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

A PROGRESS REPORT ON A SURVEY AND EVALUATION OF DEVICES FOR HANDLING TRAFFIC THROUGH CONSTRUCTION

A STUDY MADE BY THE
CALIFORNIA DIVISION OF HIGHWAYS
IN COOPERATION WITH THE
U.S. DEPT. OF COMMERCE
BUREAU OF PUBLIC ROADS

September 1965

65-20

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State of California
Highway Transportation Agency
Department of Public Works
Division of Highways
Materials and Research Department

September 1965

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HPR 1(1) Part 1-IV-18
Expenditure Auth. 951105

Mr. J. F. Jorgensen
Construction Engineer
Construction Department
Sacramento, California

Dear Sir:

Submitted for your consideration is:

A PROGRESS REPORT

ON

A SURVEY AND EVALUATION OF DEVICES FOR

HANDLING TRAFFIC THROUGH CONSTRUCTION

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

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

RNF/RD:mw
cc: LRGillis
JEWilson
ELTinney
JEMcMahon
JCObermuller
TTamburri

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I. INTRODUCTION

With the tremendous increase in traffic volume on California's freeways during recent years, the problem of controlling and routing traffic through construction zones has become acute. With this increased volume there has developed the requirement of increased permissible speed through these construction zones in an attempt to alleviate congestion and minimize the delay to the motorist. In an effort to improve the safety of the motoring public while progressing through construction zones, the Construction Department requested by letter dated October 15, 1962, Jorgensen to Hveem, that the Materials and Research Department compile a comprehensive listing of the devices being developed by industry for use as safety devices in construction zones that are available to the contractor and the engineer. With this catalog of available products, it was felt that improvement could be made in the uniformity and effectiveness of current methods and devices for controlling traffic through construction zones.

A request for funds from the Bureau of Public Roads was submitted in February 1964. In March 1964 approval for a Special Study entitled "Evaluation of Devices for Handling Traffic Through Construction" was received and Project Work Order R-64336 was assigned by the Materials and Research Department.

This study has been made in cooperation with the U. S. Bureau of Public Roads.

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II. SCOPE OF THE PROJECT

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

1. In-service tests performed in actual construction zones.

2. Use of any routine commodities tests that are applicable.

3. Special tests when required.

As this project progressed, it became increasingly evident that to prepare an accurate evaluation of traffic handling devices for construction zones, heavy emphasis must be placed on continuous observation of these devices in service in construction zones during actual construction.

It was felt, however, that some of the items listed herein did not require this extensive and lengthy observation because in preliminary review their usefulness appeared to be very limited.

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III. RECOMMENDATIONS

Because of the value we found to be gained by in-service testing in the preparation of evaluations on construction zone traffic handling devices, it is felt that a more effective over-all evaluation of these devices could be obtained using construction personnel. Continuous observation in a construction area is the only valid method of accurately evaluating the effectiveness of the majority of these devices. Construction personnel would be much more qualified to decide whether a device warrants extensive testing or has no usefulness for construction zone traffic control. The Materials and Research Department could then assist in performing any specific tests required to determine the physical properties of the devices being evaluated.

At present, the construction zone at the Madison Avenue Overcrossing on Highway 40 north of Sacramento is being used for in-service studies. The Resident Engineer and his staff on this construction contract have been very cooperative and have indicated a great deal of interest in the problem of safe conveyance of traffic through construction areas. Construction personnel are well qualified and in the best position to observe and prepare evaluations of devices for traffic control in construction zones.

This report includes and completes the initial survey of available devices and our evaluations of them. We propose that for the remainder of this program the Materials and Research Department act as a test laboratory, performing any physical tests deemed necessary by the Construction Department, and that the Construction Department prepare the final evaluations of these products. Any further devices that come to the attention of the Materials and Research Department will be forwarded to the Construction Department for their recommendation for further action.

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IV. EVALUATIONS

This interim report is intended to provide all interested parties with a listing of all the products considered in this study for use as construction zone traffic control devices. The devices are arranged alphabetically by trade name. The approximate price of each device is noted where available and its applicability to certain phases of construction zone traffic control discussed. Any tests performed by the laboratory and respective results are included, as are copies of the sales brochures.

Section I contains evaluations of those devices for which in-service testing was not considered warranted under this study at this time. Section II contains evaluations of those devices for which in-service observations have been utilized. Many of these devices are still being observed.

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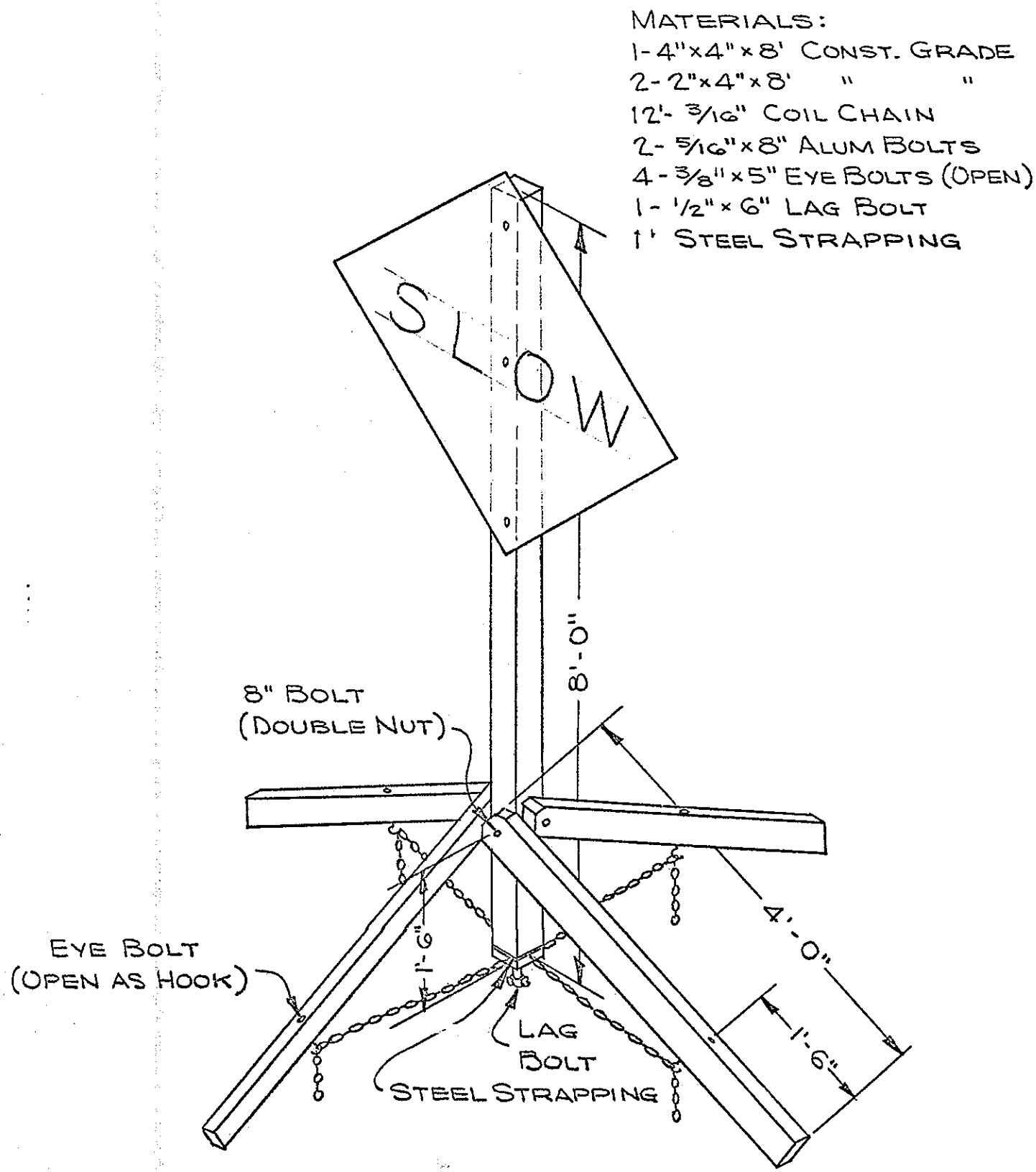
FIGURE 1



COLLAPSIBLE SIGN STANDARD

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A. SECTION I - NO IN-SERVICE EVALUATION

Collapsible Sign Standard

Merit Award Board Suggestion No. 38739
Eugene Calman, Senior Highway Engr., Dist. 11

(See Figure 1 opposite)

The cost of this collapsible sign standard has been estimated by Mr. Calman to be approximately $7.00 for materials and $3.00 for labor when these standards are fabricated in quantity.

This standard was developed to replace the presently used "Christmas tree" and ground mounted sign standards with a device that is easily transported, set up, maintained, and readily adaptable to all terrains. The major objections to the current "Christmas tree" (see Exhibit A) are its bulk and its rigidity. Almost total destruction can occur with only slight vehicular impact. The ground mounted sign post installation (see Exhibit A) is objectionable because of its lack of portability. The collapsible sign standard should be an improvement 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. Mr. Calman's "break away" design should also minimize vehicular damage.

This collapsible standard will require additional ballast to resist overturning movements when placed in locations in which ballast is required for the "Christmas tree" standard. All the steel materials should be galvanized. Although no attempt was made to verify the material list attached to Figure 1 for accuracy and completeness, some of these devices have been constructed and are in use in the southern California area.

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 requiring frequent movement of construction signs.

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FIGURE 2

D-VID-A-WAY

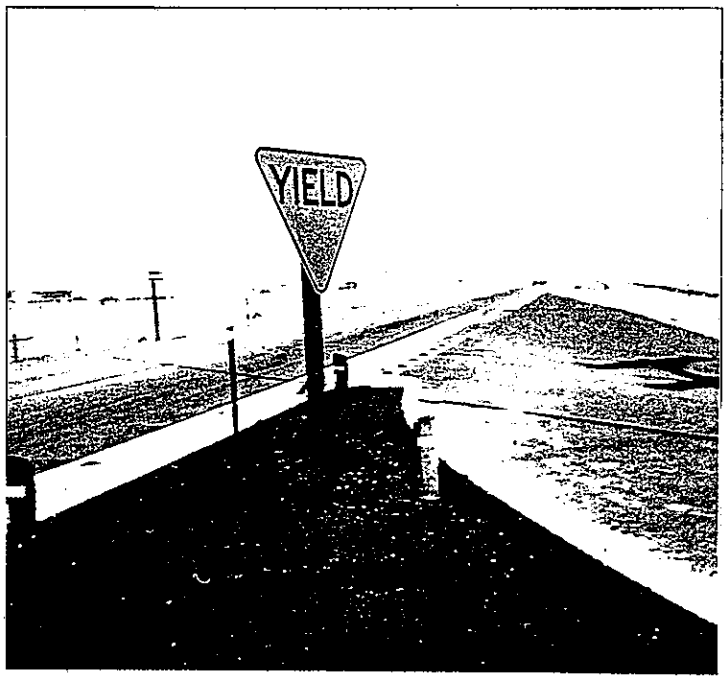
Highway Industry's Newest and Safest Way of Controlling and Separating Traffic

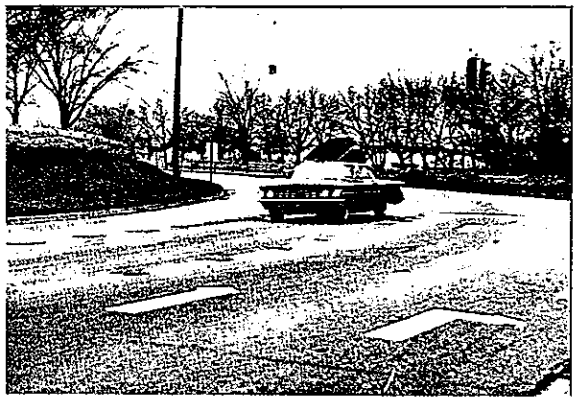
Unique D-VID-A-WAY design controls traffic—yet, vehicles will not swerve, deflect, or tip if they hit the divider. Its stamped, rugged, all-steel construction makes long-life and maintenance-free service a reality. And—it is easily installed.

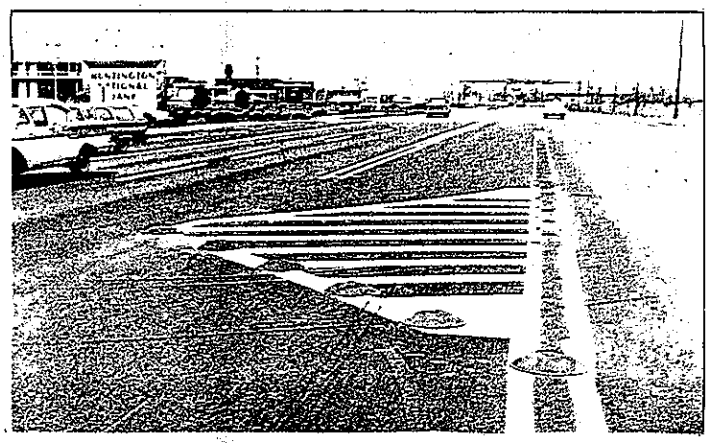
When you need visible, imposing-looking traffic separators —but cannot tolerate the traffic hazards created by more abrupt and massive barriers — D-VID-A-WAY is your answer.

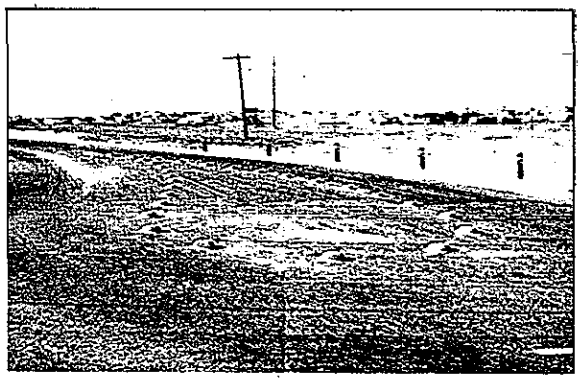
An Effective and Economical Method to:

- Divide traffic lanes.
- Channel traffic flow on access and turnoff ramps.
- Warn motorists of approaching intersections.
- Prevent passing at dangerous locations.
- Create left turn, acceleration, and deceleration lanes.
- Discourage traffic through median-strip openings.
- Establish rotary intersections and traffic-separation islands.
- Extend access islands.









