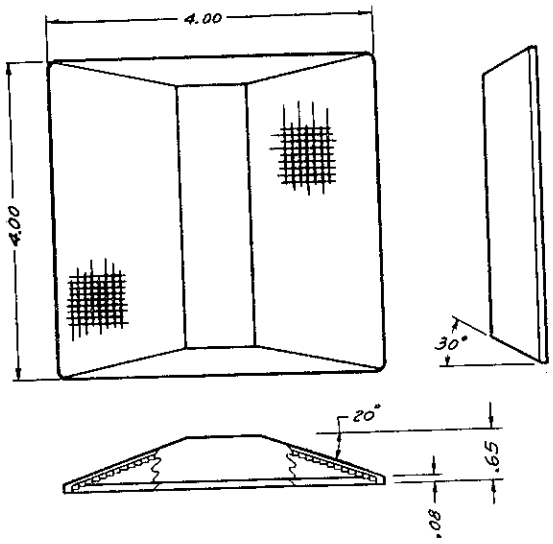
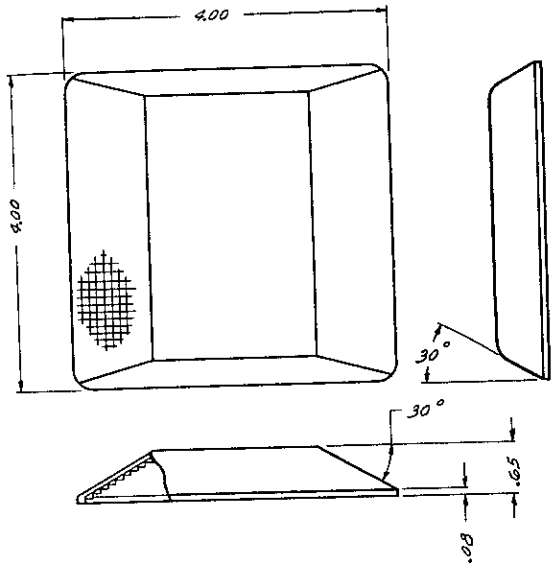
FIGURE 1

SPECIFICATIONS



88a BIDIRECTIONAL

Material	Methyl methacrylate bonded to an epoxy-base filler
Size	4″ x 4″ x ⅝″
Weight	Approx. 6 ozs.
Reflective Area	@20° 5.1 square inches per side
Colors	White, Red, Yellow and to order



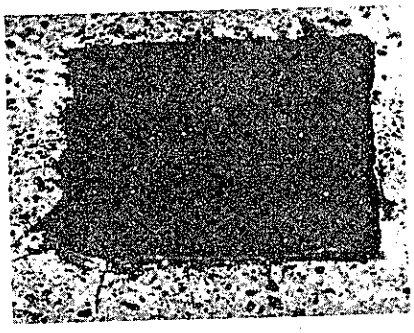
88b MONODIRECTIONAL

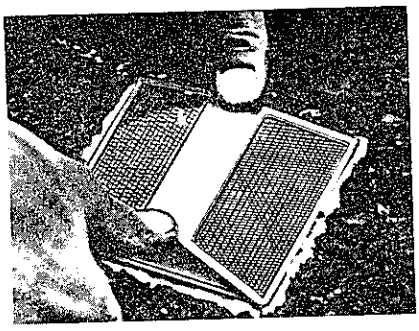
Material	Methyl methacrylate bonded to an epoxy-base filler
Size	4″ x 4″ x ⅝″
Weight	Approx. 6 ozs.
Reflective Area	@30° 3.4 square inches
Colors	White, Red, Yellow and to order

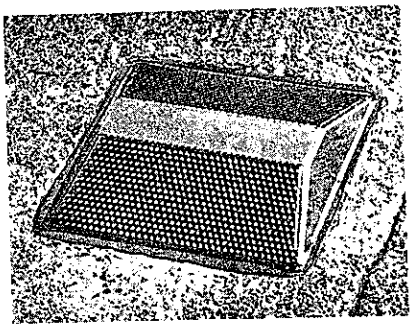
INSTALLATION

Installation of Stimsonite Reflectorized Pavement Markers requires no special tools—no special training. Each marker is factory filled with an epoxy compound, ready to bond firmly to concrete or asphaltic pavements by use of an epoxy adhesive. Application of the adhesive is quick and easy—after which the marker is simply pressed firmly to the pavement surface. In a relatively short time, the bond between the marker and the pavement is a permanent one.

ADHESIVE—A two-part epoxy adhesive should be used, available from ESNA or acquired locally. A suitable formula will be furnished on request to facilitate local purchase.







Stimsonite®
SIGNAL PRODUCTS

ESNA ELASTIC STOP NUT CORPORATION OF AMERICA
ELIZABETH DIVISION • ELIZABETH, NEW JERSEY

PRINTED IN U.S.A.

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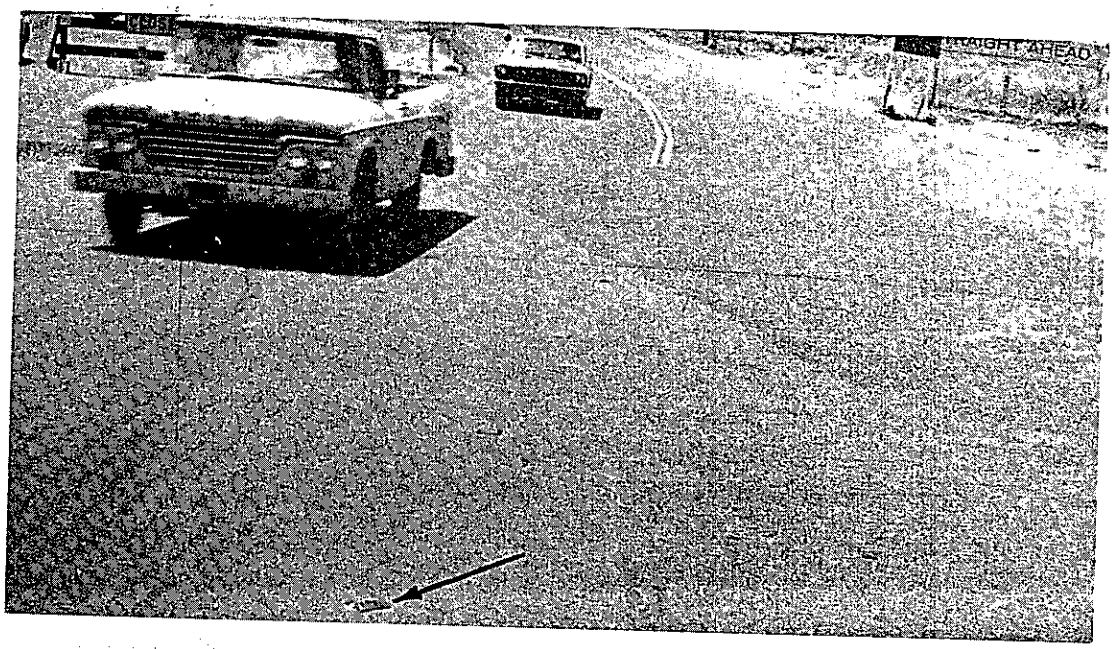
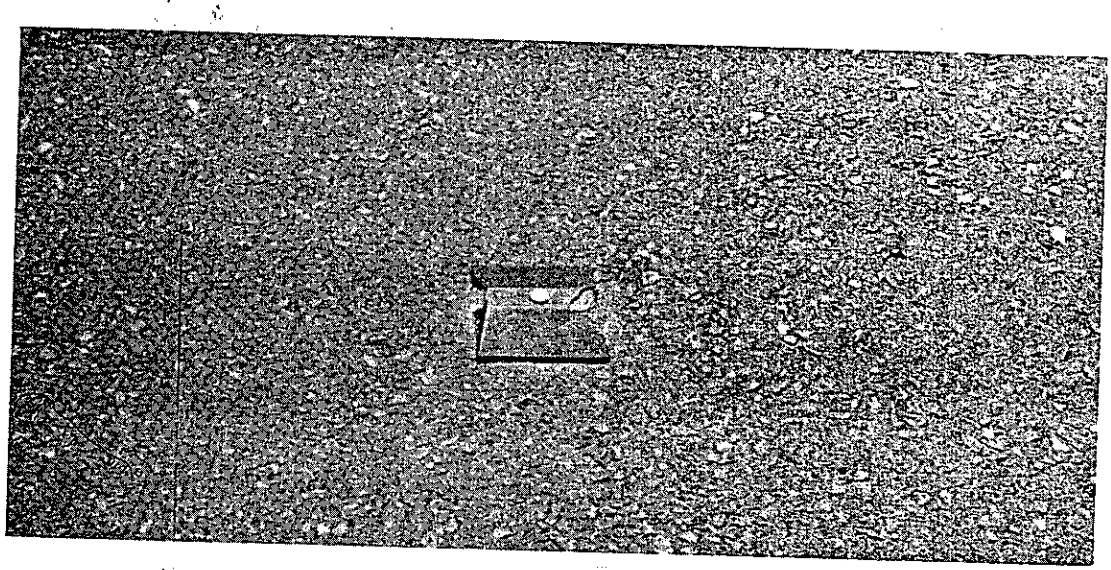
FIGURE 2



TWISTING OF MARKER



DELAMINATION OF MARKER SURFACE

FAILURE OF STIMSONITE PAVEMENT MARKER WHEN SECURED BY A NAIL AS TEMPORARY ATTACHMENT

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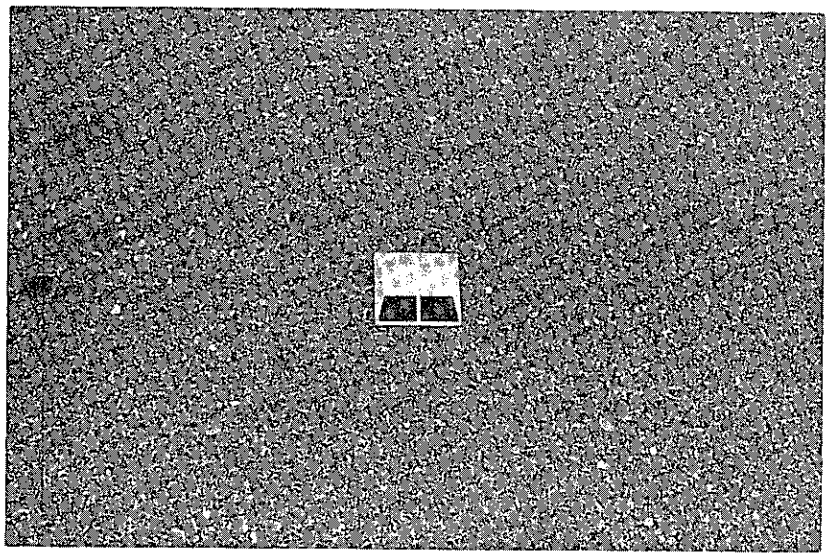
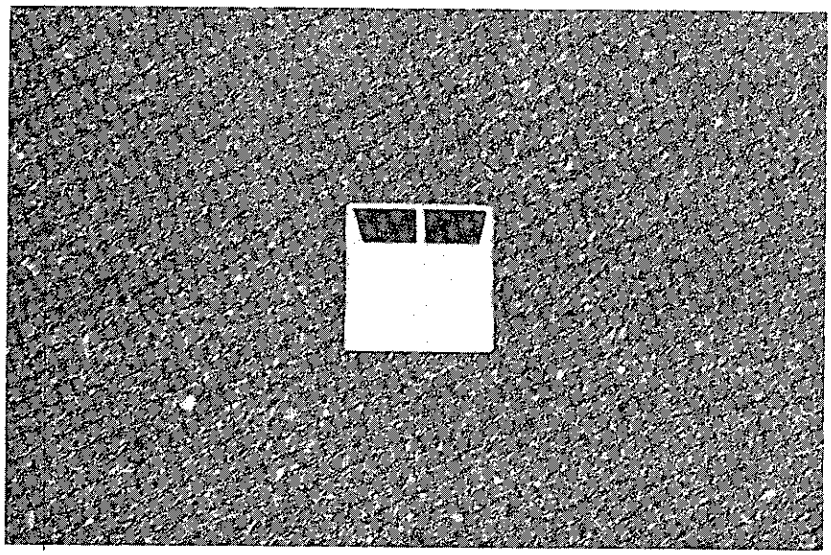
FIGURE 3





RAY-O-LITE PAVEMENT MARKER

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Ray-O-Lite

Reflex Corporation of America

Troy, Michigan

(See Figure 3)

The cost of these reflective pavement markers is approximately $1.05 each.

These units are very similar in size, shape, and effectiveness to the Stimsonite 88 pavement markers and can be attached to the roadway surface using the same methods applicable to the Stimsonite units. The surfaces of these units are molded from acrylonitrile butadiene styrene (ABS). This is a much tougher material than the methyl-methacrylate used for the Stimsonite markers and may be more resistant to fracture and delamination when mounted with two pavement nails.

A proposed method of temporary attachment is included under the section entitled "Miscellaneous Devices".

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D-Vid-A-Way Steel Traffic Dividers

Commercial Shearing & Stamping Company

1775 Logan Avenue, Youngstown, Ohio 44501

(See Figures 4 and 5)

Although this pavement marker is intended for permanent installation, the spike method of attachment to the roadway surface for which it is designed would permit a semi-permanent type of installation. As these devices are relatively large, having diameters of 12, 14, and 16 inches, width restrictions in some construction zones would preclude the use of a "button" of this size.

A delineation device similar to this marker was tested by the Materials and Research Department and found to be unacceptable due to the rapid deterioration and loss of the enameled surface from the abrasive action of vehicular tires. The standard finish on the D-Vid-A-Way marker consists of one coat of "highway yellow" enamel. However, any color can be specified. A paint that would provide sustained reflectivity and resist the constant abrasive action of vehicular tires has not yet been found.

An investigation to determine the feasibility of a reflective surface consisting of glass beads fused into porcelain on a steel backing has been conducted by this department. It was found that the possibility of obtaining this type of reflective surface commercially is remote. Also, the coating would be of little value due to the rapid accumulation of dirt on the irregular exposed beaded surface.

The requirement of a surface that will remain highly reflective under the heavy abrasive action of traffic imposes severe limitations on the usefulness of this device, as does its size in locations involving width restrictions.

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ENGINEERING DATA

Shape—Round with ellipsoidal cross-section emanating from an integral peripheral flange. A recess in the top of the divider accepts the dowel-pin head, assuring smooth divider contour.

Construction—Stamped from round steel blanks recessed, and with bolt hole ready for installation.

Material—Heavy gauge (No. 8) AISI 1008-1020 steel. Tensile strength from 45,000 to 57,000 psi and yield strength from 34,000 to 43,000 psi.

Finish—Dividers are supplied painted, unpainted, or with any finish to meet customer specifications. Standard finish is one coat of "highway yellow" enamel covering the outside of the divider.

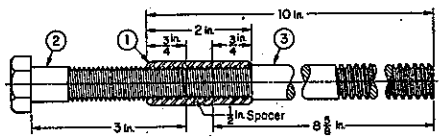
Sizes—Three sizes are standard: Type I—12 in. OD, Type I—16 in. OD, and Type II—14 in. See table below for complete engineering dimensions.

Shipping Weights—See table below.

Size	Weight With Dowel-Pin Anchor	Weight Without Dowel-Pin Anchor
Type I — 12 in.	7.5 lb	6.0 lb
Type I — 16 in.	13.0 lb	11.5 lb
Type II — 14 in.	13.0 lb	12.0 lb

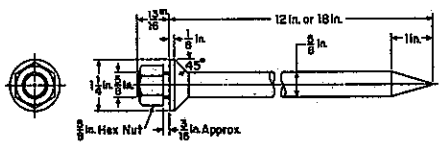
DOWEL PIN ANCHORS

Style I: For use with Type I D-VID-A-WAYS installed in either soft or hard road-surface materials. Anchors are ⅝-in. rods, 10 in. long with 3½-in. of quick-acting threads on one end and an internally threaded hexagon rod coupling on the other to accept a ⅝-in. bolt.



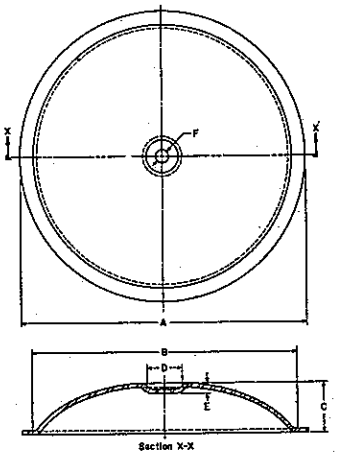
① Hex Rod Coupling ② ⅝ in. x 3 in. Hex Head Bolt ③ ⅝ in. Rod

Style II: For use with Type II D-VID-A-WAY installed only in soft road-surface materials. Anchors are ⅝-in. diameter rods, 12 or 18 in. long, pointed on one end and threaded on the other, with a 45-degree flared collar immediately under the threaded portion for seating the divider.