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D-Vid-A-Way Steel Traffic Dividers or Markers

Commercial Shearing and Stamping Company
1775 Logan Avenue, Youngstown, Ohio 44501
West Coast Plant located in Salt Lake City, Utah

(See Figure 2 opposite)

Although this pavement divider or marker is intended for permanent installation, the spike method of attachment to the roadway surface for which it is designed could allow a semi-permanent type of installation, as suggested in the manufacturer's brochure. These devices are large, having diameters of 12, 14, and 16 inches (see Exhibit B). Often there is a surface width restriction in construction zones that would not allow the use of a "button" of this size.

A delineation device similar to this steel divider has been tested by this department and was found unacceptable due to the inability of its painted surface to resist the abrasive action of vehicular tires. The standard finish on the D-Vid-A-Way consists of one coat of "highway yellow" enamel on the outside of the divider. Any finish that will meet customer specifications will be applied, however. On a smooth exposed surface such as on this device, a paint that would provide sustained reflectivity under the constant abrasion of the vehicular tires without the requirement of almost continuous maintenance has not come to the attention of this department. 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 and the coating of little value due to the rapid accumulation of dirt on the irregular surface that is created.

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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Flex-Lite

Etzon Division, Dymo Industries, Inc.
Box 1030, Berkeley 1, California

For the price of the components of this system, please see Exhibit C.

The Flex-lite illumination system consists of "non-deteriorating fluorescent glass capsules excited by high frequency and encased in a flexible, weather-proof vinyl tube". This type of device would be ideal for portal delineation. It would also be of value as a continuous delineator supported at required intervals with portable delineators along the edge of the traveled way. They appear to be sufficiently bright, and are available in various colors both in the capsules and in the vinyl tube.

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 seven per foot was observed. Because of the size of the lamps, it appears as though this seven lamp per foot line would be 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 material vary from six months on the generator tubes to five years for the fluorescent lamp capsules, thus indicating a minimum of maintenance costs. The cable probably would not be repairable if involved in a collision.

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 but the power requirement and the high initial cost impose a severe limitation on its general use.

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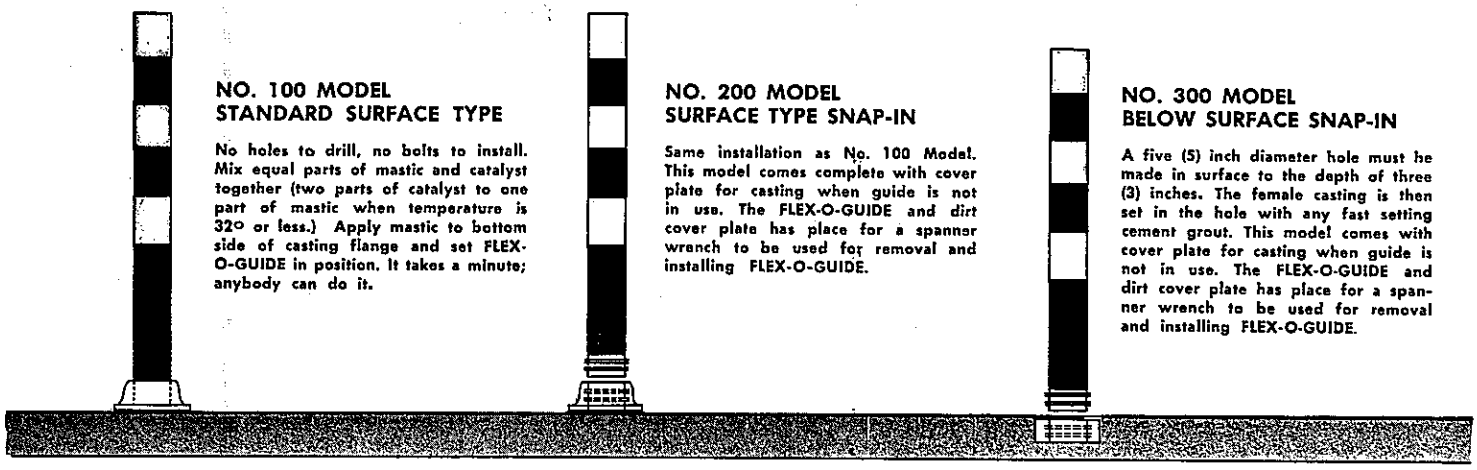
FIGURE 3

3 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.

Features:

FLEX-O-GUIDES are designed for the purpose of a safer and more practical method of channeling and guiding. These upright flexible posts of rugged construction are engineered and designed to withstand weather elements and severe contact abuse.

FLEX-O-GUIDES amazing cold mastic really holds! No costly installation charges to pay. Merely apply a thin coat of mastic and set in place.

FLEX-O-GUIDES provide a proven flexible safety marker for safer and more practical methods of channeling and guiding.

FLEX-O-GUIDES are engineered for safety with the ever increasing flow of traffic on our crowded streets and highways where control is necessary for the purpose of safety and guidance.

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 PSL — in all models.
CASTINGS:	Grey iron casting coated with yellow, rust retardant paint.

1959 MAY 1 AM 11 02
RECEIVED SACRAMENTO
DIVISION OF HIGHWAYS
MAT. & RESEARCH DEPT

Material and workmanship guaranteed — Packaged 6 per carton — Sufficient adhesive furnished.

BELL and GUSTUS, INC.
4328 Elston Avenue — Chicago 41, Illinois — IRving 8-9353

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Flex-O-Guide

Bell & Gustus, Inc.
4328 Elston Avenue, Chicago 41, Illinois

(See Figure 3 opposite)

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 this 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. It was proposed at the time of that investigation that these markers be used as temporary construction zone devices due to the fact that the epon base mastic used to attach the base to the roadway surface could be softened with a welder's torch, thus facilitating its removal and reinstallation 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. Although these devices are available in heights of 14, 20, and 26 inches, the only height worthy of consideration is 26 inches, and even this height would be marginal for an edge delineator.

The recommendations of this department from 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 limit its usefulness.

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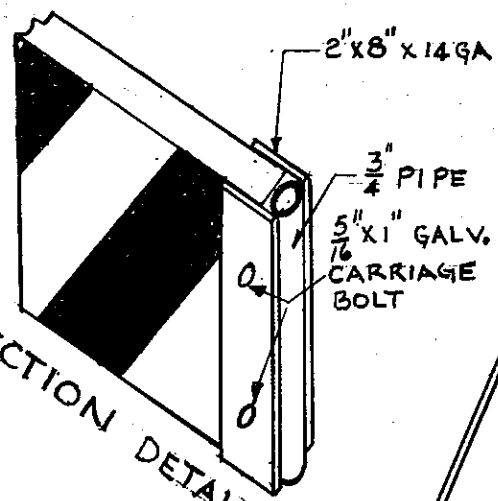
M P BARRICADE

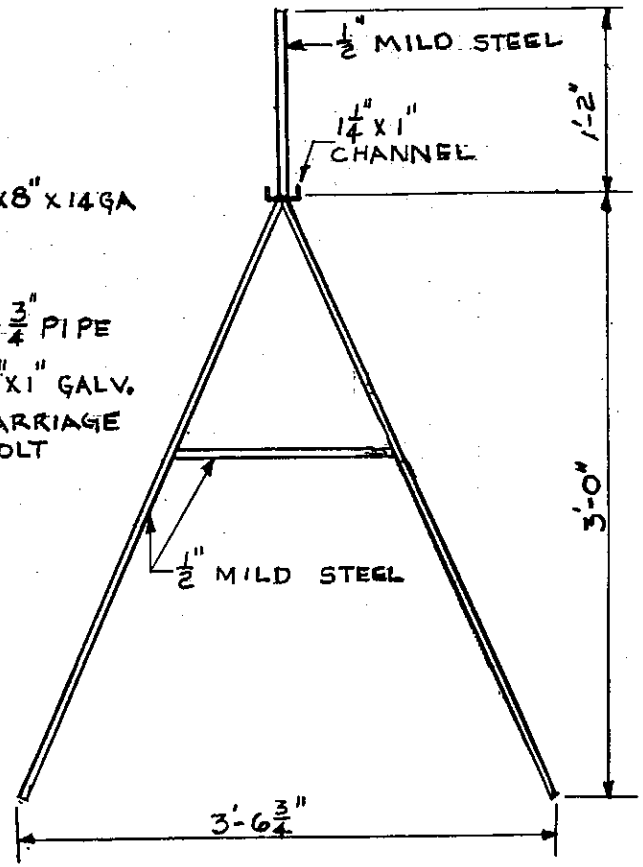
10 FT BARRICADE

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 4

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M. P. Barricade

Multi-Plastics, Inc.
2148 South Hoover, Wichita 9, Kansas

(See Figure 4 opposite)

The price of one ten foot barricade is $26.95.

This device does not appear to be particularly useful for construction zone traffic handling with the exception of those locations in which Class II barricades can be used, such as in metropolitan areas or for maintenance. The unit would be easy to handle, weighing only 33½ lbs. for a 10 foot barricade, and its 36" height to the bottom of the crossboard is adequate for minor construction. However, its stability in winds above 30 mph probably would be poor. The flexibility that allows the crossboard to bend offers little resistance to complete destruction by an impacting vehicle. This barricade might not shatter as the wooden Class II barricade does, but the crossboard would be destroyed.

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

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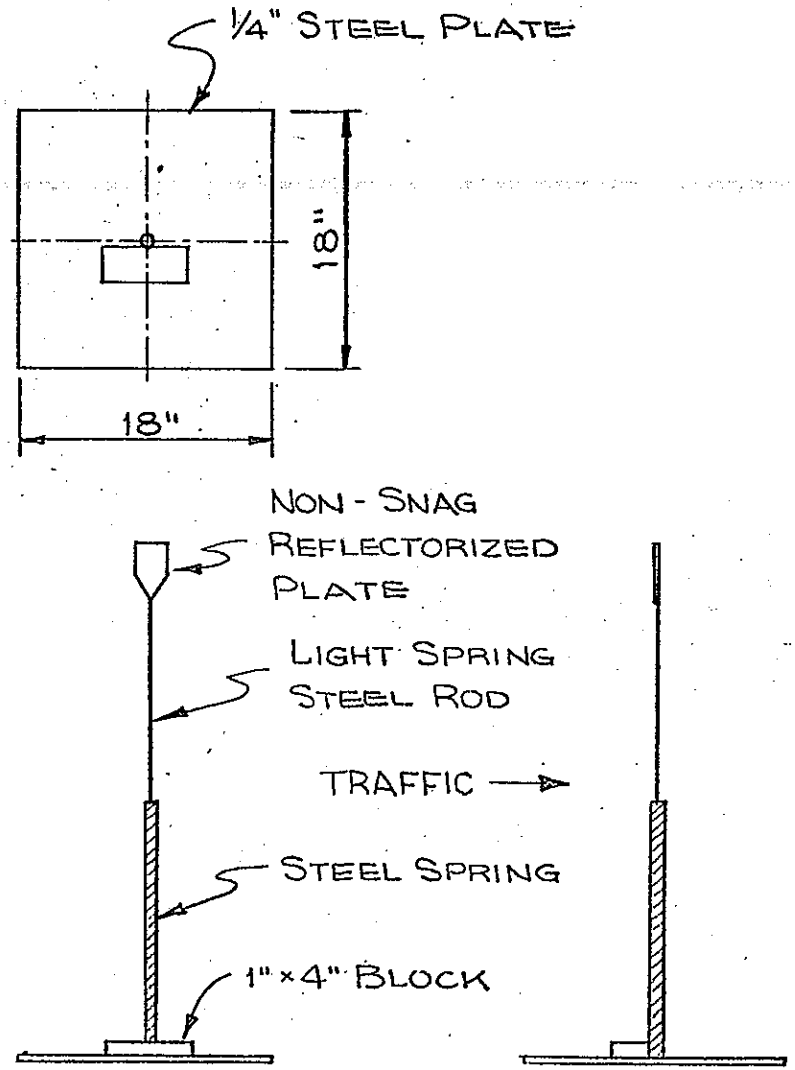
FIGURE 5



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.

TRAFFIC WARNING ASSEMBLY

FOR USE ON VEHICLE CARRYING LANES

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Traffic Warning Assembly for Use on Vehicle Carrying Lanes

Merit Award Board Suggestion No. 38824
Gerald Feenstra, Associate Highway Engineer, Dist. 08

(See Figure 5 opposite)

In an attempt to eliminate the currently used hazardous delineators consisting of 1" x 4" planks embedded in five gallon paint cans filled with concrete, Mr. Feenstra has devised this spring mounted flexible delineator. No price is available for this device.

This department has conducted tests on devices similar to this in an attempt to develop a flexible support system for guide plates. Devices consisting of rubber posts to which the guide plate was attached and spring mounted steel shafts with guide plates attached have been tested but no adequate flexible design has been found.

To withstand the high impact loading and high axial forces applied to a flexible device struck by a high speed vehicle, a moderately rigid post is required. This eliminates a spring type post connection or post. Although this type of device would be desirable, the availability of a sufficiently rigid but flexible spring, the development of a "non-snag reflectorized plate", and the design of an adequate base connection would be required before this device could be utilized for construction zone delineation or warning.

Rebounding supports have not been sufficiently developed as yet to provide a nondestructive impact without a loss of the post rigidity required for effective delineation.