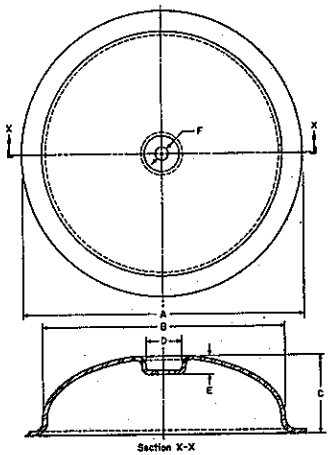


D-VID-A-WAY Dimensions

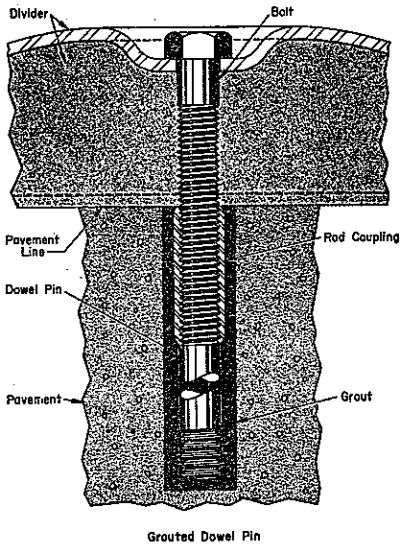
	Dimensions		
	Type I Divider		Type II Divider
	Size 12	Size 16	Size 14
Outside Diameter, A	12 in.	16 in.	14¼ in.
Ellipsoid Diameter, B	10¾ in.	14¾ in.	12 in.
Overall Height, C	1¾ in.	2¾ in.	3¾ in.
Recess Diameter, D	2 in.	2 in.	1 11/16 in.
Recess Depth, E	21/32 in.	21/32 in.	13/16 in.
Hole Diameter, F	21/32 in.	21/32 in.	21/32 in.



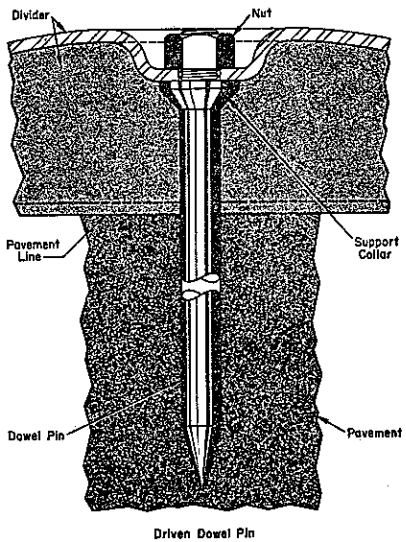
D-VID-A-WAY—Type I



D-VID-A-WAY—Type II



Style I Dowel-Pin Installed



Style II Dowel-Pin Installed

FIGURE 4

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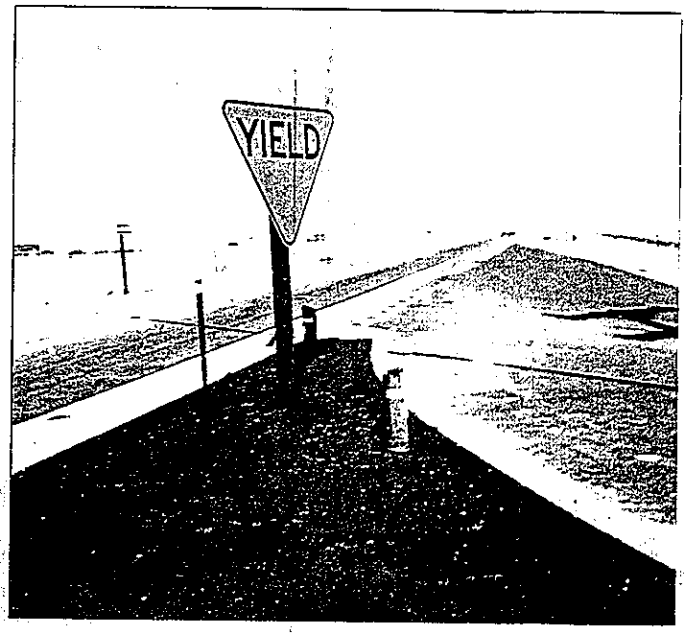
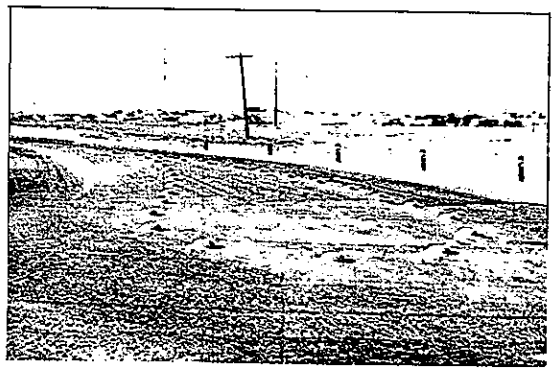
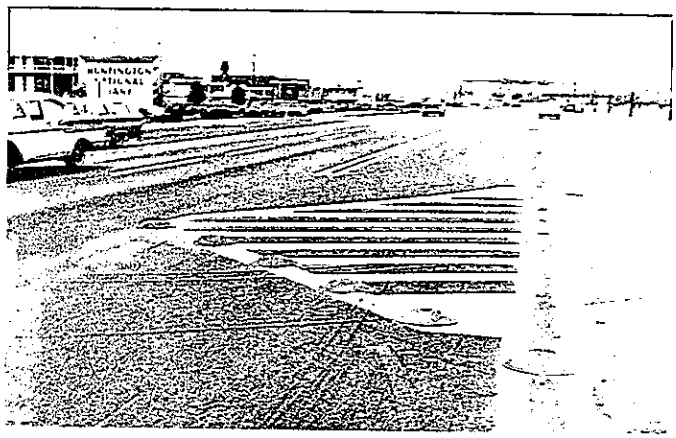
FIGURE 5







D-VID-A-WAY STEEL TRAFFIC DIVIDERS

(Photos from Sales Brochure)

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Scotch Lane Pavement Striping Tape

Minnesota Mining & Manufacturing Company

6023 South Garfield Avenue, Los Angeles, Calif. 90022

(See Figure 6)

The price of this four inch wide tape when purchased in quantity is approximately $0.14 per foot.

The tape is easy to apply and conforms well to pavement irregularities. Although a portable mechanized applicator is available, the tape can be readily applied manually and then rolled into intimate contact with the pavement surface with any rubber tired vehicle. Tamping by foot has proven unsatisfactory.

Adherence to both Portland cement concrete and asphaltic concrete is good, providing the tape is applied to a clean, dry surface at a minimum temperature of 50° F. When the temperature condition cannot be satisfied, heating the pavement with a torch has occasionally been successful. Although a pavement surface primer is available, under most conditions its use does not appear to be required. The durability of this tape appears to be adequate for the duration of most construction detours (6 to 9 months). The nighttime reflectance of this tape is equal to or better than a "beaded" paint stripe.

Removal of this tape after periods of approximately two weeks was accomplished with a minimum of effort. However, removal of two 28 month old test samples, one applied over pavement primer and one without primer, was very difficult. The use of primer did not appear to have an effect on the effort required to remove the 28 month test samples. There was no apparent difference in color of the pavement under the two week sample after the tape was removed (see Figure 7). However, there was a noticeable difference in pavement color under the 28 month test section.

Both non-reflective and reflective tapes are available in various widths and colors. They can be used for lane, edge, or median delineation. Both tapes can be readily applied on horizontal curves and can also be used for other standard pavement delineation such as cross-walks or arrows. The reflective tape is recommended for all applications where nighttime delineation is required.

Present findings indicate that this product is very good for short duration temporary lane delineation. The advantages of this tape over the paint stripe for longer durations of time (1 - 2 years) are questionable.

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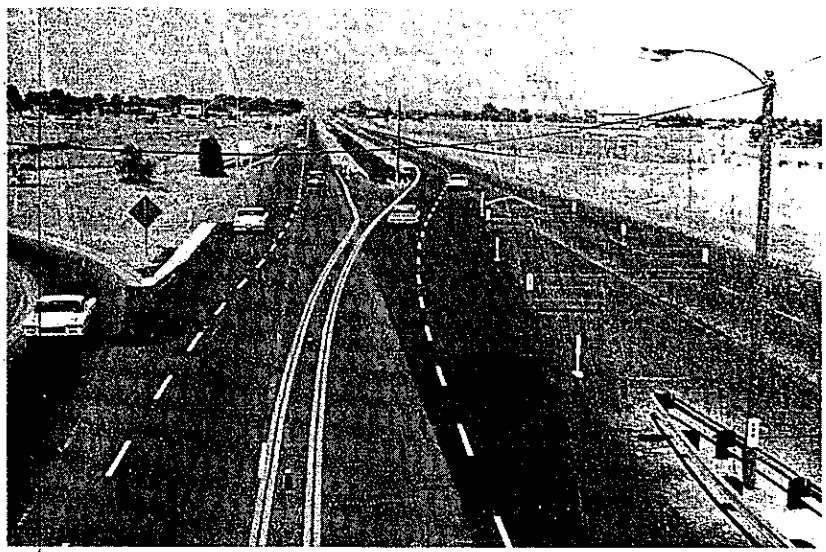
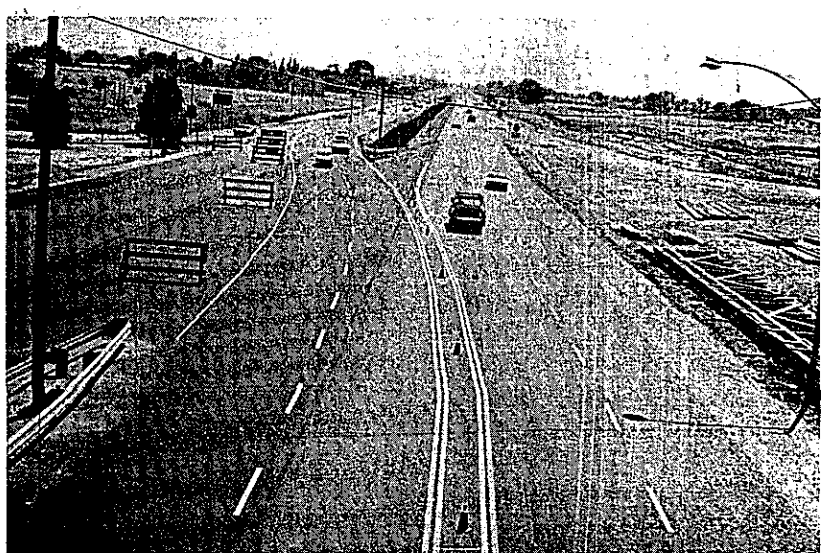
FIGURE 6



LANE AND MEDIAN DELINEATOR



LANE, MEDIAN, AND SHOULDER DELINEATOR

SCOTCH LANE PAVEMENT STRIPING TAPE

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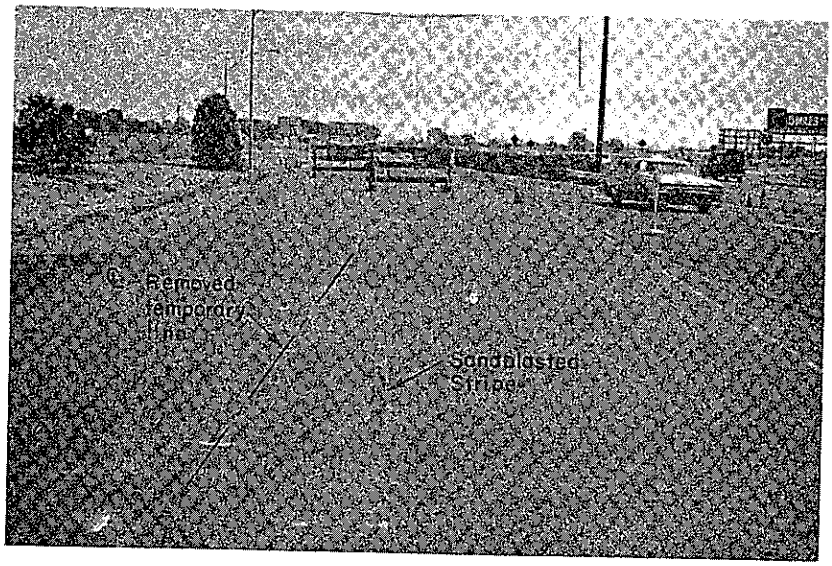
FIGURE 7



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B. Delineators

Eecopost

Eecolite Barricade Company

2972 Rubidoux Blvd., Riverside, California 92509

(See Figure 8)

The current price for this device is $7.50 each for lots of 19 or less with a discount for larger orders.

This device was originally submitted by the name of Traf-Line. Although some minor changes have been made, the essential features of the Traf-Line and Eecopost delineators are identical. The base of this device weighs approximately 35 pounds when filled with sand. Considering the relatively small surface area that is exposed to wind and the flexibility of the post, this 35 pound base weight should adequately prevent overturning or lateral movement. The post is 39" long and has small protrusions on the anchored end to prevent pull-out when struck by a vehicle. The first device submitted had small openings in the base that made insertion of the ballast material difficult. The current device has larger openings that permit easier filling but would require capping if water was used for ballast. The two 3" diameter reflectors are easy to replace. Using the handle in the top of the post, the device can be readily moved, even when the base is filled with sand. With the post removed, the unit can be stored in a minimum of space.

To determine the extent of the vehicular and delineator damage that would occur during a collision with this device, 40 mph impact tests were conducted, first with the vehicle wheels straddling the device and then with the left wheels crossing over the base (see Figure 9). The bases were filled with sand for the impact tests. In both tests, the base moved less than 16" out of position. In Test No. 1 the base rotated approximately 450° and a corner of the base was torn. The post remained in the base and, although a slight kink was formed where the post meets the base, it returned to an upright position. In Test No. 2 the base rotated approximately 45° and moved 8" out of position. There was no significant damage to either the base or the post. There was no damage to the vehicle and no control problems were experienced by the driver in either test.

The day and night visibility of the post is good. Although the post tested was yellow, an orange-red fluorescent post is now also available. After a relatively severe exposure of over 700 hours to ultra violet light, there was no significant fading or color change on a sample of the yellow post material. The orange-red fluorescent material would be more susceptible to fade under this type of exposure. Although the base now supplied is black, it is felt that the yellow post-yellow base combination would be the most effective.

This device is presently in use in southern California and has been reported as giving satisfactory service.

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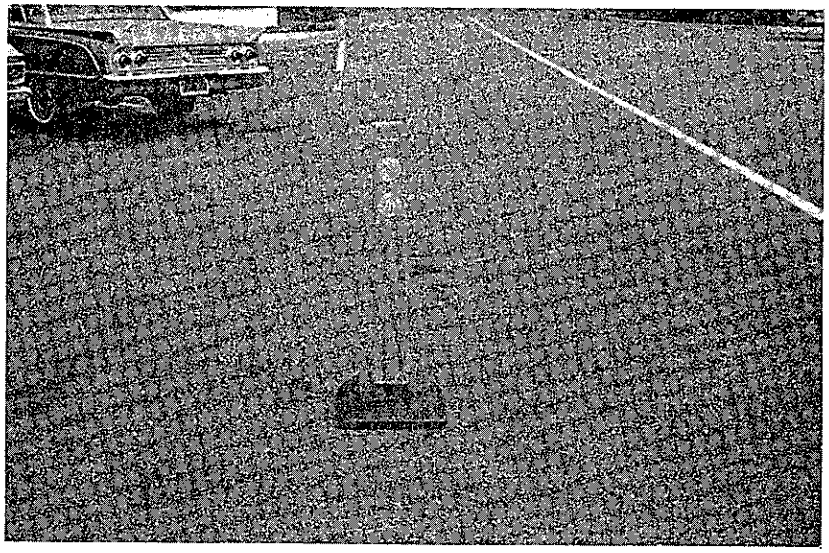
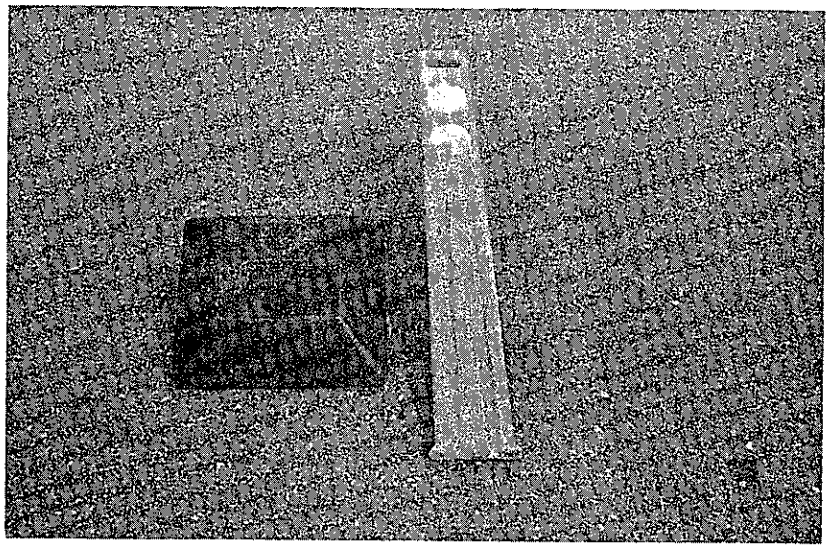
FIGURE 8