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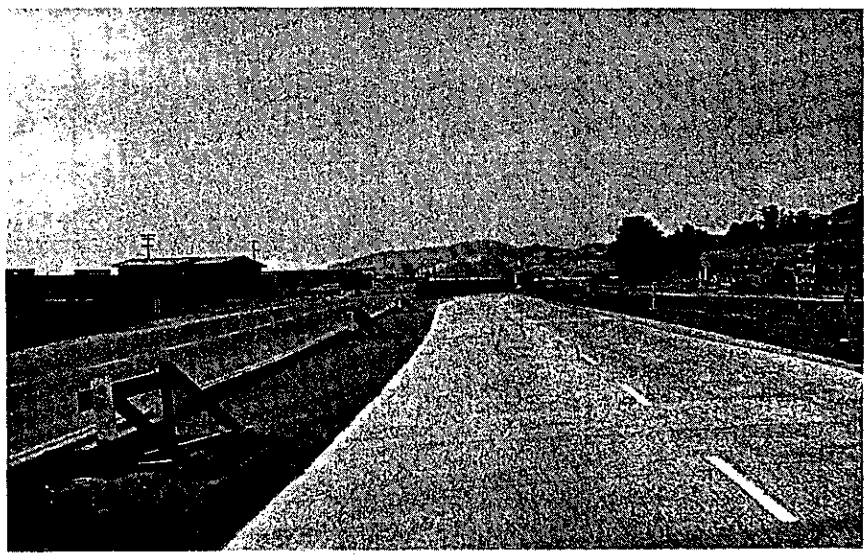
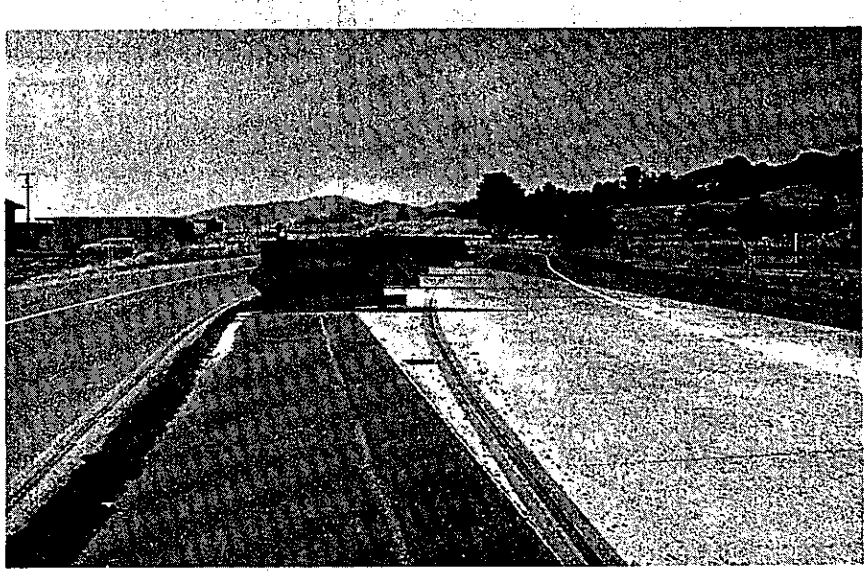
FIGURE 6





LITE SHIELD TEMPORARY TRAFFIC BARRIER

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B. SECTION II - INCLUDES IN-SERVICE EVALUATION

Lite Shield Temporary Traffic Barrier

Merit Award Board Suggestion No. 40089
Charles L. Bonar, Assistant Highway Engineer, Dist. 04

(See Figure 6 opposite)

The cost of modifying the standard Class I barricade as suggested by Mr. Bonar would be approximately $5.00.

This modification of a Class I barricade greatly improves the effectiveness of the barricade. The modification is simple and cheap (see Exhibit E) and greatly increases both the day and night visibility of the W57R arrow. The black background provides an excellent contrast with the yellow and black arrow during daylight hours and the plywood panel completely eliminates the dangerous and confusing glare situation that is presented to the driver at night as he approaches a change in alignment in the construction zone and is forced to look directly into the headlights of the opposing traffic. This addition in no way restricts the use of the barricade.

Because of the large surface area of the plywood panel, additional ballast to resist the increased wind loading would be required. Serious consideration should be given to modifying all Class I barricades with this "Lite Shield". It is a significant improvement over the current standard Class I barricade.

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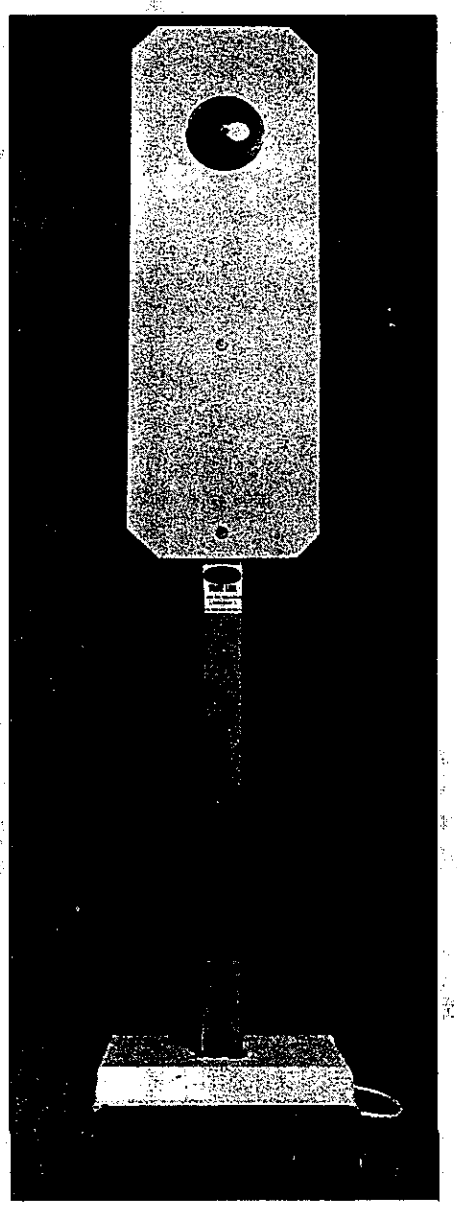
FIGURE 7

PORTA BASE Portable Traffic Delineator



STANDARD MODEL*

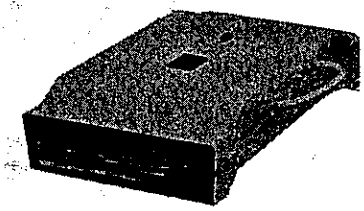
8" x 24" Guide Plate

Effective for handling traffic flow up to 50 m.p.h.

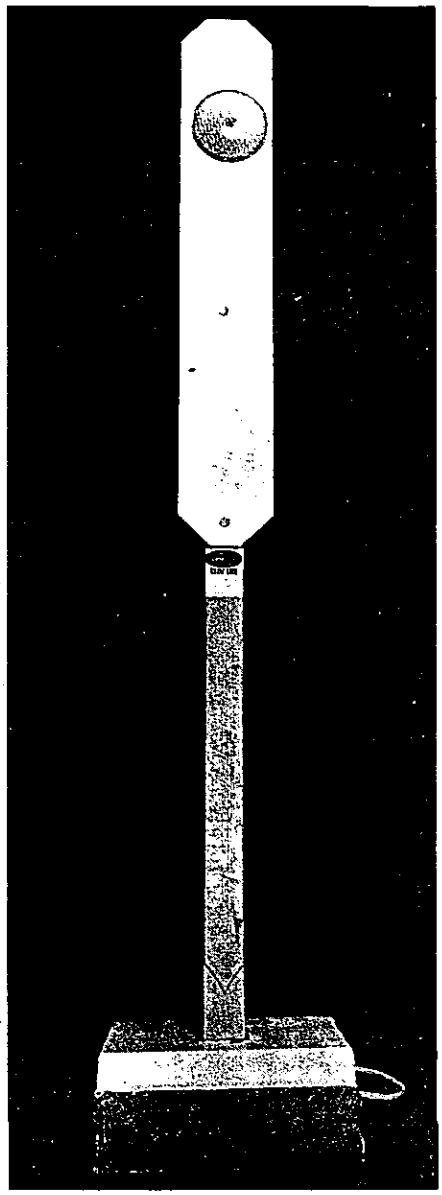
RANGER MODEL*

4" x 24" Guide Plate

For high speed traffic



35 LB. PORTA BASE



PRICE LIST

Standard and Ranger Porta Base Delineator Complete	$ 4.95
Guide Plate, 4' post and reflector	2.75
35 lb. Porta Base only, painted white and reflectorized	2.45
35 lb. Porta Base only, not painted or reflectorized	1.75
Standard or Ranger Porta Base Delineator and Mark VII Tranz Lite	17.40

*1 Reflector included with each model. Additional reflectors 55c each. Available in clear or amber color.

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Porta Base

Casell Company
Napa, California

(See Figure 7 opposite)

The price of this guide marker unit applicable to high speed construction zones (Ranger Model) is listed as $4.95 with a discount available when purchased in quantity. This cost includes the painted base, guide plate, painted four foot high post, and reflector.

This device includes the standard plastic guide plate and center mount reflector with the eight inch standard paddle width decreased to four inches. The reflector provides adequate delineation at night, but daytime delineation is very poor because of the poor target area provided by the four inch white paddle. Although this model is adequately resistant to overturning, it does not have an adequate resistance to sliding and skewing. This has required the use of additional ballast on the base (see **Exhibit F**). It has been suggested that rubber feet attached to the bottom of the base may eliminate this movement. Also, a hole in the base is provided through which a large spike could be inserted to eliminate "walking" of the base and probably much of the skewing. This would, however, require more time and effort for installing the devices and would leave a hole in the pavement surface where the spike was inserted.

Two full scale impact tests were conducted on this unit. 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 at the point of impact between the post and the bumper, and a crack developed across the base at the back of the post hole (see **Exhibit G**). The post was destroyed but the base was reusable. The cost of replacing the post and guide plate would be approximately $2.75. Test 2 was conducted with the vehicle wheels on the left side crossing over the base. This was to determine whether loss of control of the vehicle might result and also to determine the extent of the damage to the base and the degree to which the damaged base would constitute a hazard to subsequent traffic. The post again failed at the top of the base (see **Exhibit H**) and at the point of impact with the bumper. The base was broken into three sections, one of which broke apart from the base even though there was wire reinforcing in the base. No vehicular control problems

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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 the car.

These units are a big improvement over a paint can filled with concrete. Their efficiency can be greatly increased, however, by eliminating the tendency of the base to creep and by changing the color of the 4" wide paddle to increase the daytime target value.

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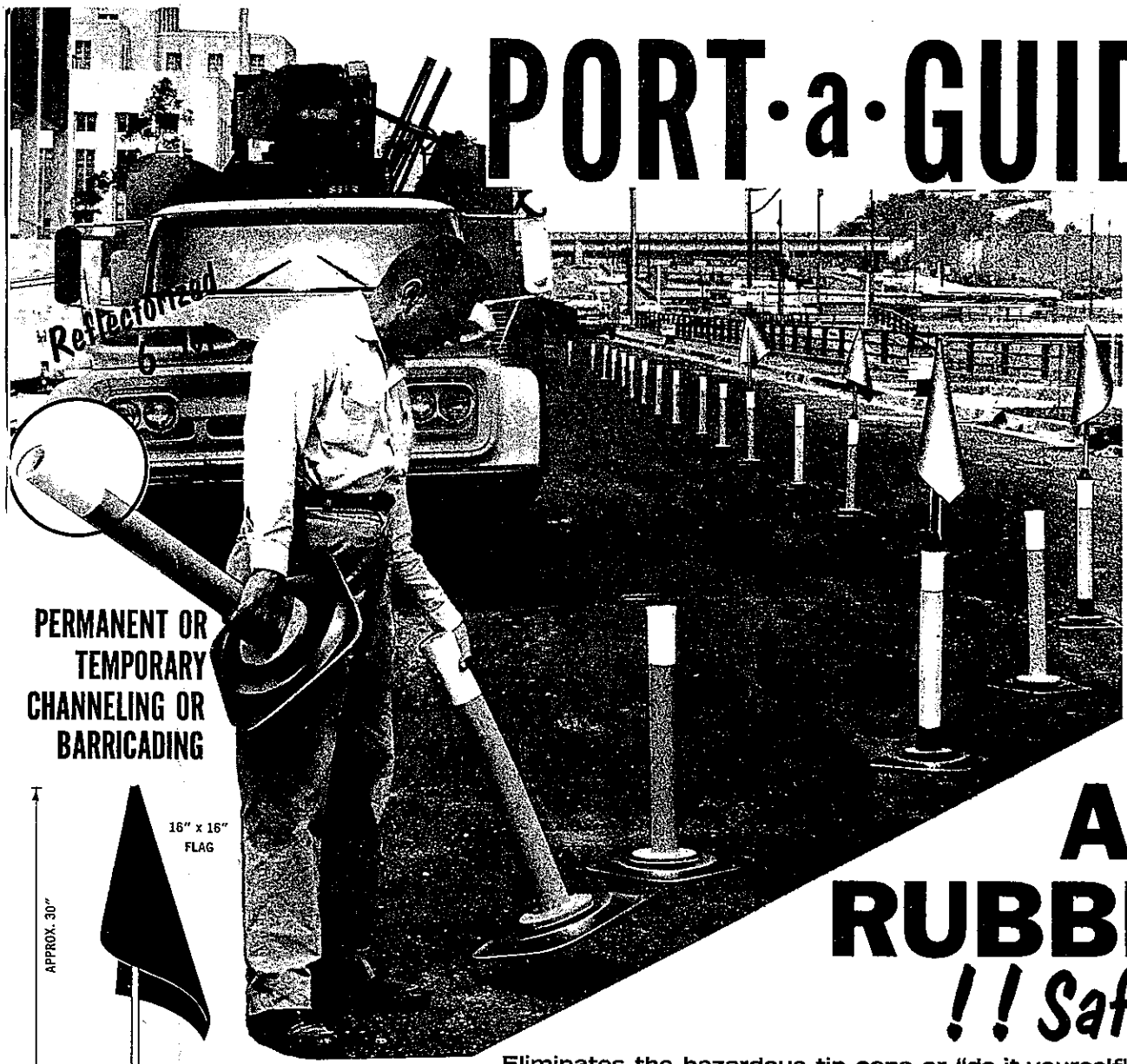
FIGURE 8

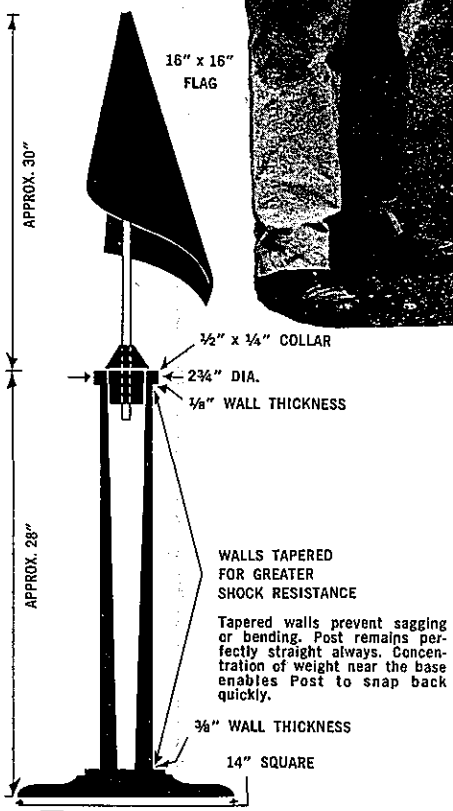


PORT·a·GUIDE POST

PERMANENT OR TEMPORARY CHANNELING OR BARRICADING

ALL RUBBER

!! Safe !!