EECOPOST DELINEATOR

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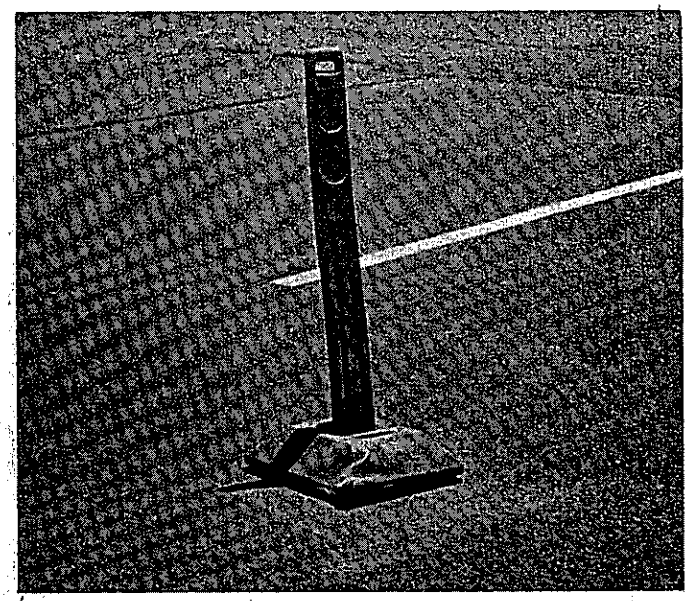
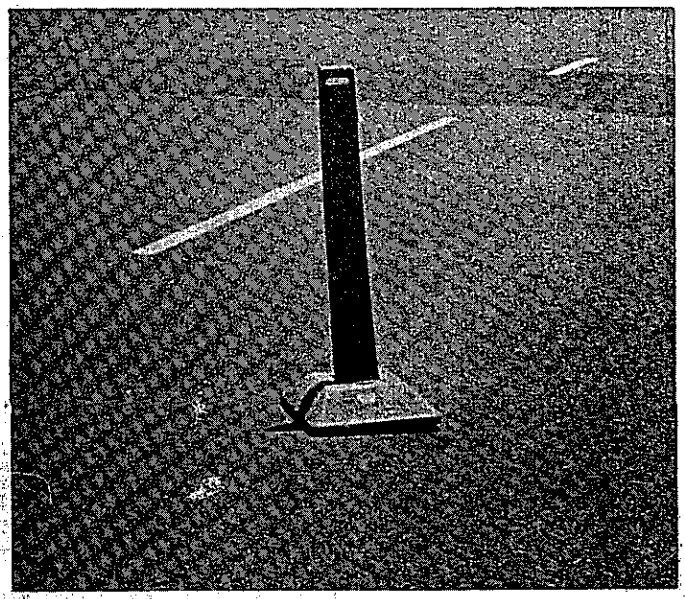
FIGURE 9



NO TIRE-DELINEATOR CONTACT



LEFT FRONT WHEEL ROLLED OVER DELINEATOR

40 MPH IMPACT TESTS

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Safety Guide Portable Highway Warning Devices

Marbon Chemical Division-Borg Warner Corporation

Washington, West Virginia

The Standard Highway Warning Device, 40 inches high, retails at approximately $13.75 for the unit consisting of a base, base lid, and post with adapter. The High Level Warning Device, 76 inches high, costs approximately $16.25 for the post, lid, and base combination. The posts and post sockets are constructed with Cycolac brand ABS polymer and are available in both 2 and 2½ inch diameters. They are pigmented with federal highway yellow and are drilled for flag shafts. The base is molded of rubber. The base lid is molded of polyethylene in federal highway yellow.

Five of these devices, four Standard and one High Level, were set up adjacent to the traveled way (30" from lane edge to base perimeter) in a construction zone in which the traffic was traveling 50-55 mph (see Figure 10). The 76" High Level Warning Device was found to have marginal stability under these traffic conditions. During one observation period, this higher device, with five flags attached, overturned after two hours' exposure to traffic. During the second observation period, this same device with first 3 flags and then 5 flags tipped twice but did not overturn.

The 40" Highway Warning Device appeared extremely stable to both overturning and sliding. The base, when filled with sand, weighs approximately 50 lbs. This appears to be quite adequate for stabilizing the 40" standard. Three 40 mph full scale impact tests were conducted with a 1963 Dodge to determine the severity of the damage to the standard, damage to the impacting vehicle, and danger of loss of control of the vehicle when colliding with the standard. Tests 1 and 2 were conducted with the vehicle wheel crossing the base and Test 3 with no wheel contact with the base. In Tests 2 and 3 the post sheared at the post-base connection, necessitating replacement of the post only (see Figure 11). The replacement cost would be approximately $4.15. In Test 1, the threaded post connection in the base failed. The replacement cost in this case would be $10.75, unless the portion of the post fitting remaining in the base could be removed. The post fitting costs approximately $1.00. The post was thrown 100 feet from the base in Test 3 but the base did not move more than one foot. There was no damage to the vehicle and no indication that loss of control of the vehicle would occur.

These units provide good daytime visibility but would require reflectorization for use at night. The stability of the High Level Warning Device is marginal but the stability of the 40" device is excellent. The high level device with flags is too large for use as delineators on very narrow shoulders. Where the shoulder width permits the use of flags, these devices are very effective daytime delineators.

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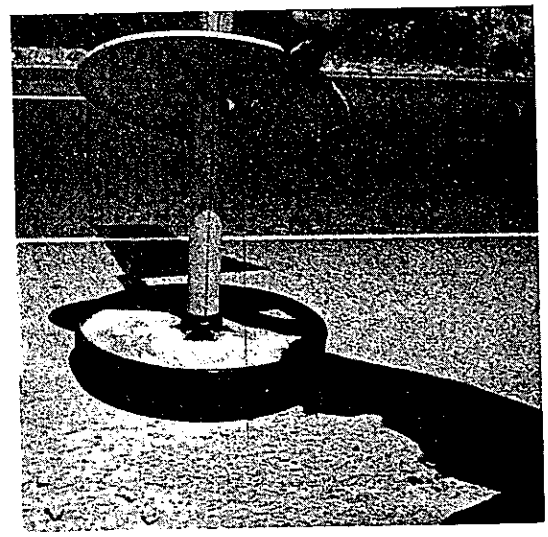
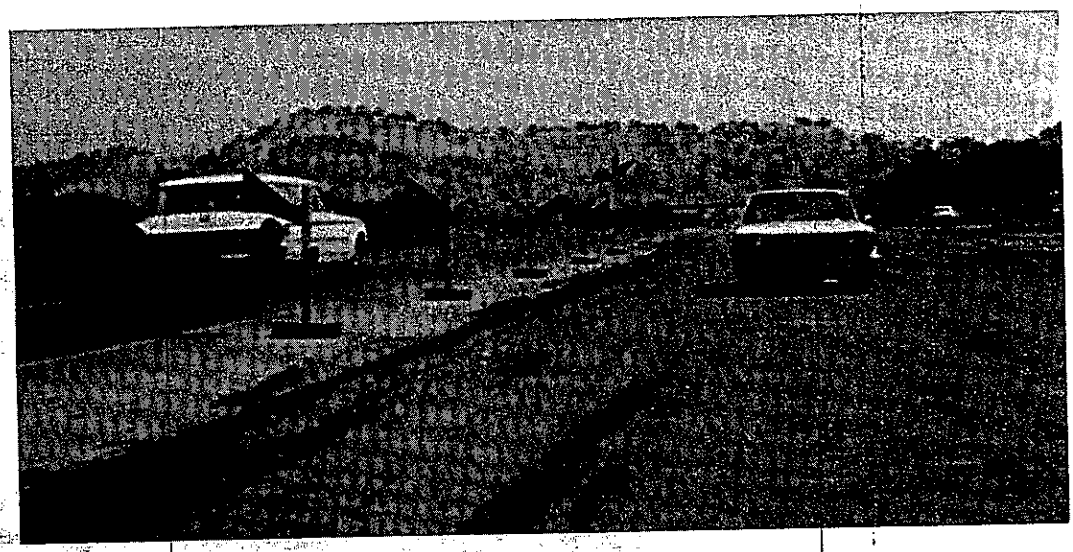
FIGURE 10





IN-SERVICE TEST

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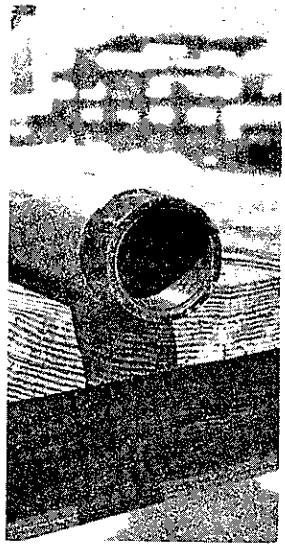
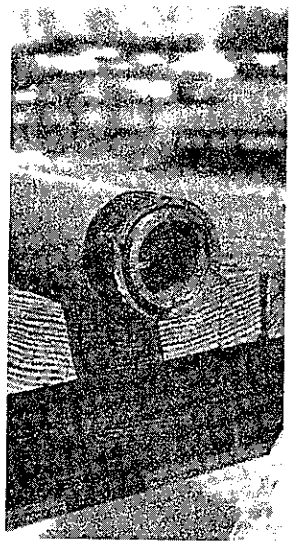
FIGURE 11



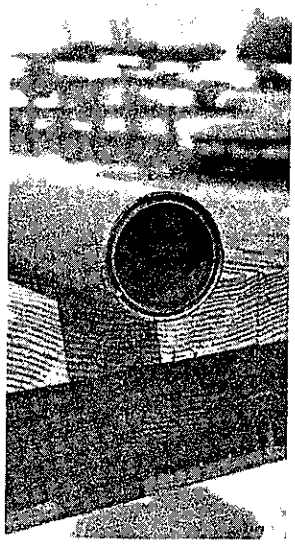
POST

UNDAMAGED



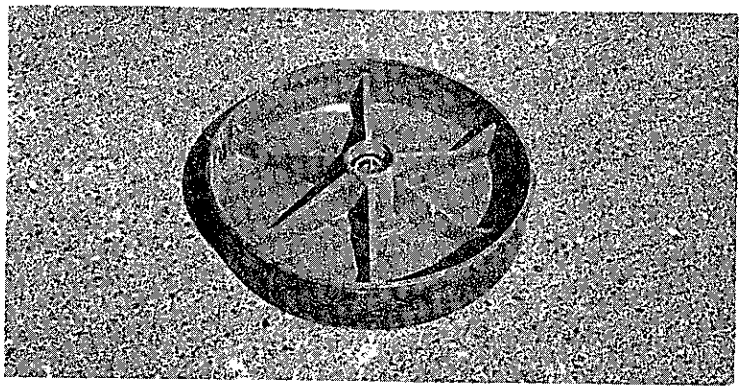
POST

TEST 1



POST

TESTS 2 and 3



BASE

TEST 1

40 MPH IMPACT TESTS

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Portable Guide Post

State of California, Division of Highways

District 05

(See Figure 12)

The estimated price for the construction of these delineators is $7.00 each. For a sketch of this device, see Figure 13.

The 39" height to the top of the guide plate is considered too low. A 48" height, which is used for standard guide plates, would be more desirable to maintain uniformity through a transition. Definite consideration should be given to changing the color of the front face of the base from red to fluorescent red or fluorescent yellow. Although either of the fluorescent pigments would be an improvement, the yellow is more noticeable, particularly for color-blind individuals. District 05 has reported no adverse experience with this device. Its stability should be good when properly ballasted.

The storage and handling characteristics of this device are poor due to its shape but would be tolerable if a small number of moves were expected.

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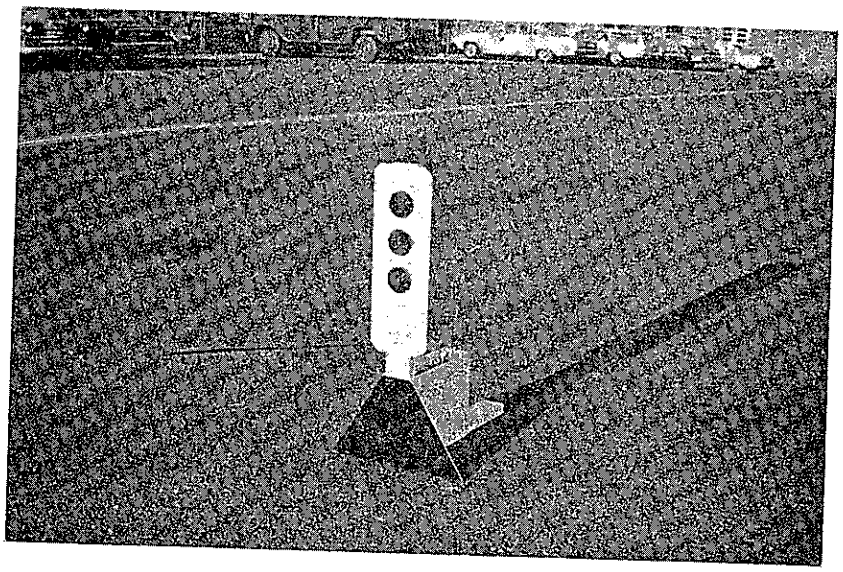
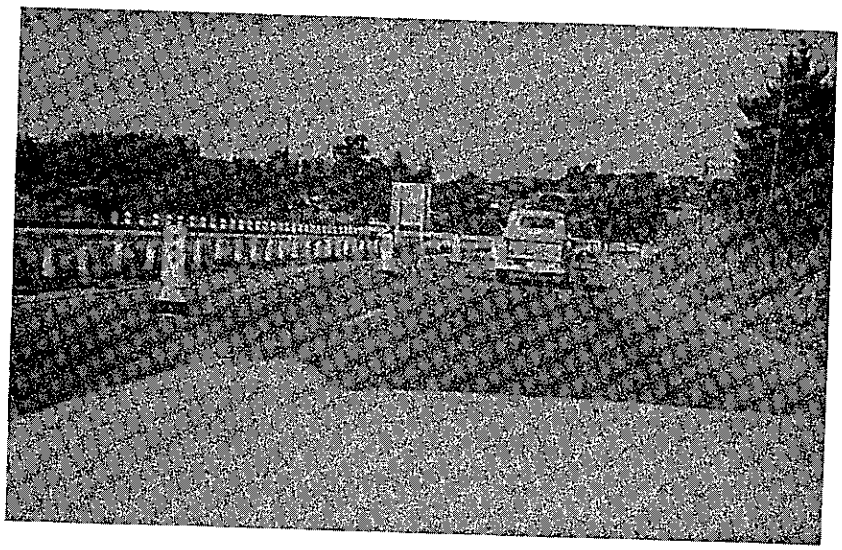
FIGURE 12





District 05

PORTABLE GUIDE POST

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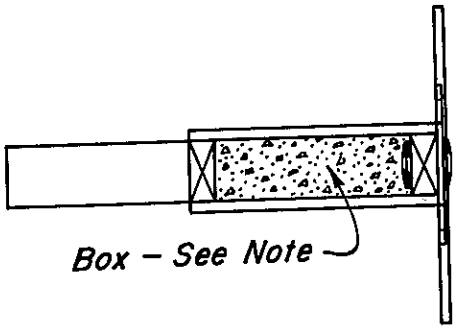
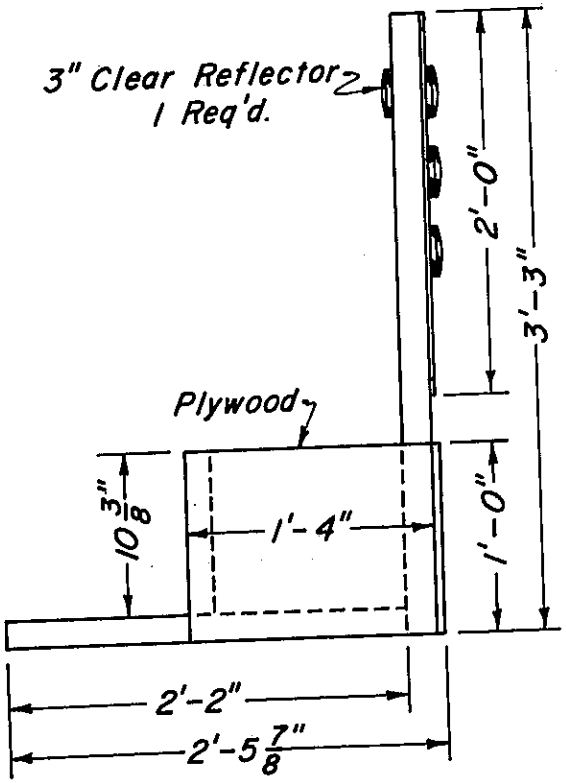
NOTE:
Fill box with gravel — If units are to be moved frequently to divert traffic, fill box with concrete and insert handle.
Paint all exposed wood surfaces white except where noted.
Use 2" X 4" and $\frac{1}{2}$, $\frac{5}{8}$ or $\frac{3}{4}$" plywood as available except where noted.

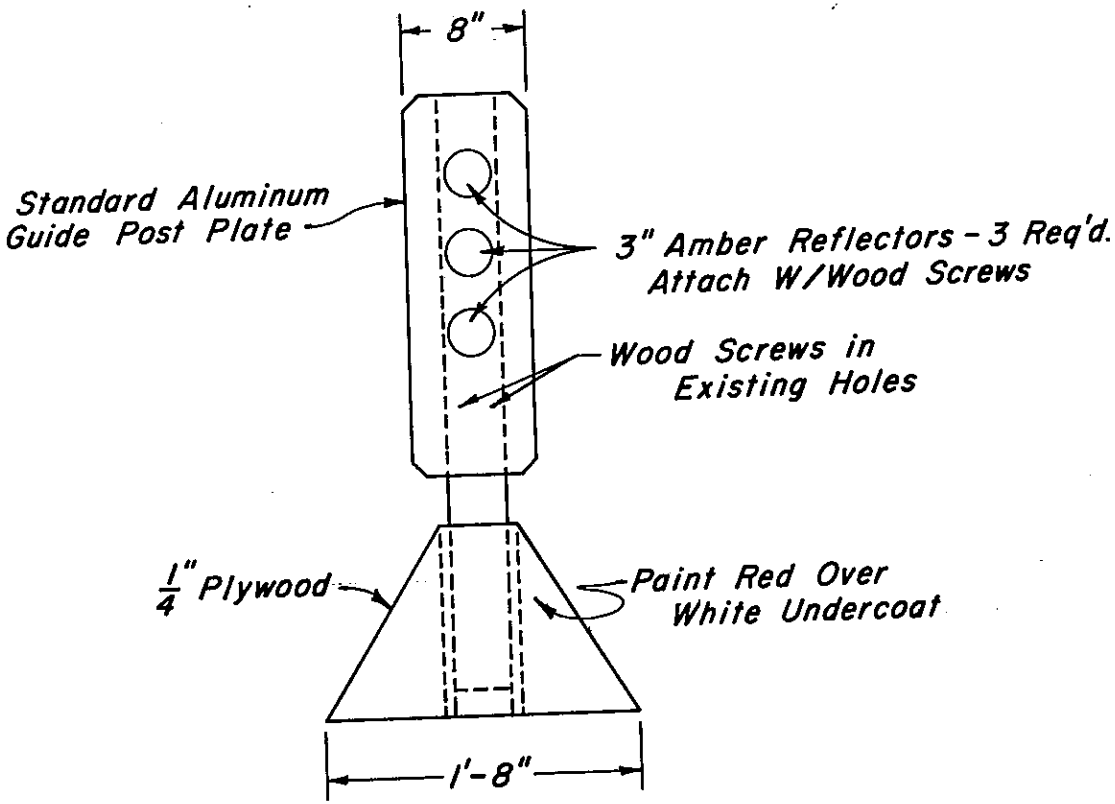
SCALE 1" = 1'-0"



TOP VIEW



SIDE VIEW



FRONT VIEW

PORTABLE GUIDE POST

FIGURE 13

Red Fluorescent Traffic Cones

The cost of 28" red fluorescent cones will vary with the manufacturer but should be approximately $5.00 each.

Traffic cones have been utilized with varying degrees of success in handling traffic through construction throughout the state. Cones are available in heights varying from 12 inches to 48 inches with the 18 and 28 inch sizes the most commonly used on construction sites. The two most undesirable characteristics of cones are the lack of reflectance and the constant maintenance that is required to keep them properly positioned with respect to the traveled way. These deficiencies are now being overcome with the use of 3" diameter reflex reflectors mounted near the top of the cone to provide the desired nighttime visibility and PK nails to attach the cone to the pavement. See Figures 14 and 15 for photographs of the cone systems in use in Districts 03 and 11.

Reflective sheeting has been used in lieu of reflex reflectors in an effort to decrease the high incidence of reflector button losses. The reflective sheeting has been moderately successful but provides considerably less target value. A reflector adaptor has been developed by the Interstate Rubber Products Corporation for insertion into the top of a cone (see Figure 16). The construction is such that two reflectors of either the same or different colors can be attached. Although this reflector adaptor will fit the cones produced by the Interstate Company, it will not fit all manufacturers' cones.

Because these cones are molded with homogeneously pigmented material, rather than an applied enamel as used in rubber cones, the maintenance required in providing a clean surface should be minimal. The use of cones greatly minimizes the chance for injuries and property damage when struck by a vehicle. The cone itself will not cause any significant property damage. However, if a cone is knocked into the traveled way, the evasive action on the part of a driver may cause a collision.

Traffic cone covers, or sleeves, are available in red fluorescent vinyl or canvas with a vinyl coating. The canvas sleeves would cost approximately $15.00 per dozen for small orders. The vinyl sleeves would cost approximately $21.00 per dozen.

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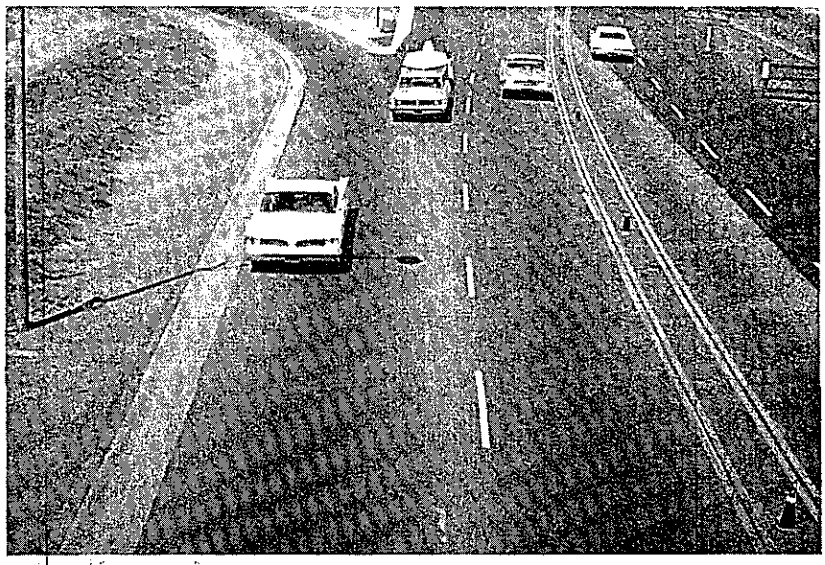
FIGURE 14



RED FLUORESCENT TRAFFIC CONES

(District 03)

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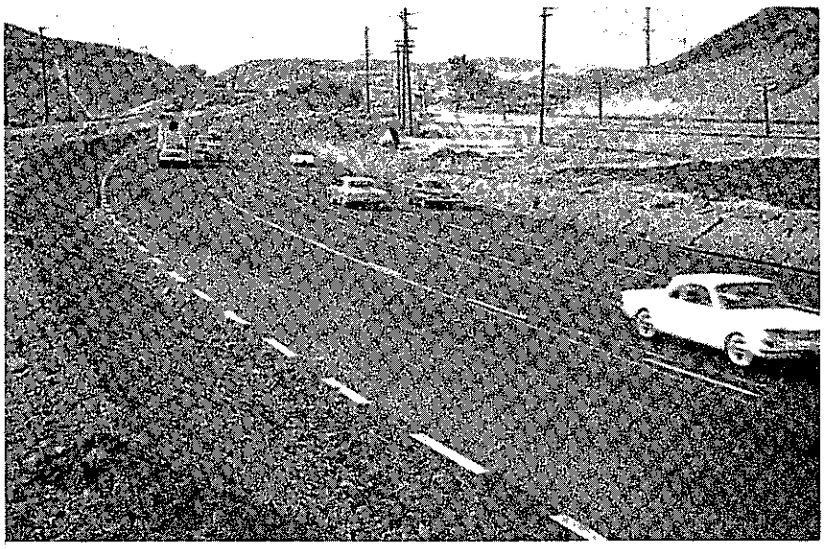
FIGURE 15



RED FLUORESCENT TRAFFIC CONES

(District 11)

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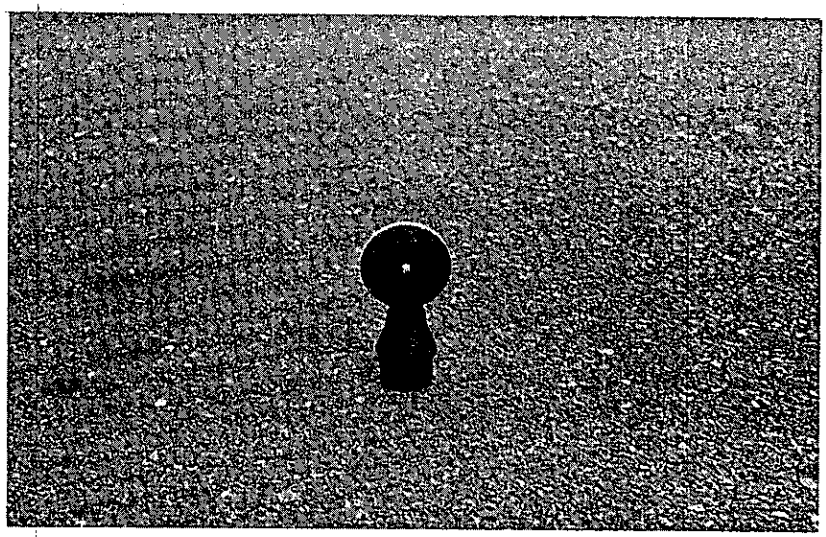
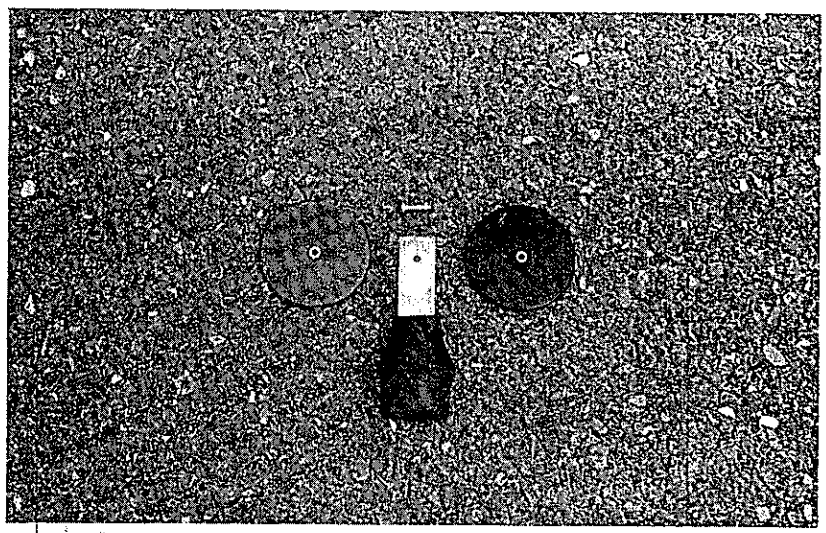
FIGURE 16





TRAFFIC CONE REFLECTOR ADAPTOR

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Port-A-Guide Post

Interstate Rubber Products Corporation

908 Avila Street, Los Angeles, Calif.

(See Figure 17)

The cost of one of these devices is $7.95. This does not include an additional cost of $1.50 for a flag adapter and one flag.

From operational experience with these units in Districts 08 and 11, they appear to require extensive modification for effective use. The 2-3/4" diameter shaft does not present sufficient surface area to provide adequate target value unless a more distinct and durable color coating can be applied to it. These units are very unstable with the flag adaptor and flag inserted into the top of the post and will overturn quite readily. Without the flag, however, resistance to sliding and overturning is excellent. The post can be flexed provided the base is fastened to the pavement surface. A unit that has not been attached to the roadway will overturn when struck by a vehicle. (A test vehicle traveling at a speed of 25 mph struck an unattached unit without a flag and displaced it approximately 25 feet.) District 11's experience indicates that the base connection may not be adequate as some failures of this connection have occurred. Even though a glass bead impregnated white paint was applied to the top of the post, it was found that additional reflectorization in the form of reflex reflectors or reflective sheeting would be required. The yellow paint on the post would require continuing maintenance, as does the paint on rubber traffic cones.

The 28" over-all height of the unit is considered marginal for edge delineation but would be adequate for use in lieu of traffic cones. These units could not be stacked in the same manner as cones, thus making handling somewhat awkward.

These units will cause no physical damage to an impacting vehicle when knocked into the traveled way, but the evasive action of a following driver could cause an accident.

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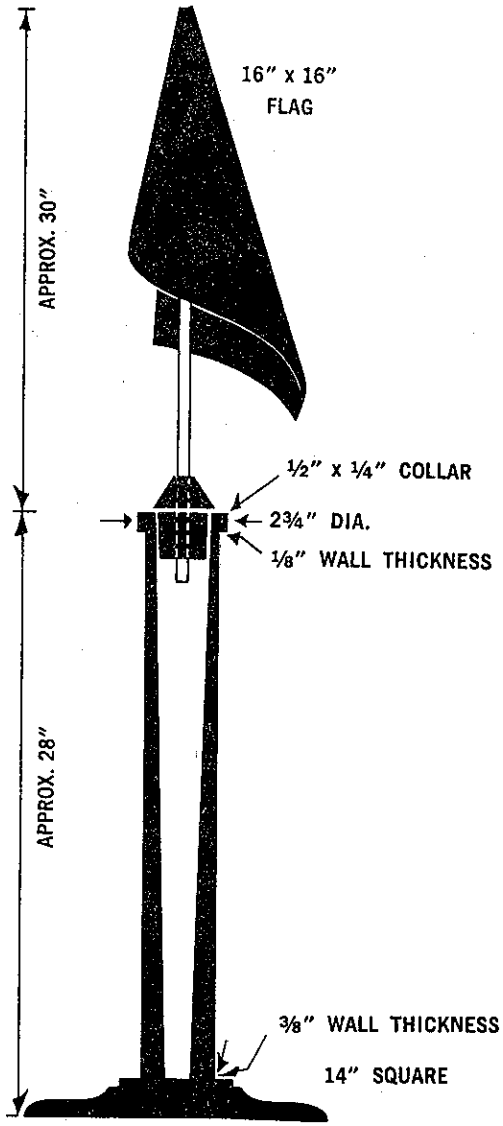
FIGURE 17



PORT-A-GUIDE POST

(Drawing from Sales Brochure)

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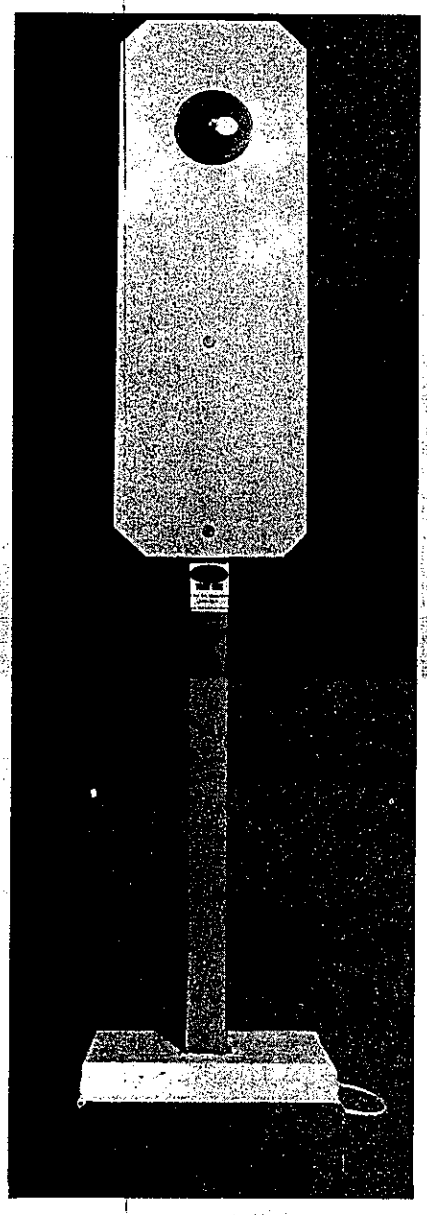
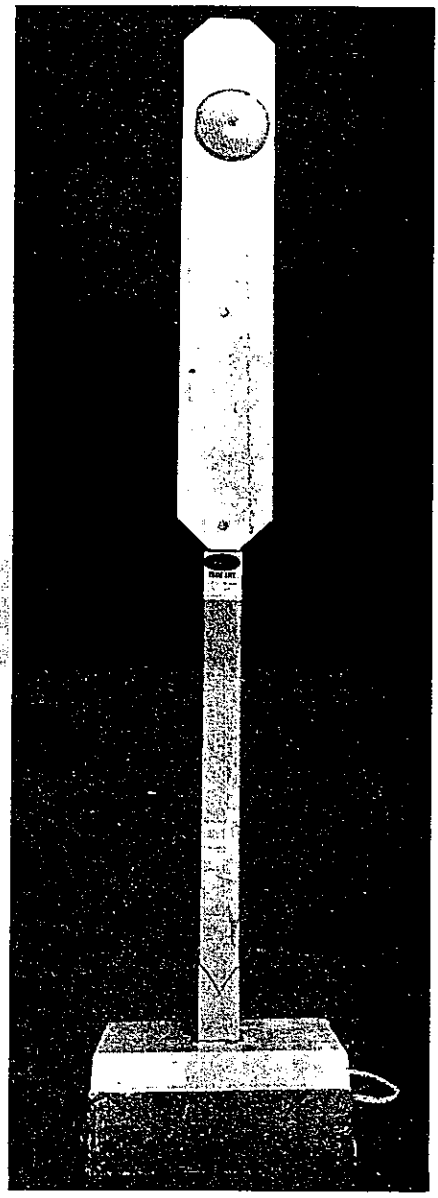
FIGURE 18



STANDARD MODEL

8" x 24" Guide Plate



RANGER MODEL

4" x 24" Guide Plate

PORTA BASE

(Photos from Sales Brochure)

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Porta Base

Casell Company, Napa, California

(See Figure 18)

The price of this guide marker unit applicable to high speed construction zones (Ranger model) is approximately $4.95. This cost includes the painted base, guide plate, painted four-foot high post, and reflector. Although production of the Porta Base has recently been discontinued by the Casell Company, the information herein has been included as representative of this particular type of device.