Eliminates the hazardous tin cans or "do-it-yourself" concrete or metal barricades.

The ALL RUBBER construction is your assurance of safety . . . to motorists, pedestrians . . . and your employees.

NO EPOXY • NO BOLTS *needed for installation*

- ★ Withstands wind velocities of 60 mph
- ★ 75% of the overall weight in the base
- ★ 80° recovery angle
- ★ All weather flexibility, remains resilient at extreme high or low temperatures

PORT-A-GUIDE POST	
painted (crude rubber)	$7.20
all yellow rubber (post), base black	$8.20
reflectorizing (6" top)	$0.75
flag adapter	$0.95
flag, ¾" staff	$0.61
approximate weight	8 lbs.

POST ONLY WITHOUT BASE Post can be bonded permanently to paving with Epoxy . . . no bolts. no clamps.	
painted (crude rubber)	$3.95
all yellow rubber	$4.95
approximate weight	3 lbs.
epoxy 25 oz. kit . $3.75 50 oz. kit . $7.50	(recommended, 2½ oz. per guide post)

Interstate Rubber Products Corp.

908 Avila Street, Los Angeles 12, California • MAdison 6-4501

Authorized Representative:

Products Built to Withstand Abuse

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Port-A-Guide Post

Interstate Rubber Products Corporation
908 Avila Street, Los Angeles, Calif.

(See Figure 8 opposite)

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

These units have been used in Districts 08 and 11 but appear to require extensive modification for effective use. The three inch shaft does not have enough surface area to provide adequate target value unless a more distinct and durable color can be applied to the post. These units are very unstable with the flag adapter and flag inserted into the top of the post, overturning quite easily. Without the flag, however, the resistance to sliding and overturning is excellent. The post can be flexed but not without fastening the base to the pavement surface, which can be accomplished using an epoxy cement. If a unit that has not been attached to the roadway is struck by a vehicle, the unit will overturn. One of these units, without a flag, was struck by a test vehicle traveling at a speed of 25 mph and was displaced approximately 25 feet and overturned. The experience of District 11 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 post, it was found that additional reflectorization in the form of reflectors and Scotchlite reflective tape is required. The yellow paint on the post would require continuing maintenance, as do traffic cones.

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

These units present no possibility of vehicular damage when hit by a vehicle. If displaced into the traveled way, however, they could cause an accident due to the evasive action of a driver.

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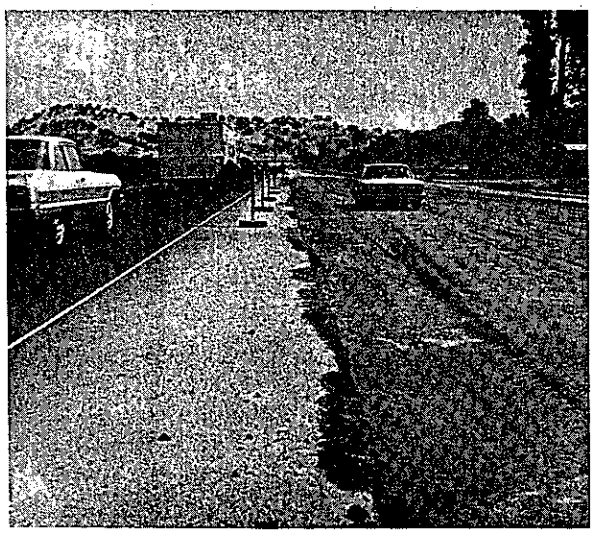
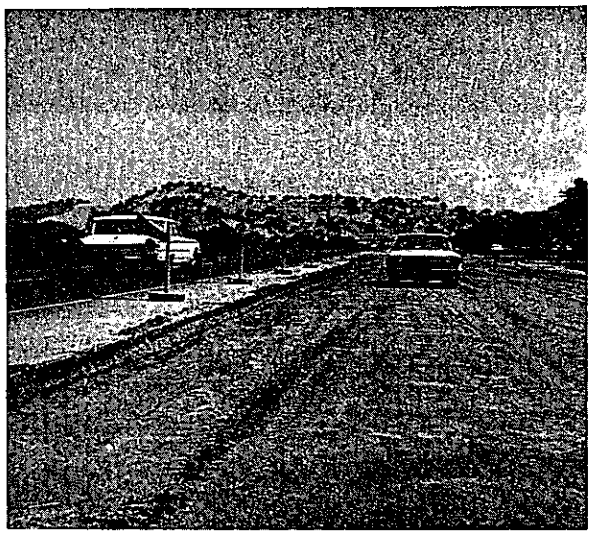
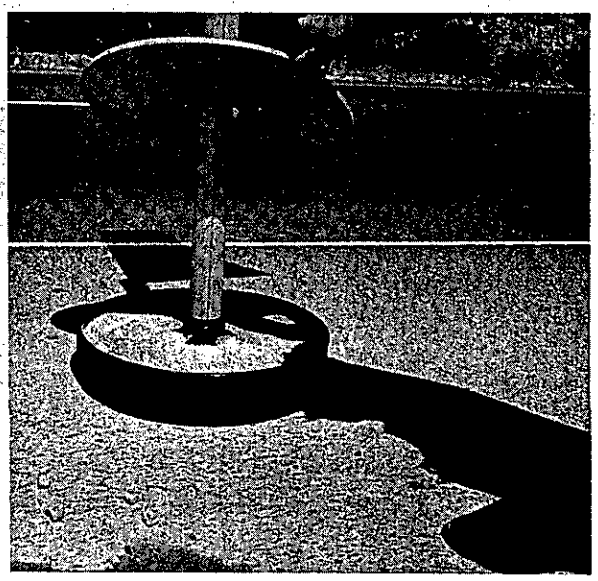
FIGURE 9





FOUR STANDARD AND ONE EXTENDED HIGHWAY WARNING DEVICE



BASE FILLED WITH SAND

(Total Base Weight Approximately 50 Pounds)

IN-SERVICE TEST SITE

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Safety Guide Portable Highway Warning Device

Marbon Chemical Division-Borg Warner Corporation
Washington, West Virginia

Local Representative: Brenton Equipment Company
101 South Park
San Francisco, California

(See Figure 9 opposite)

The 40" high Highway Warning Device would retail at $13.75 for the unit consisting of a base, base lide, and post with adapter (see Exhibit I). The High Level Warning Device would cost approximately $16.25 for the post, lid, and base combination.

Five of these standards 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 9). The 40" device, with a 36" extension, has a marginal stability in this type of situation. During one observation period, the extended device toppled after two hours. There were five flags attached to it at the time it toppled (see Exhibit J). During the second observation period, this extended standard tipped twice but did not overturn. During this second observation, three flags and then five were attached to the device. The 40" standard without extension appeared extremely stable to both overturning and sliding. The base, when filled with sand, weighs approximately 50 lbs., which appears to be quite adequate for stabilizing the regular 40" standard.

Three full scale impact tests were conducted on the 40" devices with a 1963 Dodge at 40 mph speed to determine the severity of damage to the standard, damage to the impacting vehicle, and the danger of loss of control of the vehicle when colliding with the standard (see Exhibit K). 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. This would cost approximately $4.15 to replace. In Test 1, the threaded post connection in the base failed. This would necessitate replacement of the base at a cost of $10.75 unless the portion of the post fitting remaining in the base could be removed. The post fitting itself costs approximately $1.00. There was no damage to the vehicle and no indication that loss of control of the vehicle would occur. The post was thrown 100 feet from the base in Test 3, but the base did not appear to move more than one foot.

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These units provide good daytime visibility but would require reflectorization for use at night. The stability of the extended Highway Warning Device is marginal but the stability of the standard 40" device excellent. The base, when filled with sand, provides adequate resistance both to overturning and to sliding for the 40" standard. The use of flags prohibits the use of these standards as delineators in very narrow shoulders. Where the shoulder width permits the use of flags, these devices can be quite effective as warning devices.

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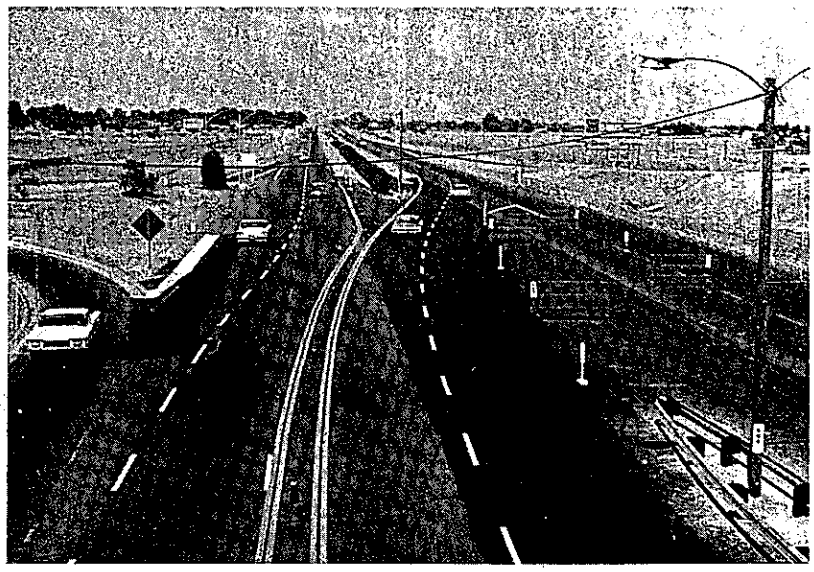
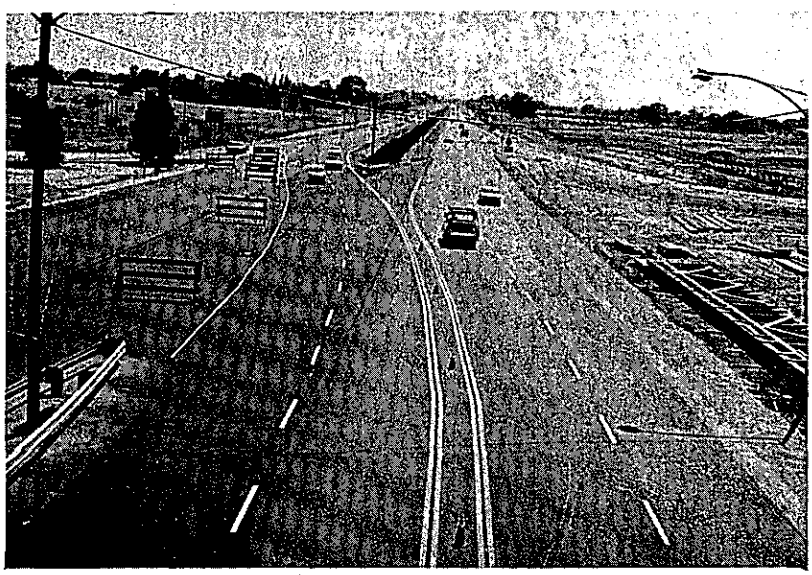
FIGURE 10



LANE AND MEDIAN DELINEATOR



LANE, MEDIAN, AND SHOULDER DELINEATOR

SCOTCH LANE PAVEMENT STRIPING TAPE

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Scotch Lane Pavement Striping Tape

Minnesota Mining & Manufacturing Company
6023 South Garfield Avenue, Los Angeles, Calif. 90022

(See Figure 10 opposite)

The price of this tape when purchased in quantity is approximately $0.14 per foot in a four inch width. For additional prices, see Exhibit M.

This product is presently being observed at three locations in the Sacramento area. The tape is easy to apply and will conform well to any irregularities in the pavement surface (see Exhibit N - top). Although a mechanized applicator is available, the tape can be efficiently applied by hand and then rolled with a vehicle. Adherence to P.C.C. or P.M.S. is good. Tamping by foot has proven unsatisfactory. This temporary lane marking is equal in reflectance to the standard beaded stripe and under normal conditions requires no primer or mastic for attachment. The durability of this tape has been good, but the observation period to date has been short (five months).

Removal of this tape was accomplished with a minimum of effort, but it should be noted that this tape was removed after being in service for a period of only two weeks. After removal, there was no evidence of the location of its attachment to the pavement as is the case with painted lines that require sand blasting for removal (see Exhibit O).

In wet weather, this tape will be no more effective than the standard painted stripe. The tape comes in various widths and colors, thus enabling use as a lane marker, median indicator, and edge delineator. It can be used on horizontal curves with a minimum of trouble.

Although both plain and reflectorized tape is available, the reflectorized (glass bead impregnated) is the most effective. Present results indicate that this tape will be an extremely useful device for temporary lane delineation through construction zones.

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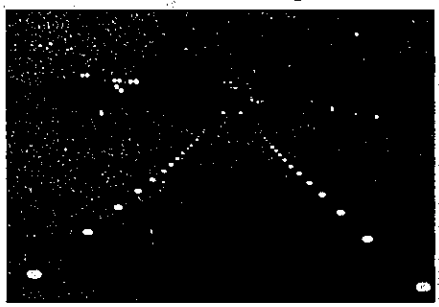
FIGURE 11

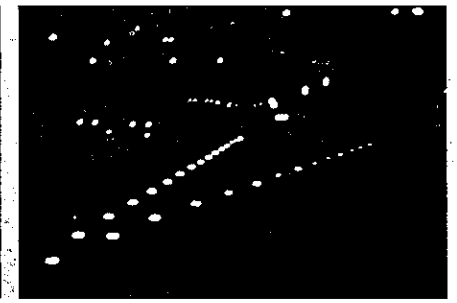
APPLICATIONS

Stimsonite Reflectorized Pavement Markers are the ideal markers for highway lane delineation. They can also be used for exit ramp marking, center line and edge line marking, and for channelizing and lane-use control. Other excellent applications are in outlining airport taxiways, curb dividers, parking lot lanes, etc. Their convenient shape permits flexibility in designing custom pavement marking symbols.