The Porta Base Ranger model includes a four-inch wide plastic guide plate and a center mount reflector. The standard model is similar but with an eight-inch wide plate. The reflector provides adequate delineation at night, but daytime delineation is very poor on the Ranger model because of the poor target area provided by the four-inch wide white paddle. Although the base of this model provides adequate resistance to overturning, it does not prevent sliding and skewing when struck. The use of additional ballast on the base is often required (see Figure 19) to prevent sliding. It has been suggested that rubber feet attached to the bottom of the base may eliminate this movement. A hole has been provided in the concrete base through which a large spike could be inserted to eliminate the skewing. However, more time and effort would be required for installing the devices and a hole would be left in the pavement surface when the spike was removed.

Two full scale impact tests were conducted on this unit. These tests were conducted to determine (1) whether there would be loss of control of an impacting vehicle, (2) the extent of the damage that would be sustained by the base and vehicle, and (3) the degree to which the damaged base would constitute a hazard to traffic. Test 1 was conducted at 40 mph with no contact between the base and the vehicle wheels. The 2" x 2" post failed at the top of the base and at the point of impact between the post and the bumper (see Figure 20). A crack developed across the base at the back of the post hole. The post was destroyed, but the base was reusable. The cost of replacing the post and guide plate would be approximately $2.75 on the Ranger model. Test 2 was conducted with the left vehicle wheels crossing over the base. The post again failed at the top of the base and at the point of impact with the bumper (see Figure 21). The base broke into three sections, one which separated from the base even though there was wire reinforcing in it. There have been some instances in which concrete bases have been flipped into the air and caused vehicle occupant injury through direct contact with the victim or through resultant collisions. These bases must be heavily reinforced to prevent demolition and shaped such that they will not become air borne if hit by a vehicle.

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No vehicular control problems were encountered, but it must be pointed out that the impacting vehicle was of the medium-heavy type ('63 Dodge) and the driver was anticipating the impact. The driver of a smaller vehicle caught by surprise might have encountered much more difficulty in maintaining control of his car.

These units are a considerable improvement over a paint can filled with concrete. However, their efficiency can be greatly increased by eliminating the creeping tendency of the base and by changing the color or size of the 4" wide paddle to increase the daytime target value. Heavier reinforcing should also be included to eliminate any possibility of base fragmentation.

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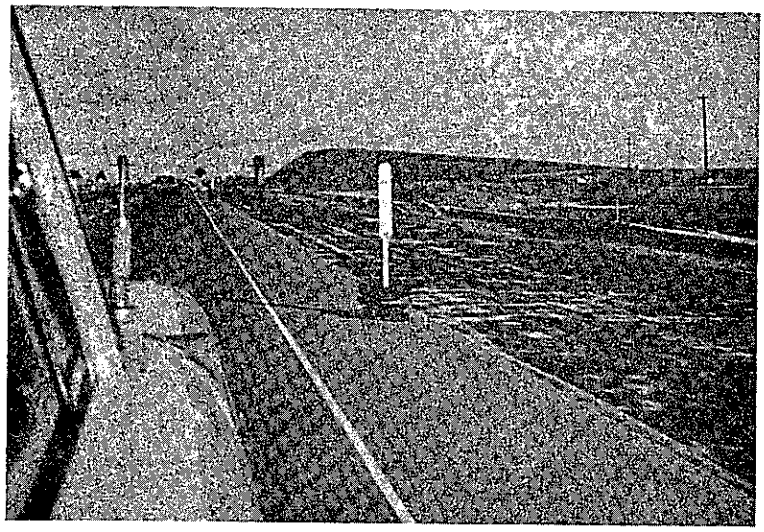
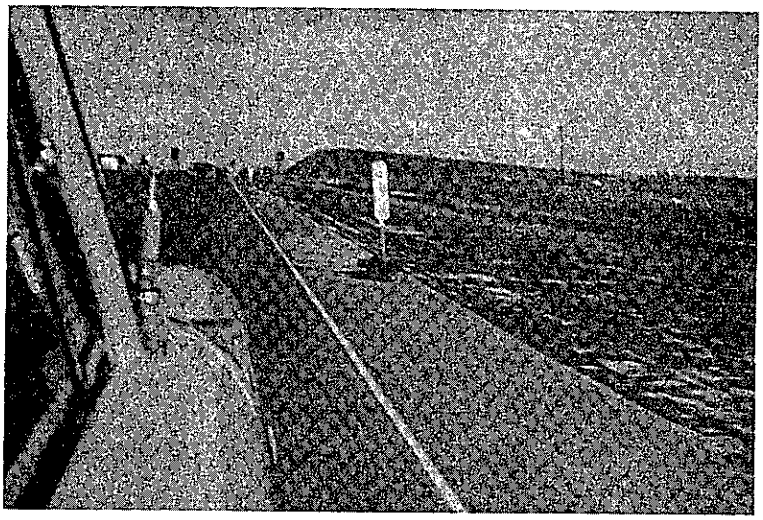
FIGURE 19



RANGER MODEL



STANDARD MODEL

BALLAST REQUIRED TO STABILIZE PORTA BASE

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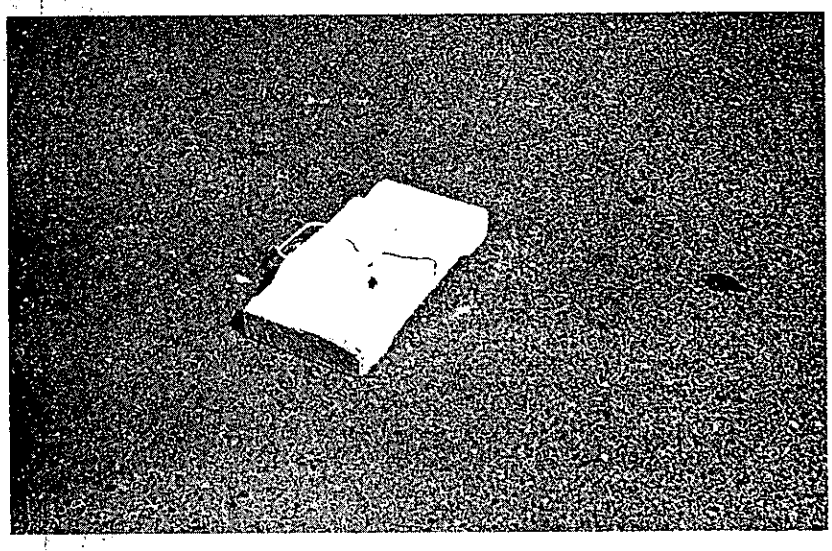
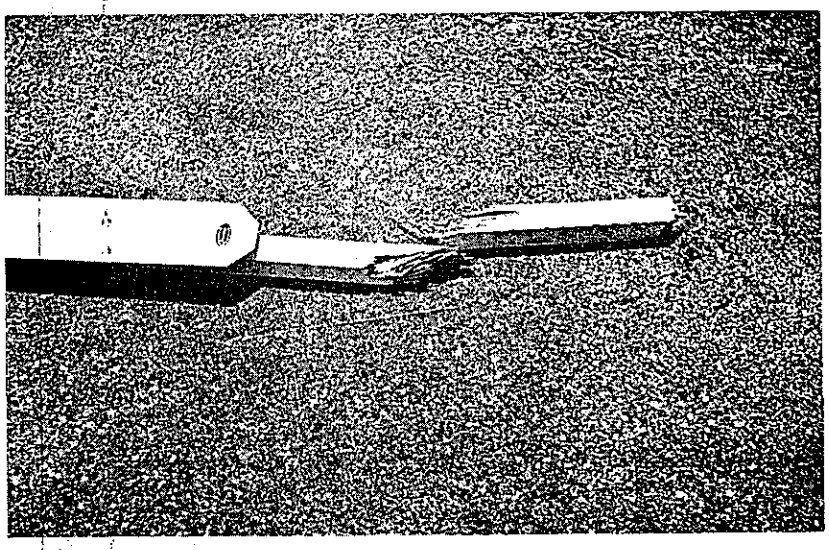
FIGURE 20



CRACKED BASE



BROKEN POST

40 MPH IMPACT TEST - TEST VEHICLE STRADDLING BASE

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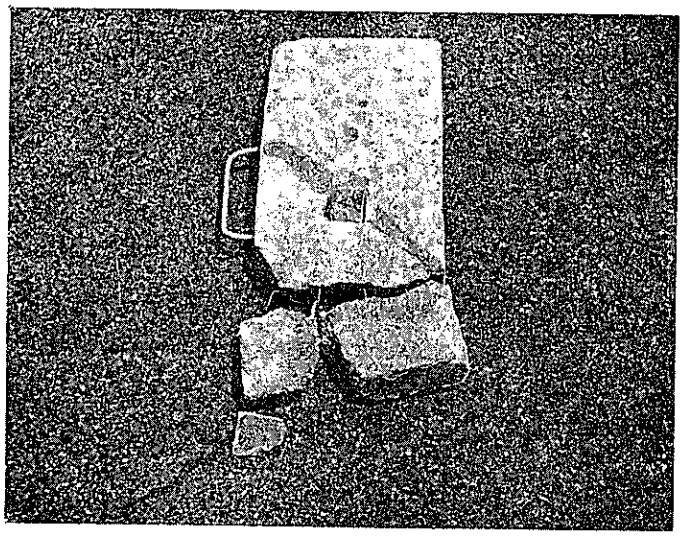
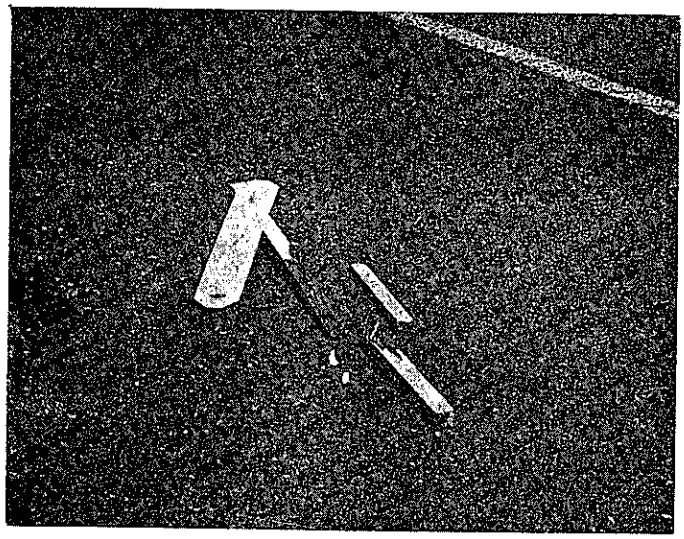
FIGURE 21



FRACTURED BASE



BROKEN POST

40 MPH IMPACT TEST - IMPACT VEHICLE WHEEL CROSSING BASE

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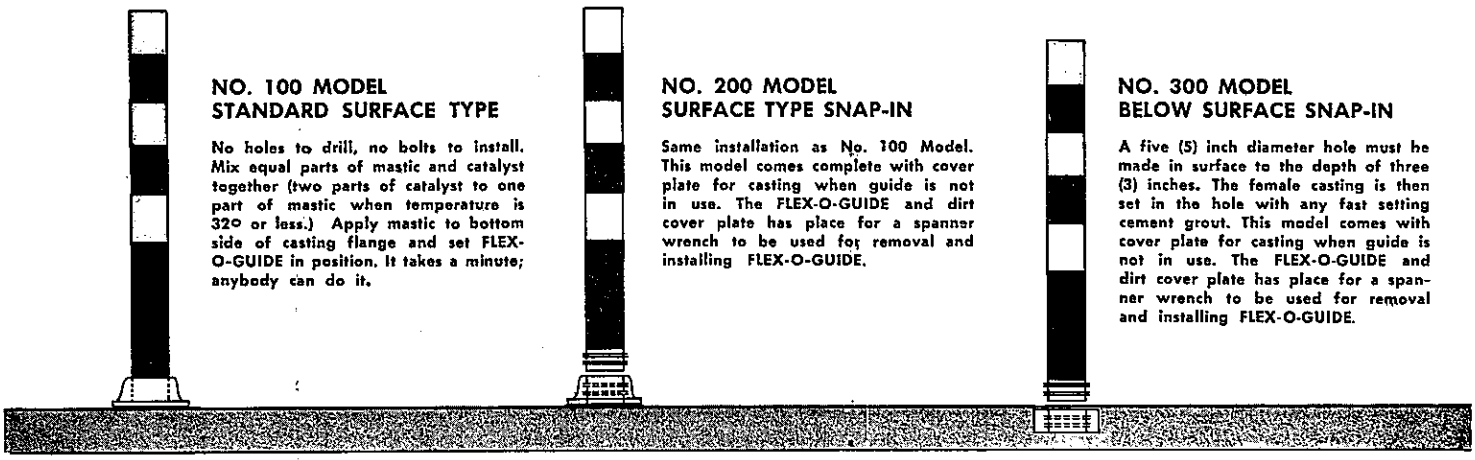
FIGURE 22

TYPES OF INSTALLATION



NO. 100 MODEL
STANDARD SURFACE TYPE

No holes to drill, no bolts to install. Mix equal parts of mastic and catalyst together (two parts of catalyst to one part of mastic when temperature is 32° or less.) Apply mastic to bottom side of casting flange and set FLEX-O-GUIDE in position. It takes a minute; anybody can do it.

NO. 200 MODEL
SURFACE TYPE SNAP-IN

Same installation as No. 100 Model. This model comes complete with cover plate for casting when guide is not in use. The FLEX-O-GUIDE and dirt cover plate has place for a spanner wrench to be used for removal and installing FLEX-O-GUIDE.

NO. 300 MODEL
BELOW SURFACE SNAP-IN

A five (5) inch diameter hole must be made in surface to the depth of three (3) inches. The female casting is then set in the hole with any fast setting cement grout. This model comes with cover plate for casting when guide is not in use. The FLEX-O-GUIDE and dirt cover plate has place for a spanner wrench to be used for removal and installing FLEX-O-GUIDE.

FLEX-O-GUIDES are produced in three heights — 14", 20", and 26".

FLEX-O-GUIDES are adapted for three types of mountings as shown, i.e., No. 100, No. 200, and No. 300, see illustrations.

Specifications:

MATERIAL:	Flex-resistant, extruded rubber containing special composition to withstand weather and contact abuse. (2¾" x 2¼" x ¼" wall thickness).
COLOR:	Black with 3" yellow bands of reflectorized, yellow, Hypolon material.
BASE:	No. 100 — 6" x 2⅜" — No. 200 6" x 2⅜", and No. 300 2⅜" (⅜" above surface).
HEIGHT:	14", 20", and 26" — in all models.
WEIGHT:	No. 100 Model, 6½ Lbs., No. 200 Model, 7½ Lbs., No. 300 Model,, 7½ Lbs. — (26" Height).
TENSILE:	2300 to 2700 PSI. — in all models.
CASTINGS:	Grey iron casting coated with yellow, rust retardant paint.

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Flex-O-Guide

Bell & Gustus, Inc.

4328 Elston Avenue, Chicago 41, Illinois

(See Figure 22)

The price of the model applicable to construction zone delineation and channelization was $9.95 in 1959.

The Flex-O-Guide device was originally developed for use as a permanent flexible barrier for channelizing traffic. This device was the object of extensive testing by the Materials and Research Department in 1959 to determine its physical properties. A report entitled "A Progress Report on the Study of the Physical Properties of Flex-O-Guide Lane Markers" was completed in 1959.

The tube tested was the Model 200 Surface Type Snap-In 26" high Flex-O-Guide. A proposal was made at the time of the earlier investigation that the Flex-O-Guide marker be used as a temporary construction zone device as the epon base mastic used to attach the base to the roadway surface can be softened with a welder's torch. This would facilitate the removal and reinstallation of the device in another location. This mastic was completely satisfactory in resisting the forces applied in several full scale dynamic impact tests at speeds of up to 70 mph. These devices are available in heights of 14, 20, and 26 inches. The only height worthy of consideration would be the 26 inch model, and even this height would be marginal for use as an edge delineator.

The recommendations of the Materials and Research Department in the above-referenced report included the suggestion of a better tube-to-base connection. The device was described as structurally adequate for 35 mph traffic as submitted by the manufacturer but in need of modifications for higher speed traffic.

This device may have limited applications in channelizing traffic in construction zones, but its lack of reflectivity, low height, semi-permanent attachment to the roadway, and high initial and maintenance cost would limit its usefulness.

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Traffic Warning Assembly for Use on Vehicle Carrying Lanes

Merit Award Board Suggestion No. 38824

(See Figure 23)

This spring mounted flexible delineator was developed for use in lieu of 1" x 4" planks embedded in five gallon paint cans filled with concrete. No price estimate can be prepared for this device until its dimensions are determined.

The Materials and Research Department has conducted tests on devices similar to this in an attempt to develop a flexible support system for guide plates. Devices consisting of (1) rubber posts to which guide plates were attached and (2) spring mounted steel shafts to which guide plates were attached were tested and found to be inadequate.

High axial, shearing, and bending forces are applied to a device when it is impacted by a high-speed vehicle. A flexible post will minimize the bending force but must absorb or transmit high axial and shearing forces due to its tendency to wrap around the front end of the vehicle. This can cause failure of the post-to-base connection or displacement of the device by the vehicle. A spring mounted rigid post would decrease the magnitude of the axial force that must be transmitted or absorbed, but its suitability would be dependent on the development of spring stiffness that would prevent excessive movement of the paddle by wind forces. Both types would require the development of a reflectorized guide plate having sufficient surface area for good daytime delineation but shaped such that it will not snag on any portion of an impacting vehicle.

The possibility of designing a spring and a reflectorized guide plate that would meet these requirements appears remote.

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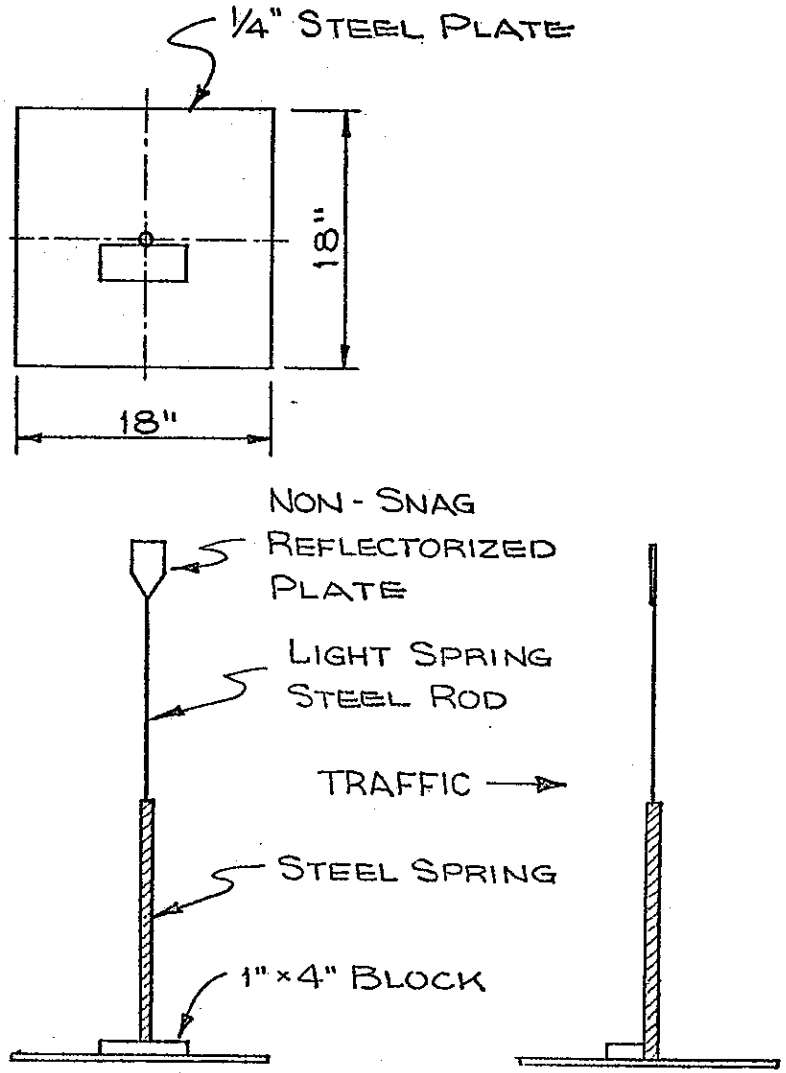

NOTE:

1. DIMENSIONS SHOULD BE DETERMINED BY TEST.
2. REFLECTOR RISER MAY BE PLACED AT EDGE OF PLATE TO PROVIDE MORE USABLE LANE WIDTH.
3. REFLECTOR RISER MAY BE SLOTTED OR THREADED AT THE BOTTOM FOR EASY DETACHMENT TO FACILITATE STORAGE OR TRANSPORTATION.

FIGURE 23

TRAFFIC WARNING ASSEMBLY

FOR USE ON VEHICLE CARRYING LANES

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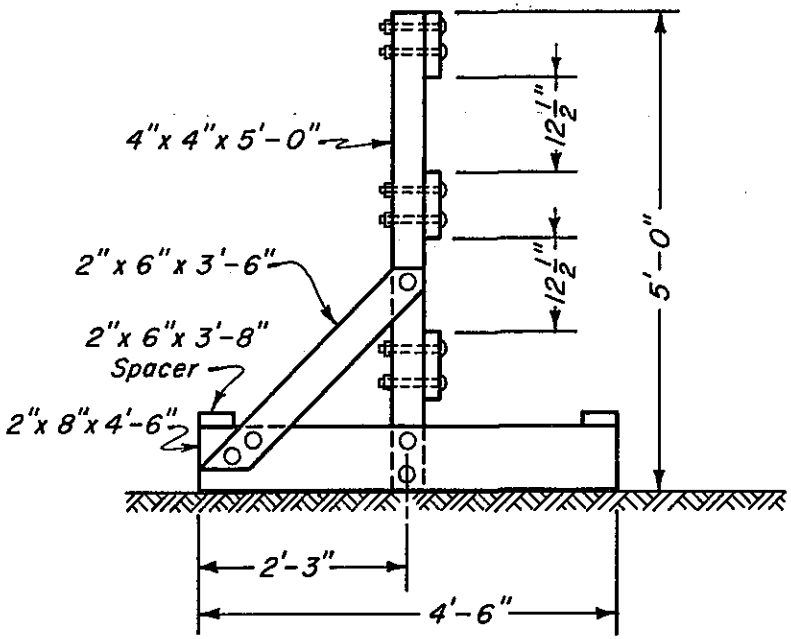
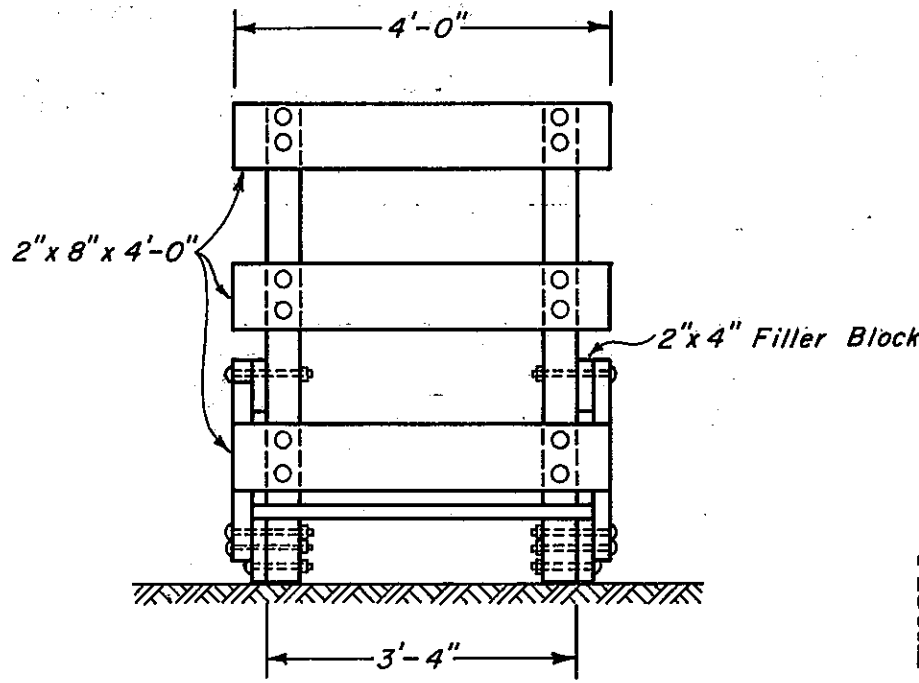


END VIEW



FRONT VIEW

FIGURE 24

CLASS I

TIMBER BARRICADES (SMALL)

NOTE: All timber to be S4S.
Use 1/2" machine bolts with cut washers and nuts.
Use 16p nails on Spacers.

SCALE 1" = 2'-0"

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C. Barricades

Small Class I Timber Barricades

State of California, Division of Highways

District 05

(See Figure 24)

These barricades should cost about 85% of the cost of a standard Class I barricade. These barricades were developed and are now a standard item in District 05. They are used for protection at minor obstructions such as open trenches and are reportedly easily handled by one man. Signs are occasionally mounted on these barricades. The district is using these small barricades in addition to the standard Class I barricades.

The small size of this barricade might encourage its use as a delineator. When barricades are used only for lane closures, with placement of the barricade 50 feet or more behind the delineation system, the larger Class I barricade may convey to the motorist an impression of a more positive barrier. However, some consideration should be given to the construction of a lane closure with the smaller barricades rather than the larger Class I barricade to minimize occupant injury and vehicular damage as barricades are not designed or intended to stop a vehicle.

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Lite Shield Temporary Traffic Barrier

Merit Award Board Suggestion No. 40089

(See Figures 25 & 26)

The cost of this modification of the standard Class I barricade would be approximately $5.00.

The modification is simple and inexpensive. When required between opposing lanes of traffic, the Type I barricade containing this modification eliminates the confusing and often dangerous glare situation that is presented to a nighttime driver as he approaches a change in alignment in the construction zone and is forced to look directly into the headlights of the opposing traffic. The addition of the light shield in no way restricts the use of the barricade.

Because of the large surface area of the plywood panel, additional ballast would be required to resist the increased wind loading. Also, this modification would add very little to the effectiveness of a barricade for lane closure only.

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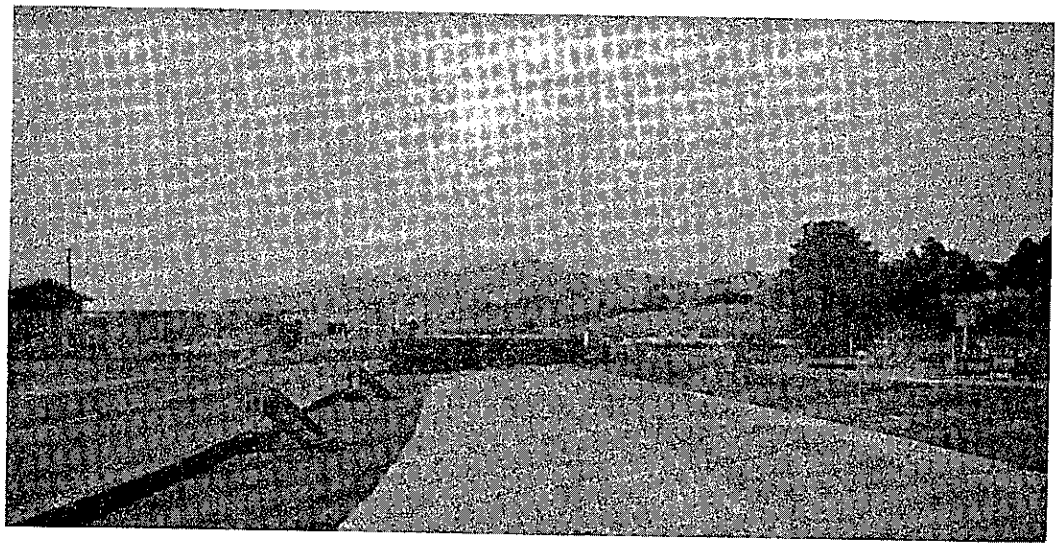
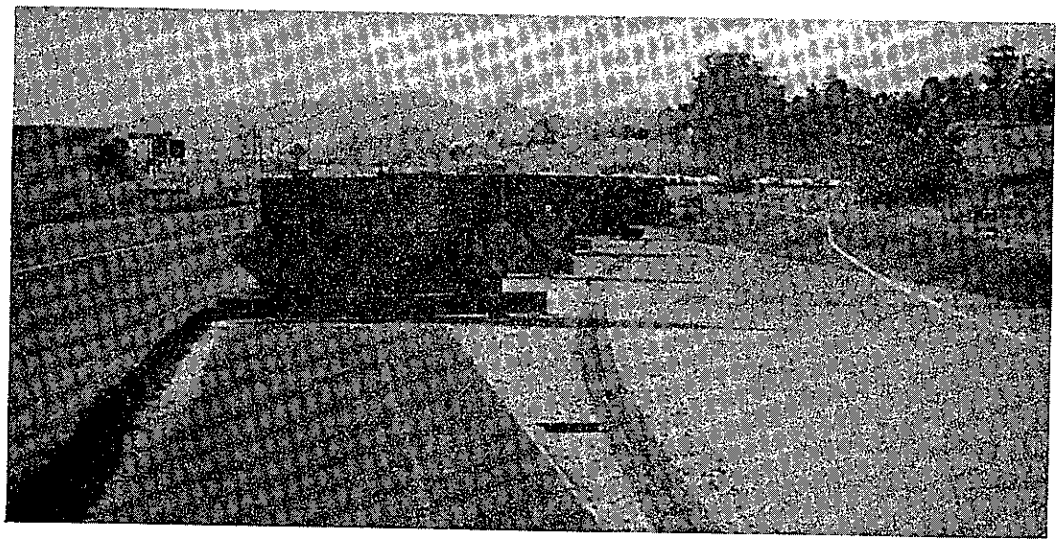
FIGURE 25





LITE SHIELD TEMPORARY TRAFFIC BARRIER

(District 04)

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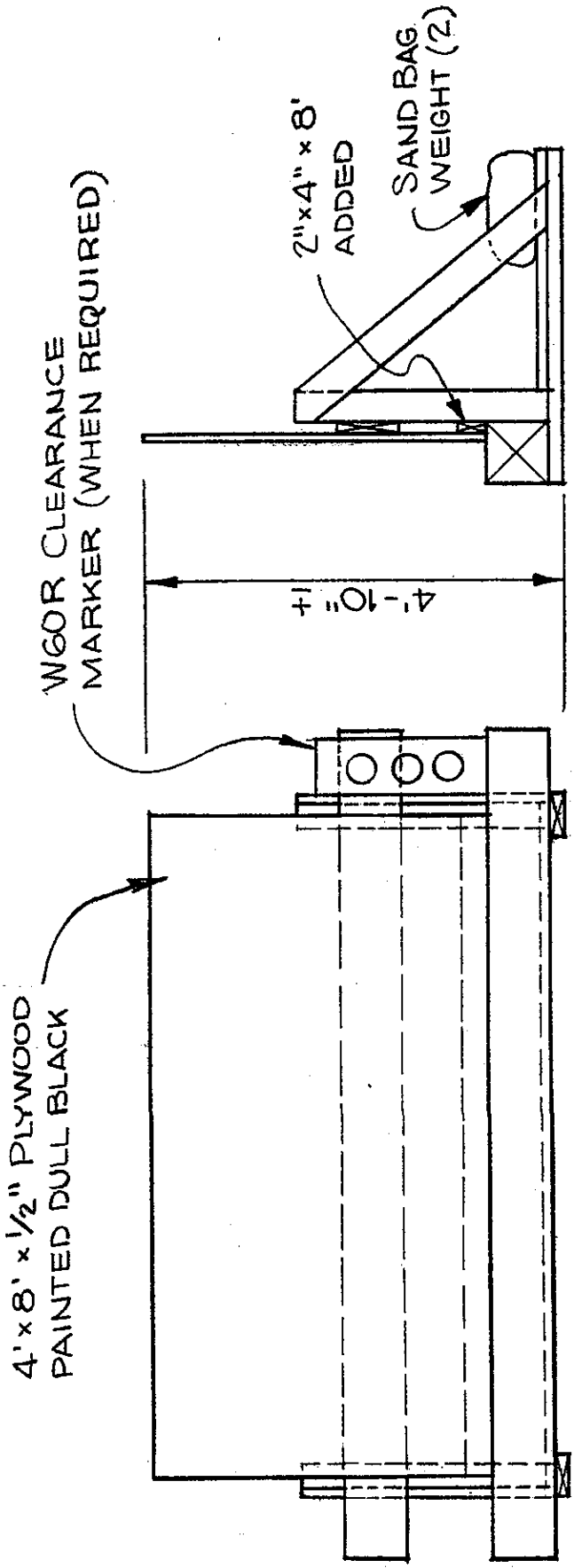
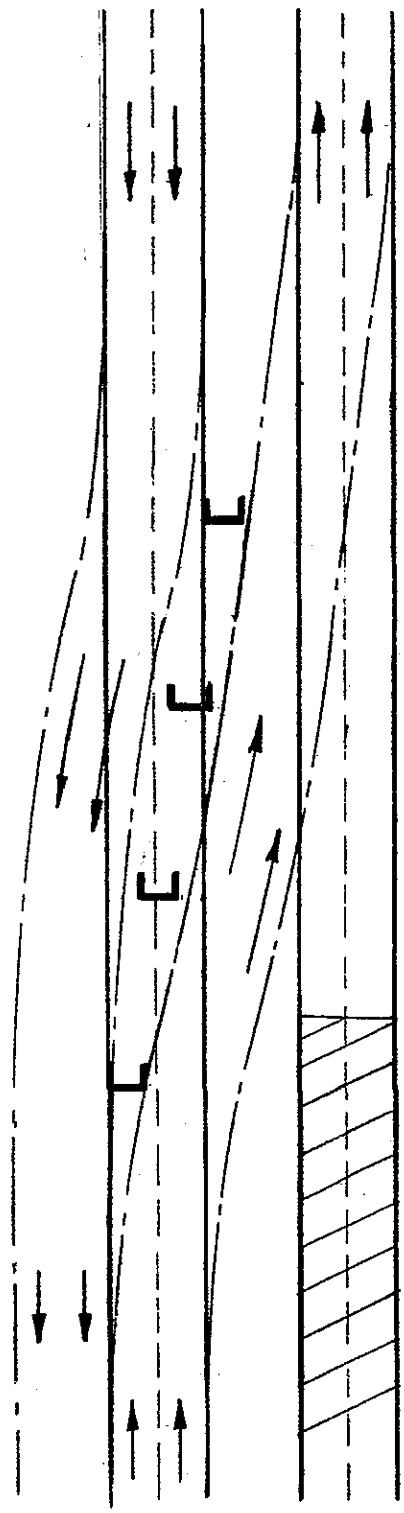
FIGURE 26