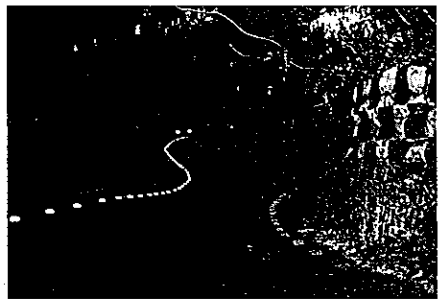
Lane line marking



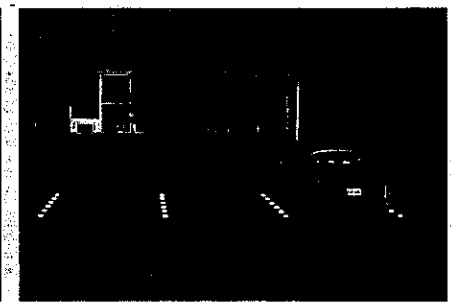
Exit ramp marking



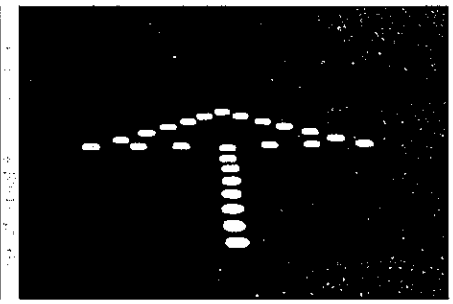
Center line and edge line marking



Channelizing and lane-use marking

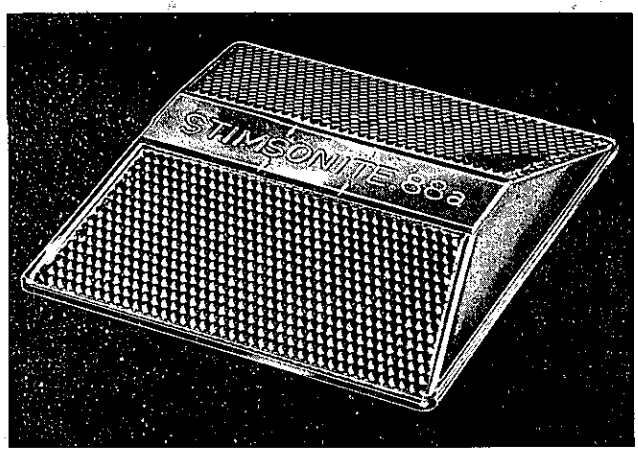


Parking lot marking

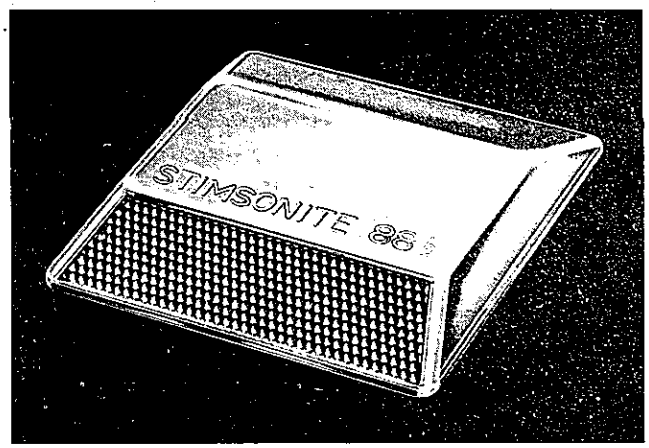


Typical pavement marking symbol

AVAILABLE FOR MONODIRECTIONAL AND BIDIRECTIONAL APPLICATIONS



Model 88a has reflective surfaces on both sides. Recommended for applications where it is necessary or desirable to observe the marker from opposite directions.



Model 88b is a higher performance unit with a single reflective surface. It is recommended for all monodirectional applications.

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Stimsonite 88 Pavement Markers

Stimsonite Signal Products
Elastic Stop Nut Corporation of America
Elizabeth, New Jersey

(See Figure 11 opposite)

The cost of these reflective units or pavement markers is listed at $1.10 each. This does not include the cost of the epoxy cement.

These wedge units were developed and have been found satisfactory for use as permanent lane delineators. The standard permanent wedge is attached to the pavement surface using an epoxy cement. This method of attachment has been found to be satisfactory, but the wedges are difficult to remove in temporary situations.

Because of the outstanding reflectance of these wedges and the various colors available (see Exhibit P), it was felt that these wedges would be useful in construction zone delineation. An attempt was made to temporarily attach them to a P.M.S. surface with one concrete nail through a hole drilled in the unit. Although the units were easy to drill, the "centermount" method of attachment to the roadway does not appear to be satisfactory (see Exhibit Q). The wedges rotate about the mounting nail and the methyl-methacrylate surface fractures, first cracking from the hole and then peeling off, thus completely destroying their effectiveness as a delineator.

Attachment with two nails has been proposed. In-Service tests of these wedges have proven that their durability, under conditions as found around Sacramento, is good. These wedges would be of great value in construction zones if an effective semi-permanent method of mounting can be developed.

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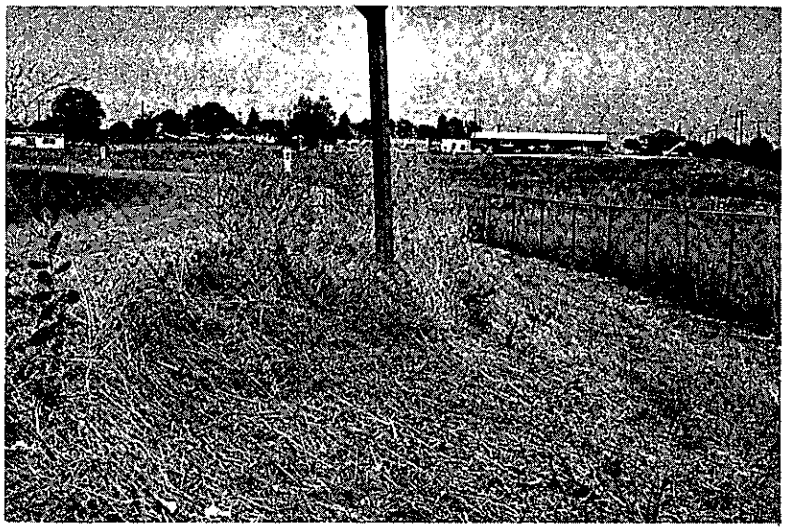
EXHIBIT A

CHRISTMAS TREE BASE



GROUND MOUNTED BASE

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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.

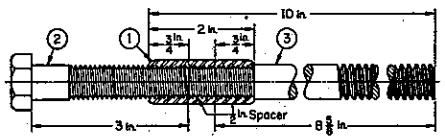
Sizes—Three sizes are standard: Type I—12 in. OD, Type I—16 in. OD, and Type II—14 in. See table below for complete engineering dimensions.

Shipping Weights—See table below.

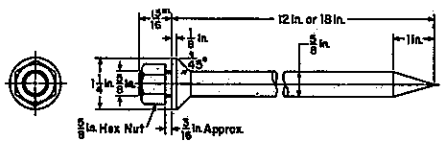
Size	Weight With Dowel-Pin Anchor	Weight Without Dowel-Pin Anchor
Type I — 12 in.	7.5 lb	6.0 lb
Type I — 16 in.	13.0 lb	11.5 lb
Type II — 14 in.	13.0 lb	12.0 lb

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.

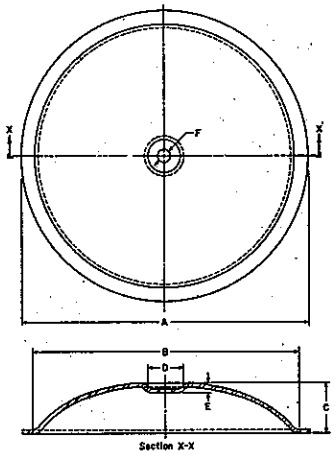


Style II: For use with Type II D-VID-A-WAY installed only in soft road-surface materials. Anchors are ⅝-in. diameter rods, 12 or 18 in. long, pointed on one end and threaded on the other, with a 45-degree flared collar immediately under the threaded portion for seating the divider.

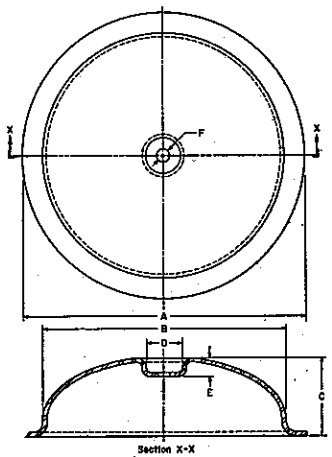


D-VID-A-WAY Dimensions

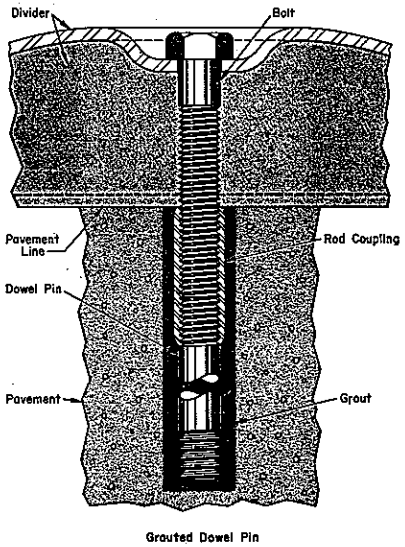
	Dimensions		
	Type I Divider		Type II Divider
	Size 12	Size 16	Size 14
Outside Diameter, A	12 in.	16 in.	14¼ in.
Ellipsoid Diameter, B	10¾ in.	14¾ in.	12 in.
Overall Height, C	1¾ in.	2¾ in.	3¾ in.
Recess Diameter, D	2 in.	2 in.	1 11/16 in.
Recess Depth, E	21/32 in.	21/32 in.	13/16 in.
Hole Diameter,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



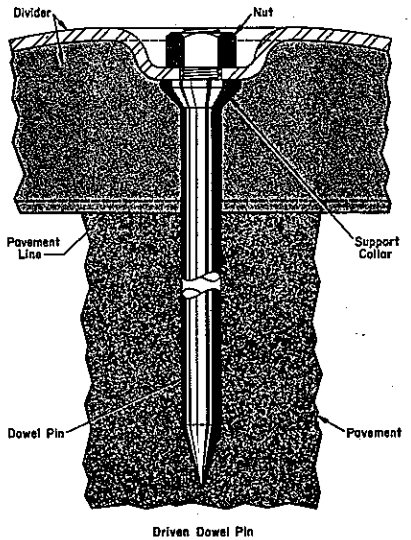
D-VID-A-WAY—Type I



D-VID-A-WAY—Type II



Style I Dowel-Pin Installed



Style II Dowel-Pin Installed

EXHIBIT B

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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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EXHIBIT D

ETZON

Exhibit D

The freshest idea in . . . *Light*

With ETZON *great vistas for new and exciting lighting can now be a reality*

ETZON

pocket size

THE VERSATILE COIL OF LIGHT

FOR A FRESH APPROACH TO DECORATIVE LIGHTING CHECK THESE UNIQUE FEATURES . . .

* EASE OF INSTALLATION
* OUTSTANDING FLEXIBILITY
* EASILY PORTABLE AND RE-USABLE
* COMPLETELY SAFE
* A WATERPROOF LINE OF LIGHT

Never before has so versatile a product been available . . .

WITH ETZON WE ARE OFFERING AN ENTIRELY NEW MEDIUM INTENSITY LIGHT SOURCE. OF ALL THE STIMULATING VIRTUES POSSESSED BY THE ETZON SYSTEM THERE ARE TWO IMPORTANT POINTS THAT APPEAR CONTRADICTORY . . .

- PERMENANCE AND DURABILITY
- FLEXIBILITY AND REUSABILITY

ETZON ACCOMPLISHES THESE TWO EXTREMES BY ACHIEVING ITS LIGHT THROUGH MINIATURE, NON-DETERIORATING FLUORESCENT GLASS CAPSULES EXCITED BY HIGH FREQUENCY AND BY ENCASING THESE IN A FLEXIBLE, WEATHERPROOF VINYL TUBE. WITH JUST THIS BRIEF INTRODUCTION TO THE ETZON SYSTEM, EXCITING AND HERETOFORE IMPRACTICAL LIGHTING EFFECTS ARE POSSIBLE.

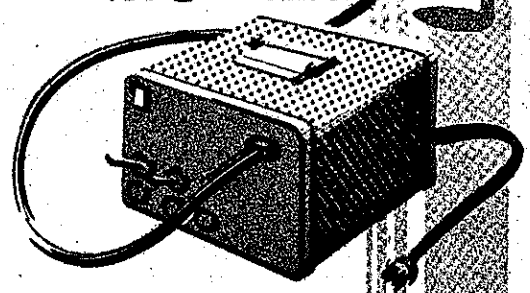
THROUGH THE USE OF THIS EXCLUSIVE NEW HIGH FREQUENCY POWER SUPPLY WE ARE ABLE TO OFFER THE RUGGED, DURABLE AND FLEXIBLE ETZON SYSTEM. THIS SYSTEM IS A SIMPLE 'PLUG IN' INSTALLATION AND IS ABSOLUTELY SAFE TO HANDLE WHEN IN OPERATION.

HERE ARE SOME OF THE OPERATING CONDITIONS UNDER WHICH THIS AMAZING NEW PRODUCT HAS PERFORMED OUTSTANDINGLY:

- INSTALLATIONS WHERE MAINTENANCE OF THE LAMPS IS IMPOSSIBLE.
- INSTALLATIONS WHERE THE LINE WILL BE SUBJECTED TO VIBRATION AND SHOCK.
- TEMPORARY APPLICATIONS IN COMPLEX DESIGNS WHERE THE MATERIAL MAY LATER BE REUSED IN NEW AND DIFFERENT DESIGNS.
- INSTALLATIONS IN WATER.
- INSTALLED AS MAINTENANCE FREE LIGHT SOURCES BEHIND DIFFUSION SURFACES TO GIVE A PERMANENT AND UNIFORM DISPERSION OF LIGHT.