LITE SHIELD BARRICADE DETAIL

(STANDARD TIMBER BARRICADE MODIFIED AS SHOWN)



TYPICAL INSTALLATION

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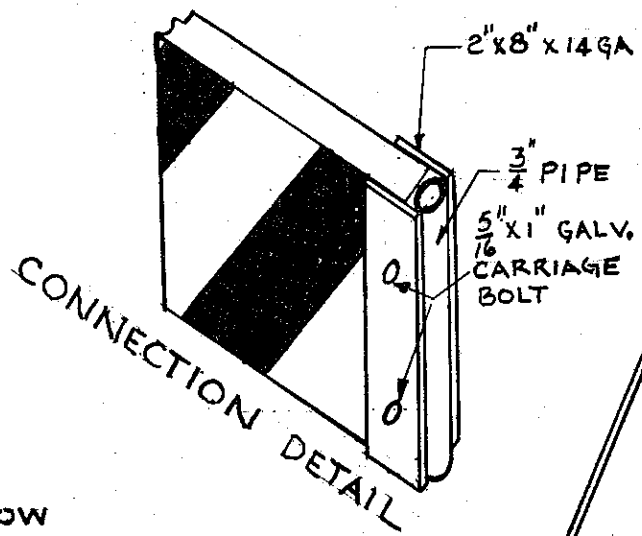
M P BARRICADE

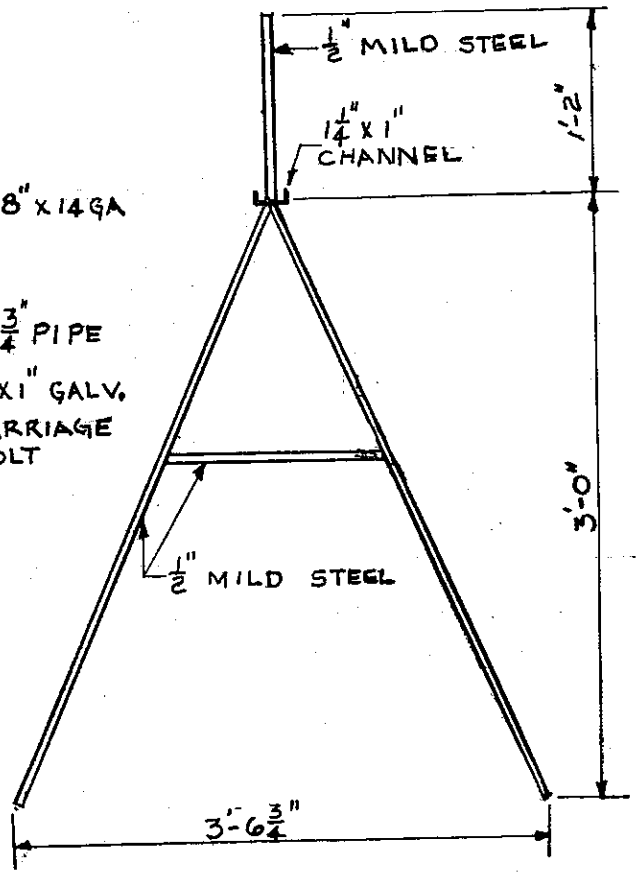
10 FT BARRICADE

5 FT BARRICADE

3 FT BARRICADE



CONNECTION DETAIL



STAND

CROSS BOARD COMPOSITION
FIBERGLASS

COLORS
BLACK & WHITE BLACK & YELLOW
RED & WHITE

REFLECTORIZED WITH M-M BODIT

SHIPPING WT.
3' BARRICADE 20 LB
5' BARRICADE 23 1/2 LB
10' BARRICADE 33 1/2 LB

FIGURE 27

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M. P. Barricade

Multi-Plastics, Inc.

2148 South Hoover, Wichita 9, Kansas

(See Figure 27)

The price of one ten-foot barricade is $26.95.

This device does not appear to be particularly useful for construction zone traffic handling except in metropolitan areas or for maintenance. The unit is easy to handle, weighing only 33½ lbs. for a ten-foot barricade. The 36" height to the bottom of the crossboard would be adequate for minor construction. However, the stability of this device in winds above 30 mph would be poor. Due to the flexibility of the crossboard, this device would offer little resistance to complete destruction by an impacting vehicle. This barricade might not shatter on impact as does the wooden Class II barricade, but the crossboard would be destroyed.

This barricade is too small and light to be used for major construction zones on freeways.

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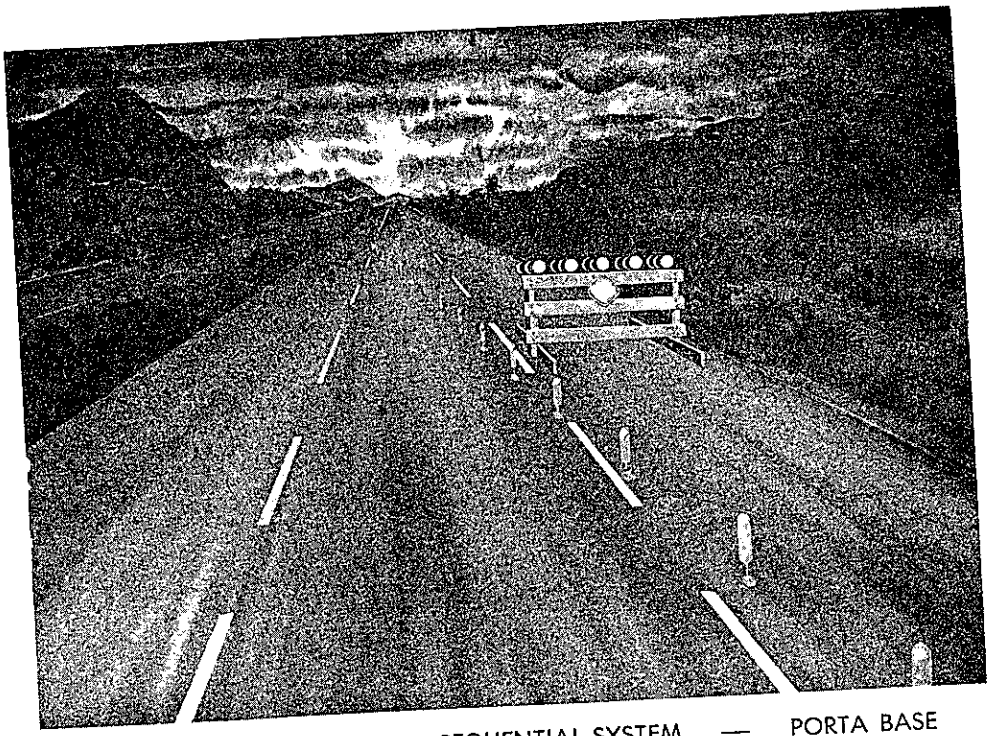
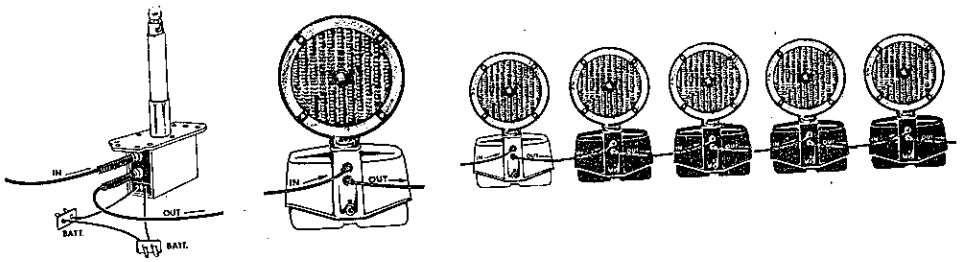
FIGURE 28

SEQUENTIAL SYSTEM



TYPICAL APPLICATION — SEQUENTIAL SYSTEM — PORTA BASE



CIRCUIT LITE BASIC SYSTEM

A Sequential System is five Tranz Lites; a leader and four followers, connected by a cable which plugs into each circuit. The leader sends an electrical impulse through the cable flashing each individually powered follower in sequence. As many followers as required may be controlled by a single leader. Flash duration on each unit is approximately 200 milleseconds with 60-80 flashes per minute. 6 volt system — 7 week's operation. 12 volt system — 1 week operation.

Each light will operate in the complete system, in a partial system, or individually.

(Portion of Sales Brochure)

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D. Lights

Sequential Flashers

Casell Company

P. O. Box 336, Napa, California

(See Figure 28)

The approximate cost for a series of five sequential flashers with 100 feet of line between each flasher is $115.00.

The intent of this application of the flasher units was to present the motorist with a series of sequentially flashing lights that would indicate the direction of the detour. The circuitry in these flashers is such that a definite time interval elapses between the flashes of adjacent units and the flashes are in sequence.

If one of the units fails, due to either bulb or battery failure, the system will "jump" this gap and continue to flash in sequence with approximately the same interval between flashes. The increased resistance due to a double length of wire in this gap will cause the time between adjacent flashes to alter slightly.

These "sequentials" should not be used as delineators. They may be suitable for use at the entrance to a construction zone and/or at an abrupt change in the alignment of the traveled way through the construction zone. As with other flashers, the intensity, frequency, and duration of the flashes can be varied, as can the time interval between flashes on adjacent units. The system examined had a limitation of five flashes before a new pulse would begin in the leading unit. Alteration of the frequency of the flashers would be required if more than five flashers were desired for a sequential system.

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Northern Signal Company

Local Distributor: Level Lite

523 Old County Road, San Carlos, California

(See Figures 29 & 30)

The current cost for the three items produced by this manufacturer that were observed for this study are as listed below for quantities of less than 200:

Model No. 5A Flasher	$33.50 (saw buck incl.)
Model No. 5A Steady Burn	$33.50 (saw buck incl.)
Model No. 4H Header	$33.75 (saw buck not incl.)

The Model 5A flasher should meet all the requirements suggested by the Bureau of Public Roads. However, these flashers will not meet the State of California Service and Supply Specifications for 6 Volt Traffic Warning Flashers dated January 1967 as shown in the following table:

Item	Northern Signal Company Flasher	January 1967 S & S Specifications	Remarks
Flash Rate	75 FPS	60 ± 5 FPS	Fail
Dwell	27.5%	20 - 28%	Pass
Lens Color	-	ASA D.10.1 yellow signal lens spec.	Does not appear to meet spec.
Head Turn	180° ±	359°	Fail

Compliance with several sections of the Service and Supply specifications dealing with the physical characteristics of the case, the current drain, and the isoflux lines were not determined.

The current "Manual of Warning Signs, Lights, and Devices for Use in Performance of Work upon Highways" issued by the Department of Public Works prohibits the use of flashers "for delineating the path traffic is to follow". Consequently, the Model 5A flasher was modified to a steady burn device for use as a delineator. One of the problems associated with the use of this delineator would be in finding or developing a safe support for it. The use of the common "saw buck" has raised many objections as to target value, height, and danger if struck

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by a vehicle. The larger Class I or II barricades would provide a satisfactory mounting for the steady burn delineator but the advisability of using barricades for delineators is questionable.

The Model 4H header is an extra bright flasher that is intended for use as the initial, or leading, flasher. Although this unit is 10 to 12 times as bright as the standard flasher and will definitely attract the driver's attention, it may also confuse him. If this Model 4H header unit is to be used, a support to elevate it more than the standard 42" should be considered.

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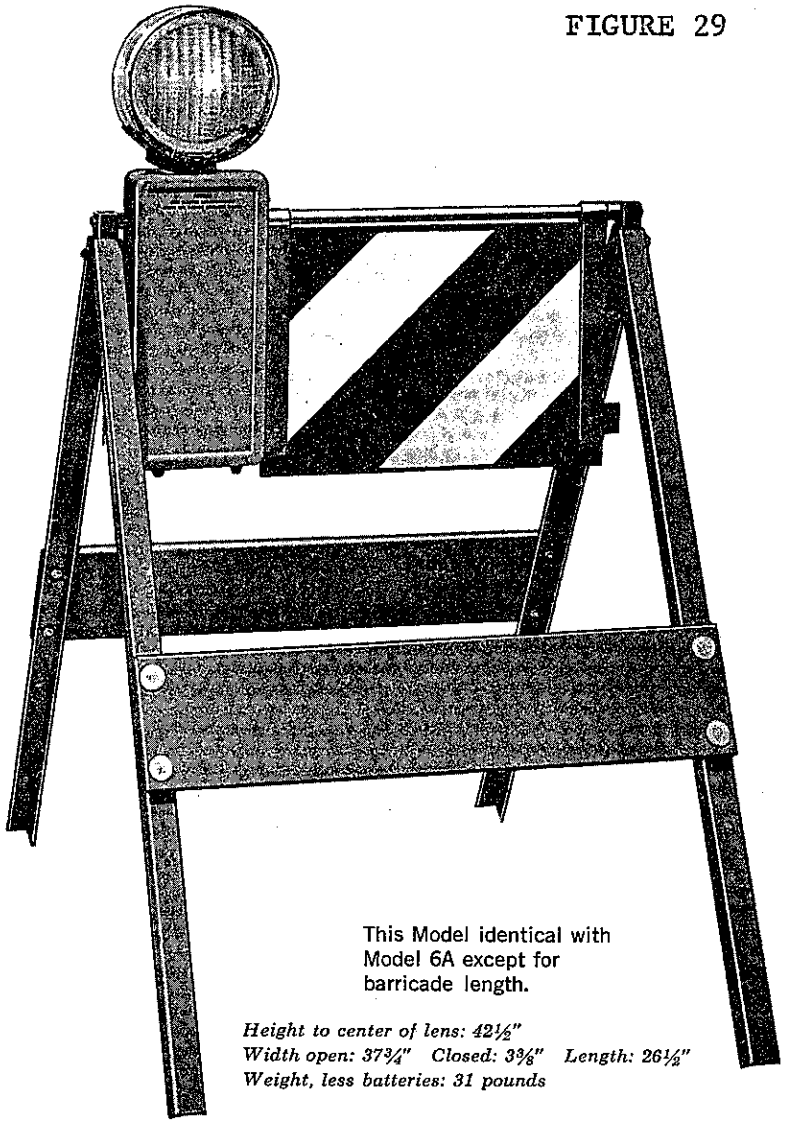
FIGURE 29



This Model identical with Model 6A except for barricade length.

Height to center of lens: 42½"
Width open: 37¾" Closed: 3⅜" Length: 26½"
Weight, less batteries: 31 pounds

NORTHERN SIGNAL COMPANY

FLASHER SPECIFICATIONS

(Excerpt from Sales Catalog)

Model No. 5A

(25% duty cycle — solar switch)

Model No. 5B

(10% duty cycle — no solar switch)

Spherical reflector available for this flasher head. Converts flasher to a "one way" light and increases candle power about 30%.

TECHNICAL SPECIFICATIONS:

Models 6A and 5A

For Technical Specifications of Models 6B and 5B see Page 6.

1. Voltage: 6.
2. Lamp: #1850. Life: more than 1500 flashing hours.
3. Flash duration: not less than 220 milliseconds. Duty cycle — nominal 25%.
4. Flash rate: 75 plus or minus 4 flashes/minute.
5. Operating system: transistor/oscillator warranted to operate from −20°F to +140°F without significant change in flash rate or duration.
6. Beam candle power: 34 using amber lens. Red lenses available; reduce illumination about 25% (see Page 19).
7. Candle power ±5° off beam: 28 — horizontal and vertical (see Page 19).
8. Diameter of lens: 7". Border: reflective. Composition: Butyrate.
9. Optical: the lens has a convex, articulated surface and an annular fresnel configuration in its concave surface. The lens produces a horizontal, rectangular pattern which conforms to specifications issued by various highway commissions.
10. Battery capacity: up to 4 lantern type 6-volt batteries. Plug and socket connection (see Page 14).
11. Battery life; using 4 batteries, continuous flashing at about 70°F to an end voltage of 4.0 volts: in excess of 60 days. (At 4.0 volts 75% of battery capacity has been expended.) Solar switch automatic cut-off approximately doubles battery life, 120 days.
12. Lamp may be changed from inside cabinet at same time batteries are changed. Lens need not be removed (see Page 15).
13. Color: Cabinet — traffic yellow, baked over prime coat.
    Barricade — traffic yellow legs and leg spacer boards.
    Swinging panel — black with white 4 inch stripes. Yellow stripes available.
    Steel fittings — cadmium plated.
14. Net weight, less batteries: Model 6A, 6B, 33 pounds; Model 5A, 5B, 31 pounds.
15. Special wrenches for tamper-resistant fasteners: Cabinet and lens head — #50. Barricade swing rod wrench — #75.