THESE AND MANY OTHER UNIQUE APPLICATIONS ARE POSSIBLE WITH THE NEW ETZON SYSTEM. ON THE REVERSE OF THIS PAGE YOU WILL FIND VALUABLE TECHNICAL INFORMATION ALLOWING YOU TO ACCURATELY DESIGN WITH ETZON.

model 104 generator



New Products of Value . . .

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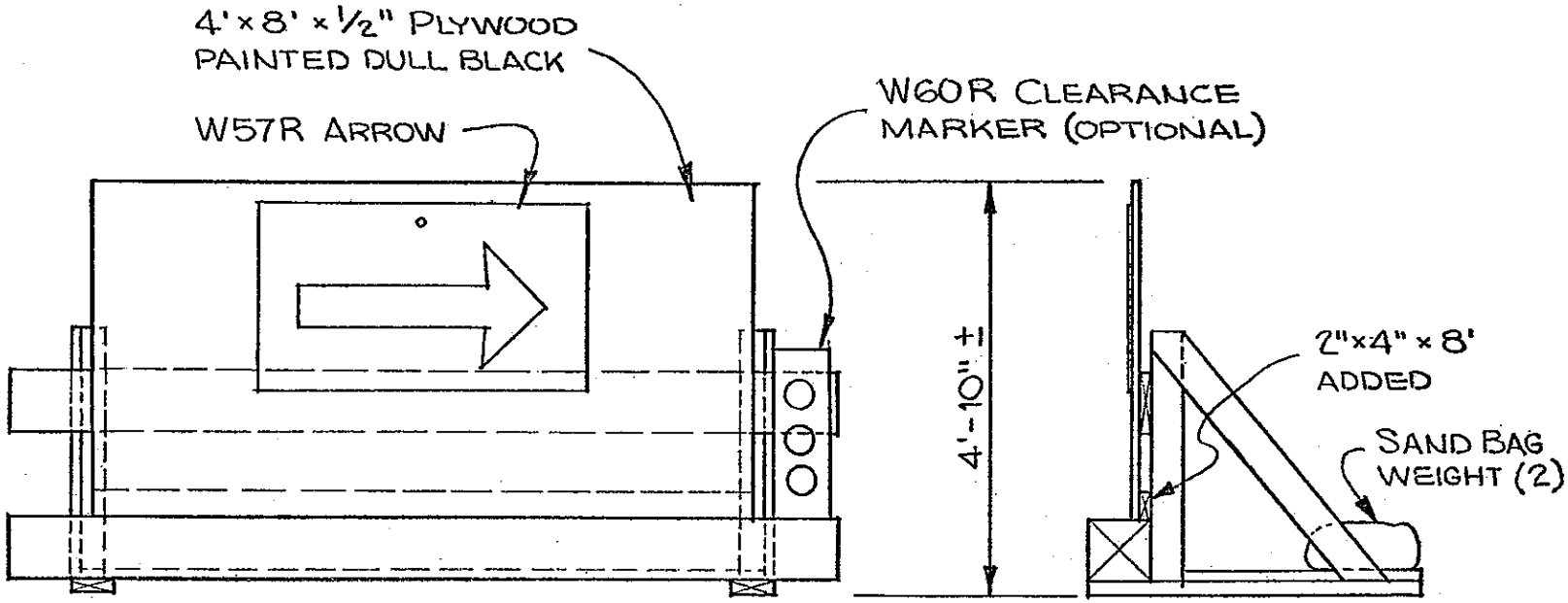
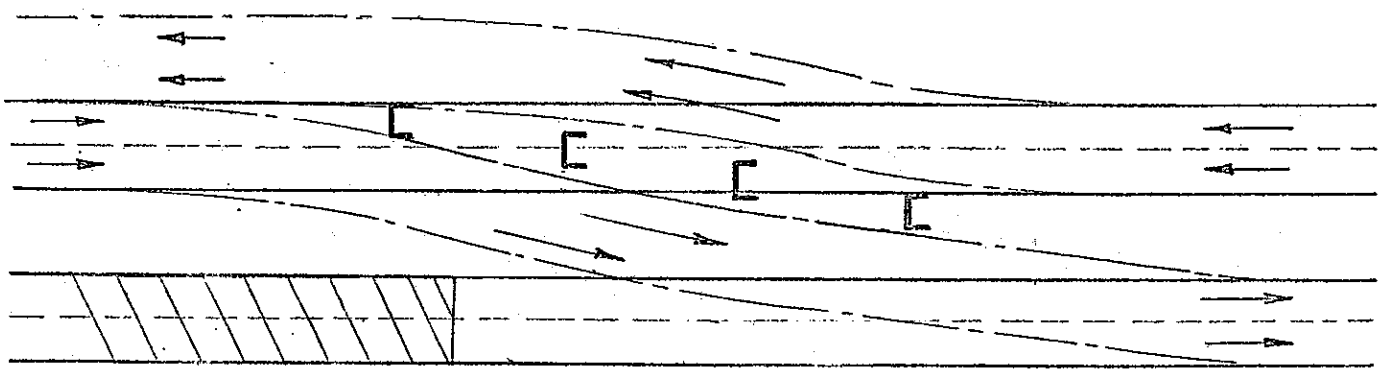


LITE SHIELD BARRICADE DETAIL

(STANDARD TIMBER BARRICADE MODIFIED AS SHOWN)



TYPICAL INSTALLATION

EXHIBIT E

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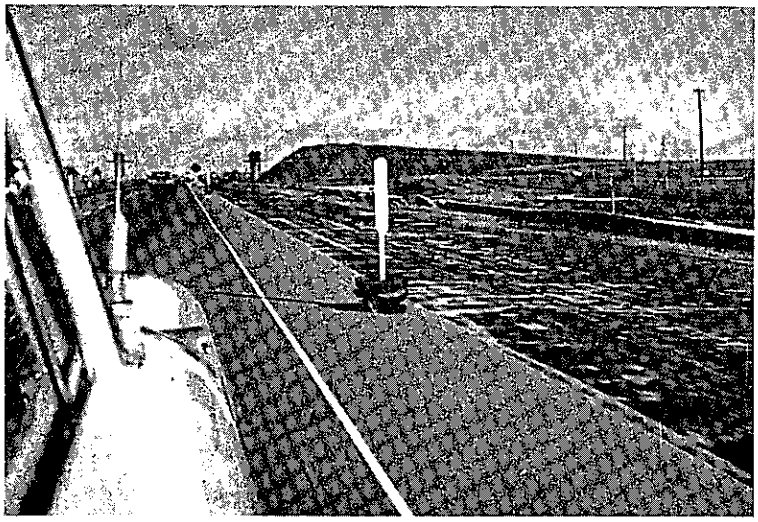
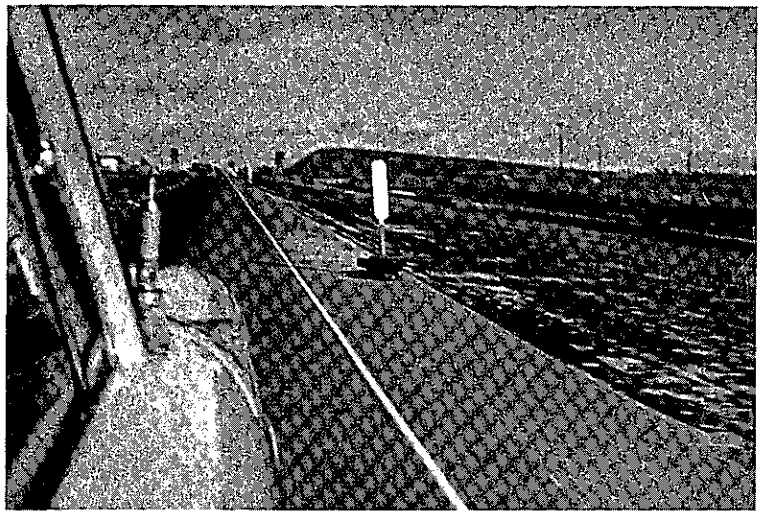
EXHIBIT F



RANGER MODEL



STANDARD MODEL

BALLAST REQUIRED TO STABILIZE PORTA BASE

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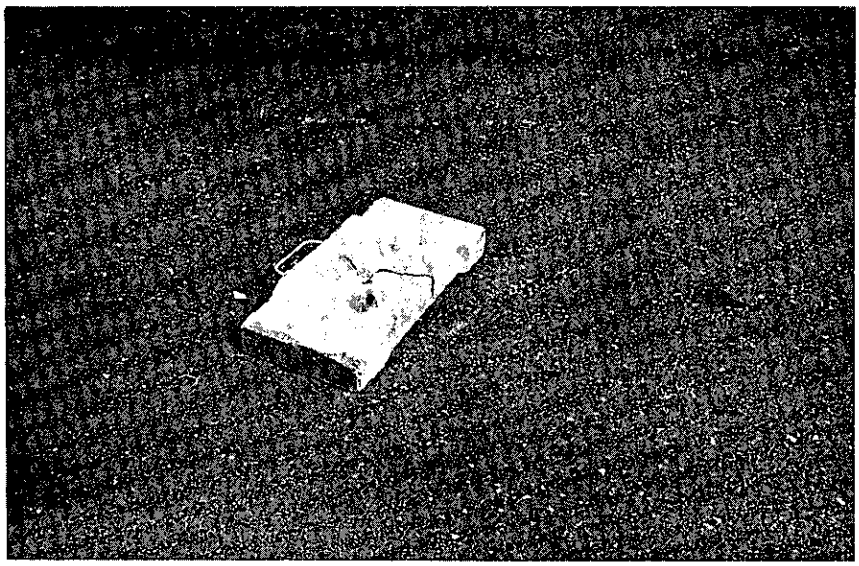
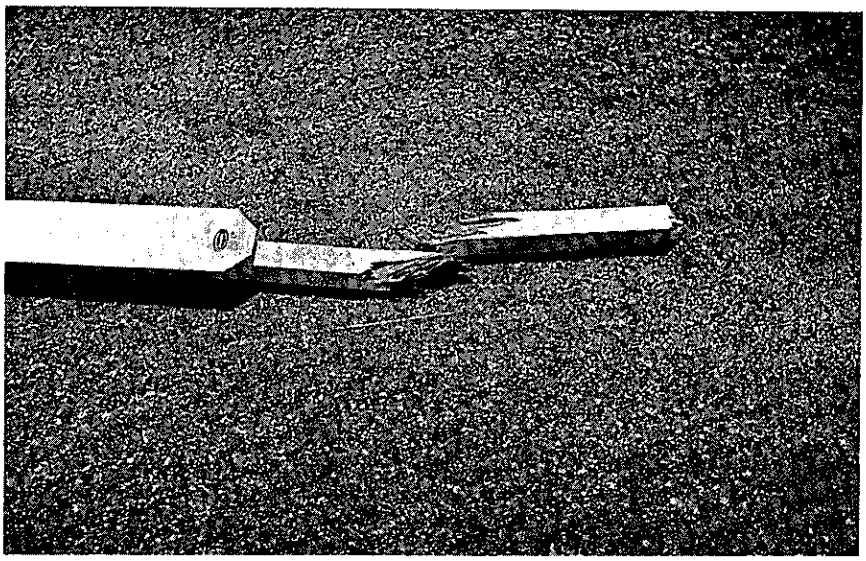


CRACKED BASE



BROKEN POST

40 MPH IMPACT TEST - TEST VEHICLE STRADDLING BASE

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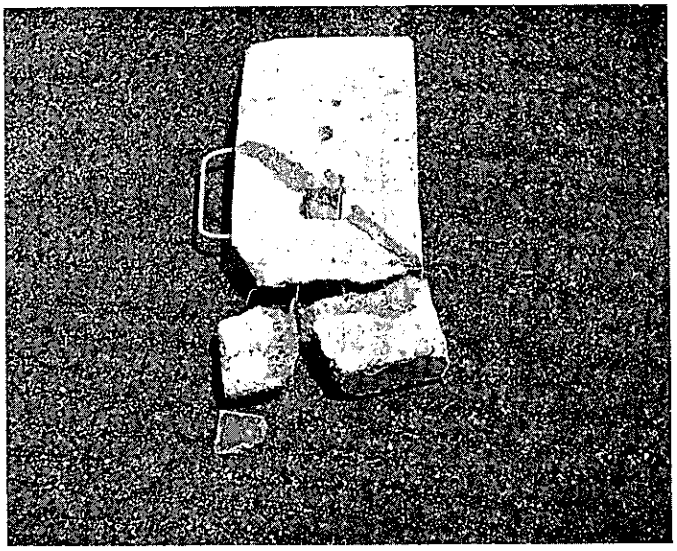
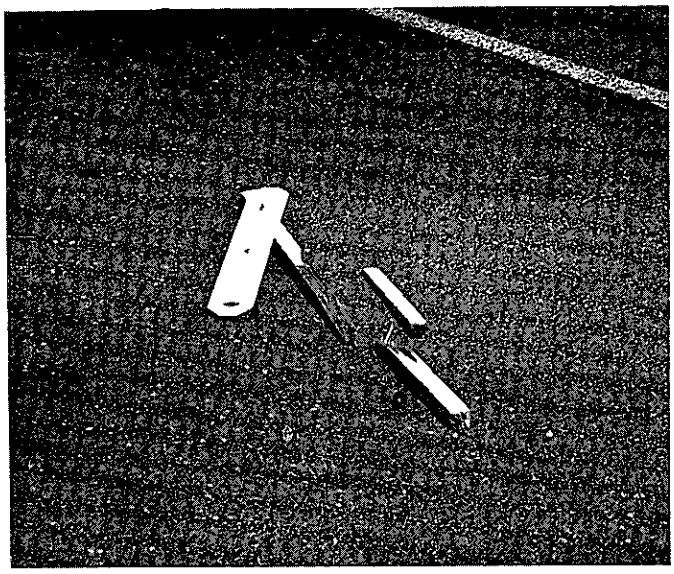


FRACTURED BASE



BROKEN POST

40 MPH IMPACT TEST - IMPACT VEHICLE WHEEL CROSSING BASE

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Instant advance warning for motorists, safeguarding highway maintenance, repair or construction crews and utility crews.