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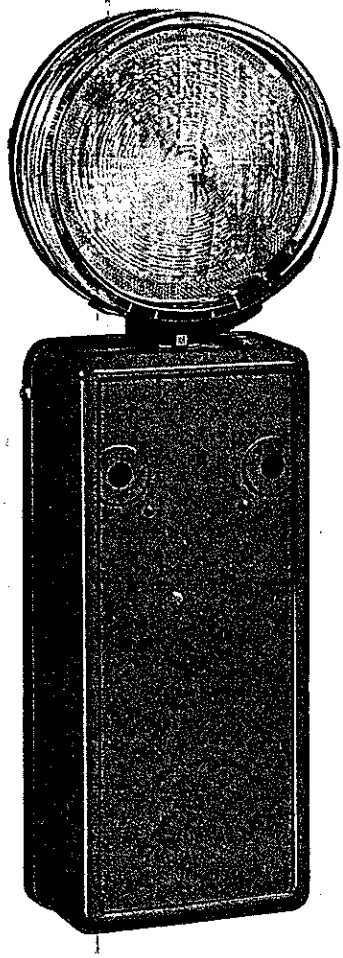
FIGURE 30

NORTHERN SIGNAL COMPANY

HEADER SPECIFICATIONS

(Excerpt from Sales Catalog)



Model No. 4H (Header Light) with reflector

Model No. 4R (Header Light) 2 directional

"BOLT-ON" type HEADER LIGHT

Solar Switch Controlled

GENERAL INFORMATION

Prepared with two mounting holes for bolting to signs, highway barricades, vehicles, farm equipment, permanent school signs — wherever extra warning impact is needed. The cabinet is die formed of 14 gauge steel. Both cover and back of cabinet are debossed for added strength. The lens head consists of a tough, weather-resistant clear plastic which has withstood years of field use and has earned the distinction of being the most durable of all flasher heads (see Page 15). Orange colored plastic is available for additional daylight visibility. The head swivels through 90° or can be locked in one position. The flasher is equipped with external battery test terminals and a "push" switch — on/off.

TECHNICAL SPECIFICATIONS:

Models 4H, 4R

1. Voltage: 12.
2. Lamp: #957. Life: more than 1500 flashing hours.
3. Flash duration: not less than 150 milliseconds. Duty cycle — nominal 15%.
4. Flash rate: 60 plus or minus 4 flashes/minute.
5. Operating system: transistor/oscillator warranted to operate from −20°F to +140°F without significant change in flash rate or duration.
6. Beam candle power, amber lens: exceeds 300. Reflector increases candle power about 25% (400 c.p.) (see Page 19).
7. Candle power ±5° off beam: exceeds 250. Reflector increases candle power about 25% (300 c.p.) (see Page 19).
8. Diameter of lens: 7". Border: reflective. Composition: Butyrate.
9. Optical: the lens has a convex, articulated surface and an annular fresnel configuration in its concave surface. The lens produces a horizontal, rectangular pattern which conforms to specifications issued by various highway commissions.
10. Battery capacity: up to 4 lantern type 6-volt batteries. Plug and socket connection (see Page 14).
11. Battery life: using 4 batteries, continuous flashing at about 70°F to an end voltage of 8.0 volts: in excess of 5 days. (At 8.0 volts 75% of battery capacity has been expended.) Solar switch automatic cut-off approximately doubles battery life, 10 days.
12. Lamp may be changed from inside cabinet at same time batteries are changed. Lens need not be removed (see Page 15).
13. Color: traffic yellow, baked over prime coat.
14. Net weight, less batteries: 9 pounds.
15. Special wrenches for tamper-resistant fasteners: Cabinet and head ring — #50.

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Flex-Lite

Etzon Division, Dymo Industries, Inc.

Box 1030, Berkeley 1, California

For the price of the components of the system, see Figure 31.

The Flex-Lite illumination system consists of a series of "nondeteriorating fluorescent glass capsules excited by high frequency and encased in a flexible, weather-proof vinyl tube". This type of device would be good for portal delineation such as false work at bridges. It would also be of value as a continuous delineator supported at required intervals along the edge of the traveled way. The capsules appear to be of sufficient brightness and are available in various colors.

The generator required for these lines is capable of illuminating 265 feet and costs $254. Although the lamp spacing in the line is offered in one, two, three, four, and seven lamps per foot, only the unit with seven per foot was observed. Because of the relatively low intensity of the lamps, it appears that the seven lamp per foot line would the most desirable choice. This line can be purchased in lengths of up to 138 feet, with a cost of $552 for the 138 foot section. With one 28-foot cable extension, which costs $14.50, the total cost of a 138 foot delineator would be $820.50, or approximately $6.00 per foot. The guarantees on this system vary from six months on the generator tubes to five years for the fluorescent lamp capsules, thus indicating a minimum of material maintenance costs.

This lighting system appears to be very useful for portal delineation, edge delineation, and channelization at the entrance to a construction zone and/or at a narrow portion of the traveled way within the construction zone. However, the power requirement and the high initial cost impose a severe limitation on its general use.

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FIGURE 31

ETZON FLEX-LITE

INDIVIDUAL EQUIPMENT PRICE LIST

LUMINOUS LINES

Regular Line—Clear vinyl tubing with white, pink, blue and green colored lamps or combinations.

Di-Color Line—Red, green and amber colored vinyl tubing with colored lamps.

	Lengths, Feet	Regular Line	Di-Color Line
#14 1 lamp per foot	26½	$ 50.00	$ 53.00
	55	100.00	106.00
	79½	150.00	159.00
	106	200.00	212.00
	130½	250.00	265.00
	159	300.00	318.00
	212	400.00	424.00
	265	500.00	530.00
#24 2 lamps per foot	26	$ 58.00	$ 61.00
	52	116.00	122.00
	78	174.00	183.00
	104	232.00	244.00
	130	290.00	305.00
	156	348.00	366.00
	208	464.00	488.00
	260	580.00	610.00
#34 3 lamps per foot	25½	$ 66.00	$ 69.00
	51	132.00	138.00
	76½	198.00	207.00
	102	264.00	276.00
	127½	330.00	345.00
	153	396.00	414.00
	204	528.00	552.00
#44 4 lamps per foot	25	$ 74.00	$ 77.00
	50	148.00	154.00
	75	222.00	231.00
	100	296.00	308.00
	125	370.00	385.00
	150	444.00	462.00
	200	592.00	616.00
#74 7 lamps per foot	23	$ 92.00	$ 95.00
	46	184.00	190.00
	69	276.00	285.00
	92	368.00	380.00
	115	460.00	475.00
	138	552.00	570.00

GENERATORS

#104 for line lengths to 265 feet	$254.00

CABLE

28 foot lengths (for extensions up to 196 feet, in multiples of 28 feet)	14.50

FLASHER

M-50 (electronic)	50.00

NOTE:

To compute the cost of the complete FLEX-LITE system, select the length of Luminous Line and lamp spacing wanted and add the price to that of the generator, which will be the cost of a complete system. Accessories, such as Extensions and the Flasher, are priced separately and added to the total.

All prices are F.O.B. the ETZON plant, Berkeley, California and subject to change without notice.

DYMO

ETZON DIVISION of

DYMO INDUSTRIES, INC., BOX 1030 BERKELEY 1, CALIFORNIA • PHONE 654-7272 AREA CODE 415 • CABLE: DYMO

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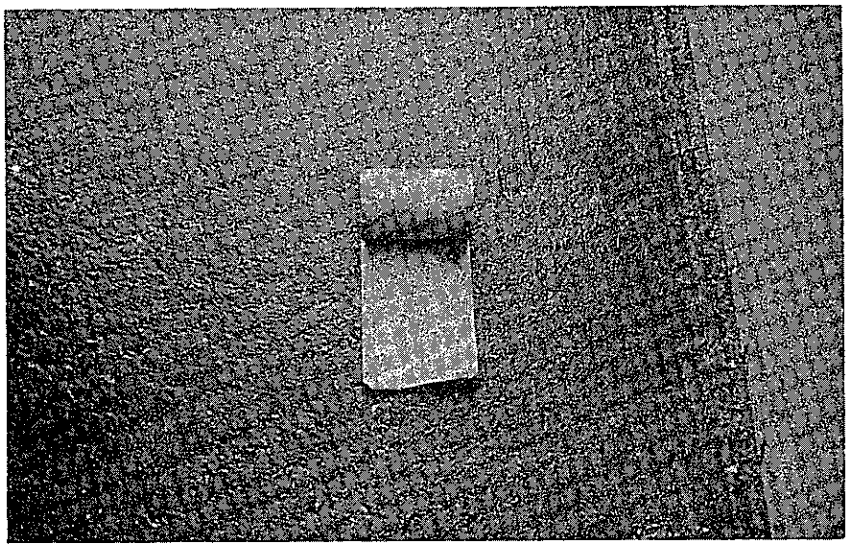
FIGURE 32



BUTYL #7500 ADHESIVE

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E. Miscellaneous Devices

Intercoastal Butyl #7500 Adhesive

The Flasher Company

6329 Elvas Ave, Sacramento, Calif.

(See Figure 32)

This semi-permanent pressure sensitive adhesive tape costs $18.66 for a 4" wide 50' long roll. This butyl adhesive has been successfully used to attach pavement markers to both asphalt and portland cement concrete for periods of up to six months and should be considered for placement of pavement markers on semi-permanent detours. However, this adhesive tape does not develop its bonding strength when installed over dirt or moisture on the pavement surface. Therefore, it is important that the roadway be thoroughly cleaned and dry before placement is attempted.

The use of a good rubber cement primer should improve adhesion, particularly in humid weather. The 50' roll will provide enough adhesive for 120 - 130 pavement markers, thus costing approximately $0.15 per marker.

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Collapsible Sign Standard

Merit Award Board Suggestion No. 38739

(See Figure 33)

The cost of this collapsible sign standard would be approximately $7.00 for materials and $3.00 for labor when fabricated in quantity.

This standard was developed to replace the presently used "Christmas tree" (see Figure 34) and ground mounted sign standards with a device that is easy to transport, set up, maintain, and is adaptable to all terrains. The major objections to the current "Christmas tree" are its bulk and rigidity. Almost total destruction can occur with only casual vehicular impact. An objection to the use of a standard ground-mounted sign installation is its lack of portability. The collapsible sign standard should be an improvement over both these methods as it is collapsible for ease of transportation, can be positioned easily by one man, and should be able to withstand moderate vehicular impacts without total destruction. The "break away" feature should also minimize vehicular damage. As with the "Christmas tree" standard, this collapsible standard will require additional ballast to resist overturning movements in some locations. All the steel hardware should be galvanized. Some of these devices have been constructed for use in southern California and reports indicate that they have provided satisfactory service.

The ease of transportation and handling and the increased stability provided by this collapsible sign standard are a definite improvement over the "Christmas tree" base and ground mounted sign post for locations in which frequent movement of construction signs is required.

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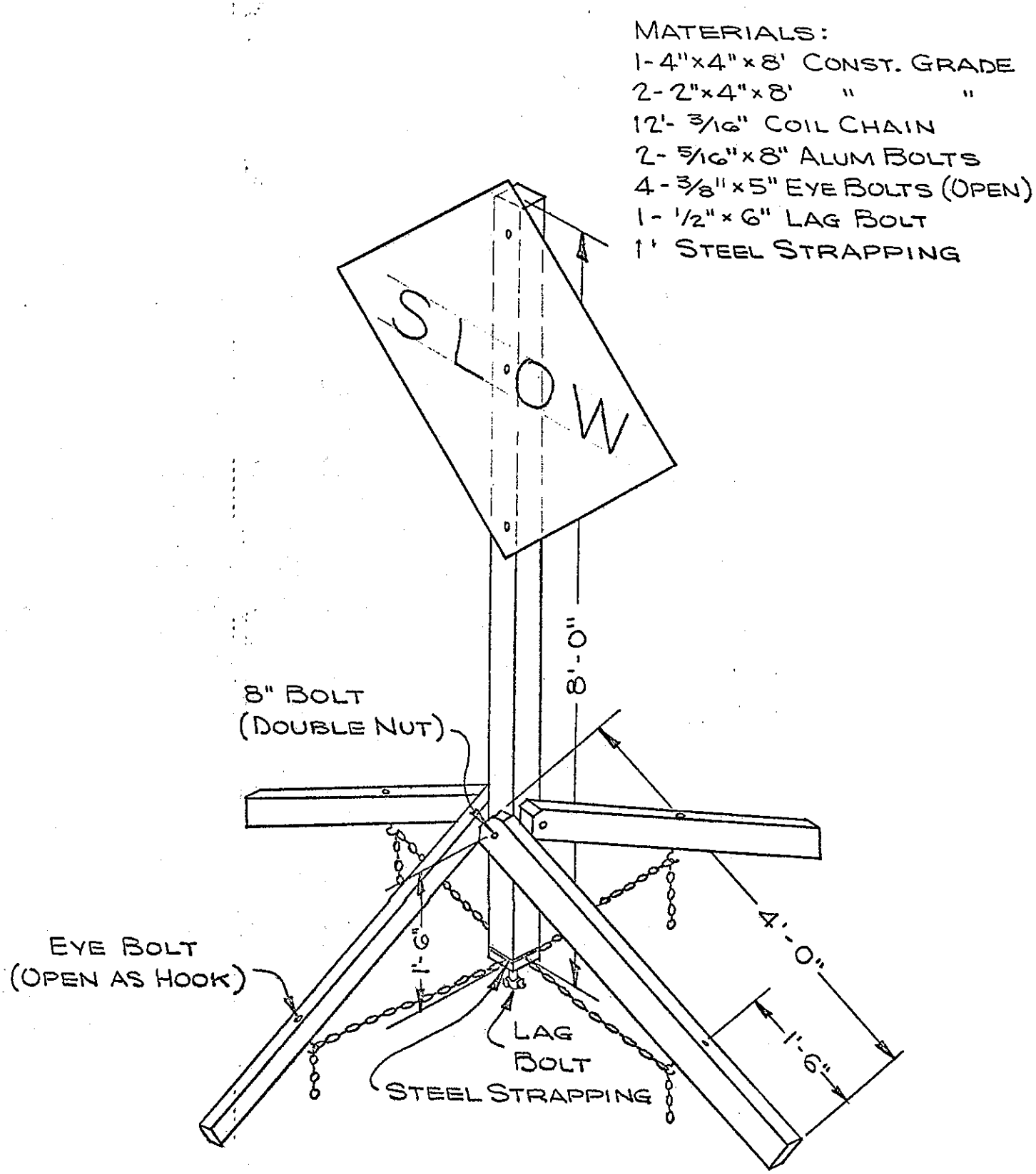
FIGURE 33



COLLAPSIBLE SIGN STANDARD

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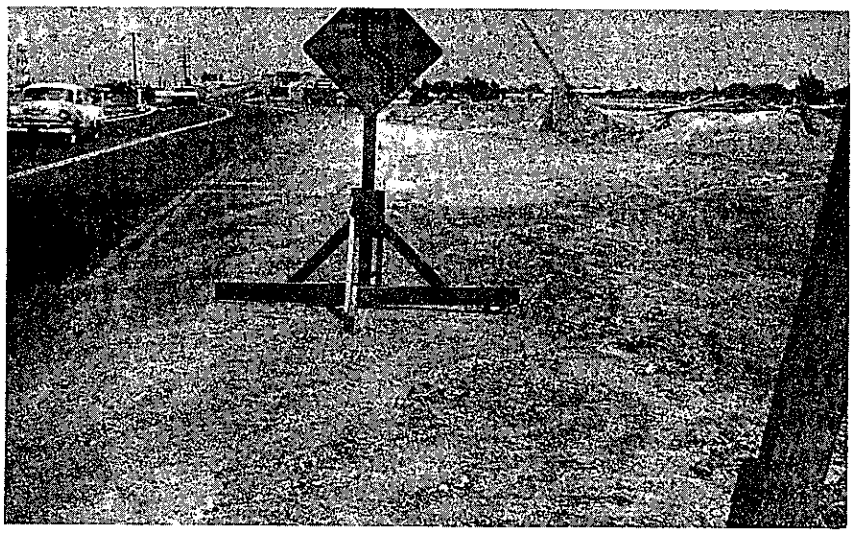
FIGURE 34



CHRISTMAS TREE BASE

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Traffic Counter Hose

The cost of the 9/16" diameter traffic counter hose is approximately $0.07 per lineal foot. This hose is also available in semi-circular cross section with a ½" radius for $0.15 per lineal foot. The cost of clamps and spikes is approximately $0.40 per section of hose.

This type of device has been suggested for use as a rumble strip located near the entrance of a construction zone and/or at changes in alignment. However, the 9/16" hose may not be of sufficient diameter to produce a rumble. As little practical operating experience has been obtained on this suggested method of warning, the diameter of the hose, the spacing between hoses, and the location of the rumble strip with relation to the situation requiring its use would all have to be established. The total material cost for a set of six 9/16" diameter hoses across a 36-foot roadway would be approximately $22.50. Larger diameter hose would be more expensive. The maintenance requirements would be dependent on the ADT at the construction location. With heavy traffic, the hose may not last more than three or four weeks. Also, maintaining the hose tension would require regular attention.

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