- Commands attention—highly visible in the line of sight—traffic engineered and highway tested for maximum attention and safety.
- Maximum stability—will not topple or "drift".
- Rust-proof, easy to clean. Requires no painting or other maintenance.
- Inherently harmless—highly resilient for maximum safety to workmen, motorists, vehicles. No metal or wood hazard.
- Federal Highway approved colors.
- Designed to accommodate standard flashers and reflectors.

All Safety Guide Devices are in accord with applicable traffic safety rules and regulations. Standard signs are furnished blank or will be imprinted to order at a slight extra charge.

MATERIALS AND DESIGN

CENTER POSTS

Heavy-duty, 2½" diameter post of CYCOLAC brand ABS polymer, drilled to hold Safety Guide flags and reflectors (adapters available to hold signs and lights). Never gets out of shape or alignment. Will not rust or corrode. Integral color—Federal Highway Yellow. Also available in 2" diameter CYCOLAC polymer.

BASE ASSEMBLY

Base—Black, heavy-duty rubber, ribbed for extra strength. Grooved sole prevents skidding. Can be easily filled with sand, gravel or similar materials to provide stability required.

Center socket—Molded CYCOLAC ABS with protected male threads. Snap-locks into base. Cannot turn or loosen.

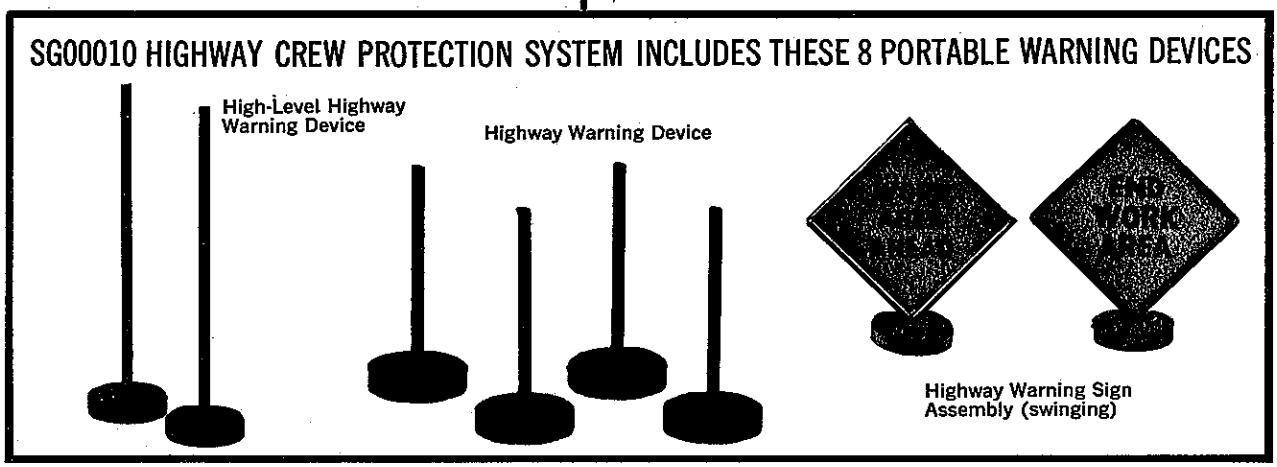
Lid—Federal Highway Yellow polyethylene. Snaps shut. Releases upon impact to minimize collision damage.

SIGNS

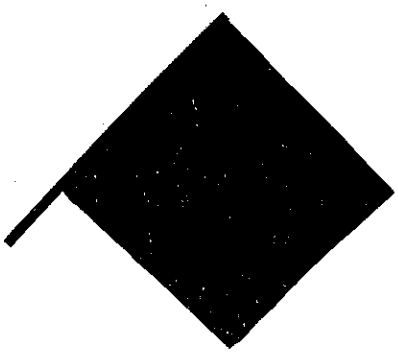
⅛" CYCOLAC ABS polymer in Highway-approved integral colors. Needs no painting, will not chip or peel. CYCOLAC will not corrode; retains shape, even after impact.

SWINGING SIGN FRAMES

1½" schedule 40 extruded pipe of tough, rigid CYCOLAC Brand ABS. Fittings are molded from same rugged material.



CYCOLAC AND SAFETY GUIDE ARE REGISTERED TRADEMARKS OF BORG-WARNER



FLAGS & STAFFS

SG 02080	18" x 18" Red Nylon Flag with 24" staff
SG 02090	18" x 18" Red Nylon Flag with 30" staff
SG 02100	24" x 24" Red Nylon Flag with 30" staff
SG 02110	24" x 24" Red Nylon Flag with 36" staff
SG 12018	18" x 18" Red Nylon Flag with welt
SG 12028	24" x 24" Red Nylon Flag with welt
SG 13018	24" Flag Staff, slotted & drilled
SG 13028	30" Flag Staff, slotted & drilled
SG 13038	36" Flag Staff, slotted & drilled

FLASHERS, REFLECTORS AND EQUIPMENT AVAILABLE ON REQUEST

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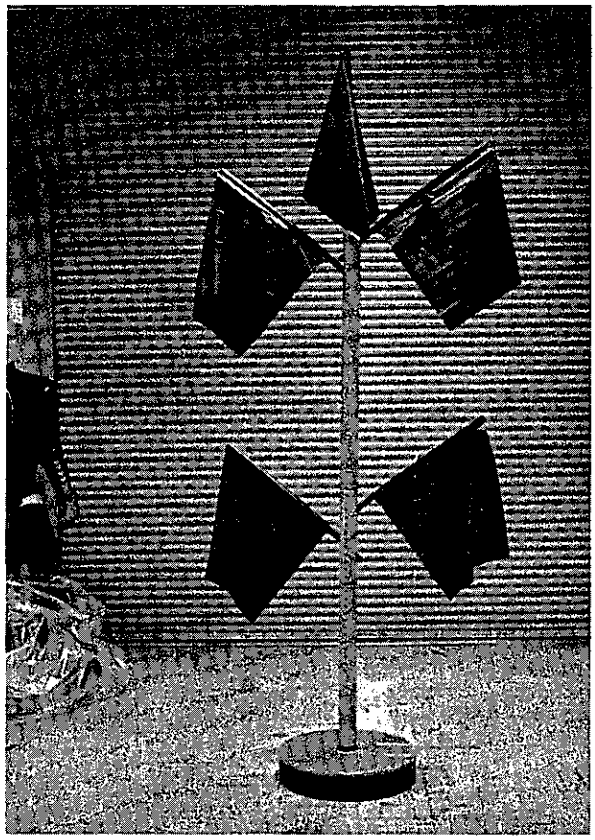
EXHIBIT J



EXTENDED 40" DEVICE WITH FIVE FLAGS

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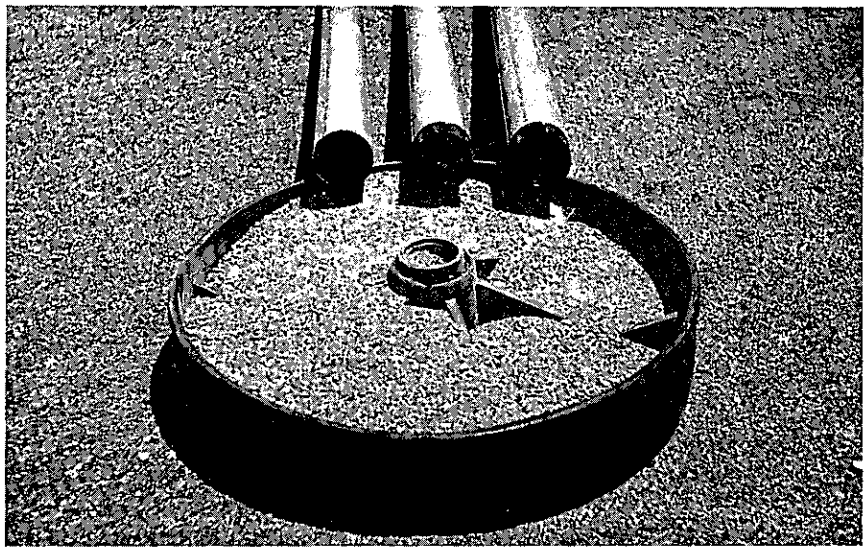
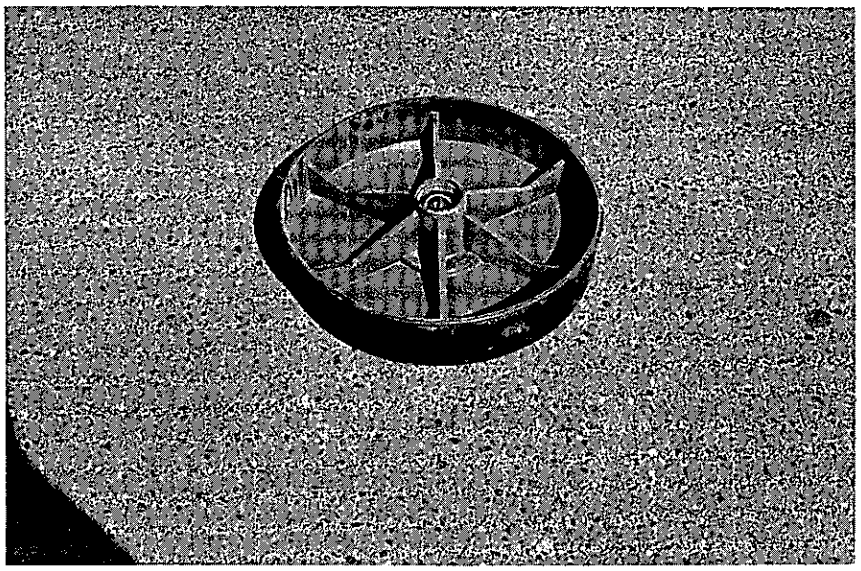


TESTS 2 and 3 - TEST 1 - UNDAMAGED POST



BASE - TEST 1

SAFETY GUIDE IMPACT TESTS

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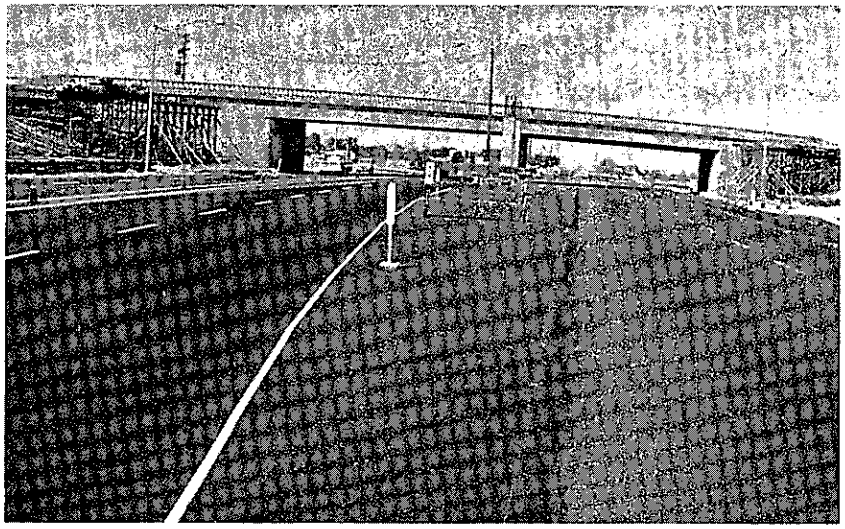

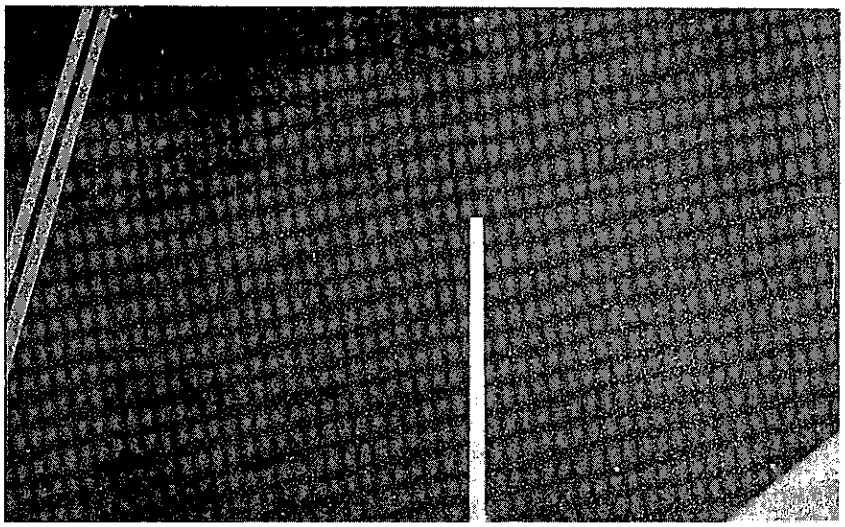

SCOTCH LANE PAVEMENT STRIPING TAPE

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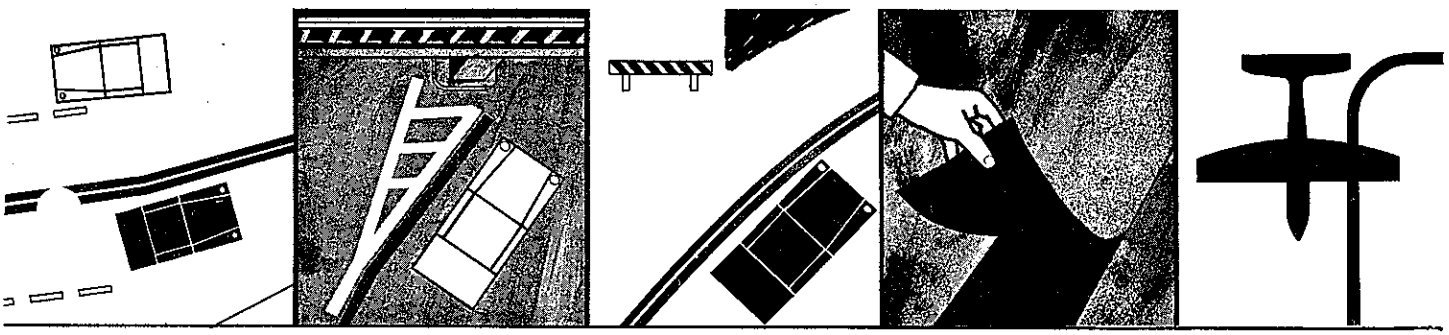

CHANNELIZATION GORE MARKINGS HAZARD ZONE REMOVABLE AIRFIELD MARKINGS

Scotch·Lane®
BRAND

"SCOTCH-LANE" BRAND PAVEMENT STRIPING TAPE

No. 526 Reflective
No. 525 Plain

Price Schedule
April 15, 1965

PRODUCT DESCRIPTION

No. 526 is reflective and No. 525 non-reflective plain pressure sensitive tapes which are available in Highway Yellow or White and are designed for semi-permanent lane marking of asphalt or concrete road surfaces. No. 526 tape is reflectorized to provide maximum nighttime visibility where detours, construction zones or closed lanes present a hazard. The line is quickly applied and is readily removed whenever the line has served its purpose. It eliminates unnecessary waiting for paint equipment, traffic coning, etc.

NET QUANTITY PRICES

No. 526 Reflective

Size	*Rolls per unit	1-4 Units		5-14 Units		15 or more Units		Broken Units	90 day 100 units	
		per roll	per unit	per roll	per unit	per roll	per unit	per roll	per roll	per unit
4"x60 yds.**	8	$30.64	$245.12	$28.60	$228.80	$25.32	$202.56	$47.80	$24.04	$192.32
6"x60 yds.	8	$45.96	$367.68	$42.90	$343.20	$37.98	$303.84	$71.70	$36.06	$288.48

No. 525 Non-Reflective

4"x60 yds.	8	$17.12	$136.96	$15.96	$127.68	$14.16	$113.28	$26.68	$13.44	$107.52
6"x60 yds.	8	$25.68	$205.44	$23.94	$191.52	$21.24	$169.92	$40.02	$20.16	$161.28

* One Unit equals 8 rolls. ** 180 yard lengths are available for machine applications.

"SCOTCH-LANE" PRIMER IS APPLIED AT A RATE OF 450 LINEAL FEET 4" WIDE PER GALLON OR APPROXIMATELY 3 GALLONS PRIMER PER UNIT (8 ROLLS).

ASSORTING PRIVILEGE:

1. Full units of No. 526 may be combined with full units of No. 525 to make quantities.

2. Broken units, when combined on same order with full units, will be invoiced at the 1 to 4 unit price.

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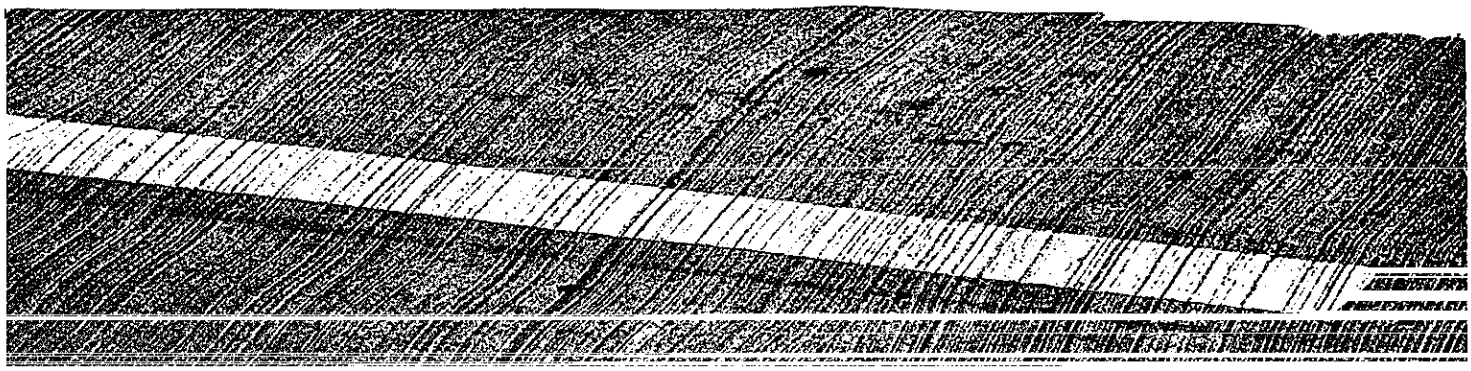
EXHIBIT N



This photo shows you how "Scotch-Lane" conforms even to a rough pavement surface. Note sharp, clean edges with no paint spatters.

SAMPLE OFFER
6 yards Scotch·Lane® BRAND Pavement Striping Tape
FREE

See for yourself if "Scotch-Lane" Pavement Striping Tape is as good as we say it is. Take us up on this FREE SAMPLE OFFER—and use "Scotch-Lane" on your own streets.

Reflective Products Division 3M COMPANY
ST. PAUL, MINNESOTA 55119

Reflective Products Division
3M Company, 2501 Hudson Road
St. Paul, Minnesota 55119

Gentlemen:
If "Scotch-Lane" Pavement Striping Tape is as good as you say it is, I have to see it myself. Please send me 6 yards (NO CHARGE) so I can check it out.

NAME_____

POSITION_____

ORGANIZATION_____

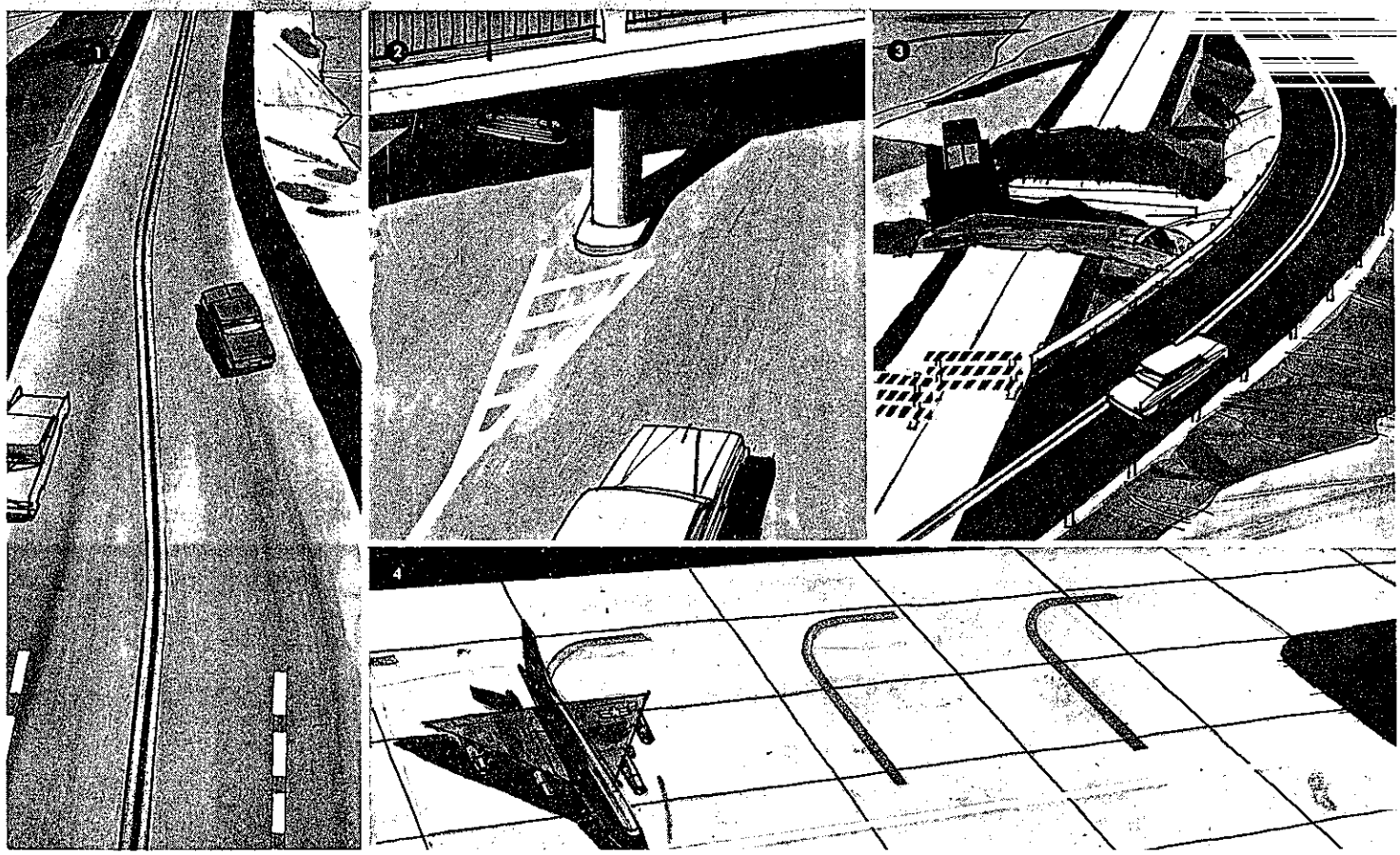
ADDRESS_____

CITY_____ STATE_____ ZIP_____

"SCOTCH-LANE" IS A REGISTERED TRADEMARK OF 3M COMPANY

1. Test lane marking. 2. Gore marking. 3. Construction detours. 4. Airport ramps.

L-SL2 (352) CP



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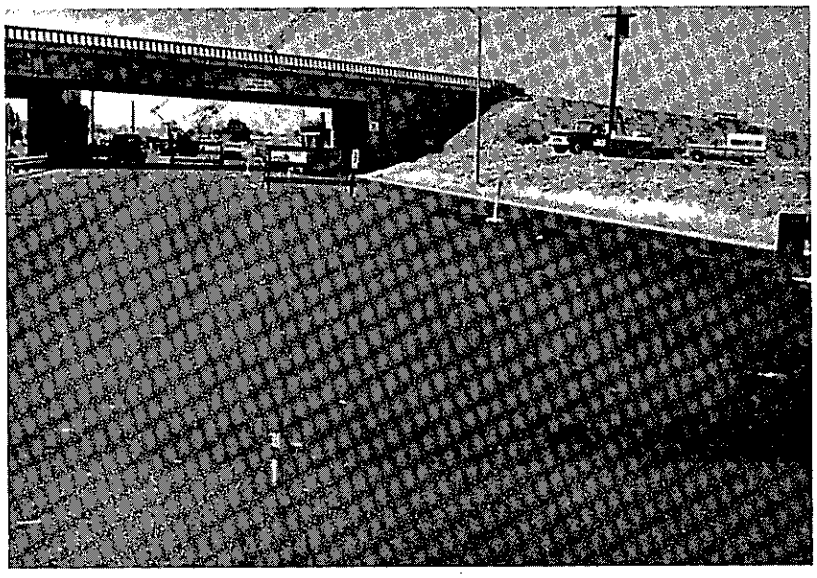
REMOVED TAPE vs SANDBLASTED PAINT STRIPE



REMOVED TAPE

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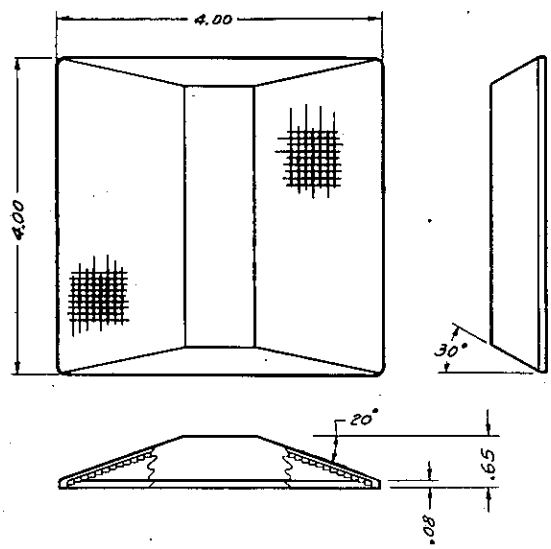
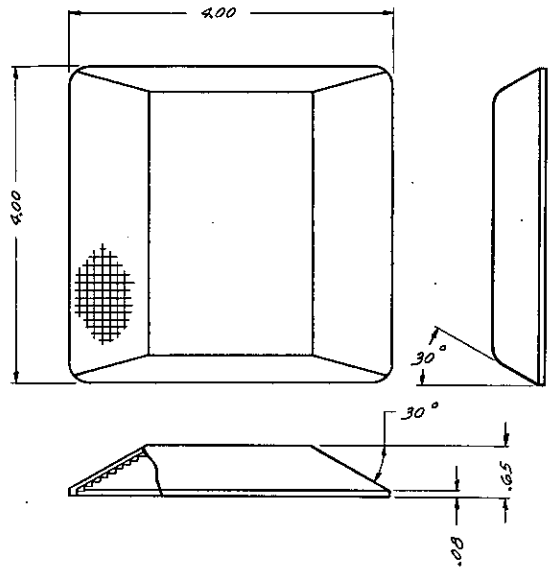
SPECIFICATIONS



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



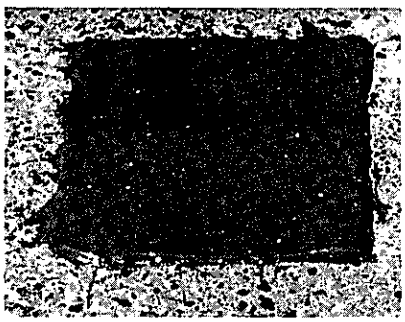
88b MONODIRECTIONAL

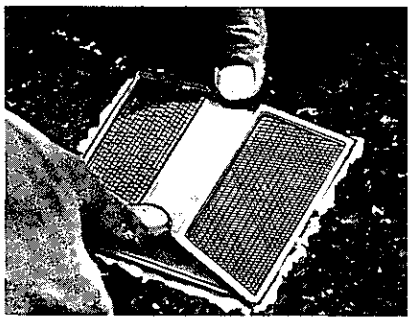
Material	Methyl methacrylate bonded to an epoxy-base filler
Size	4″ x 4″ x ⅝″
Weight	Approx. 6 ozs.
Reflective Area	@30° 3.4 square inches
Colors	White, Red, Yellow and to order

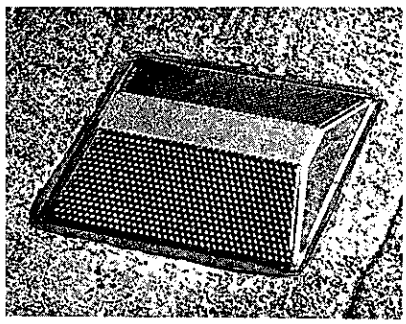
INSTALLATION

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

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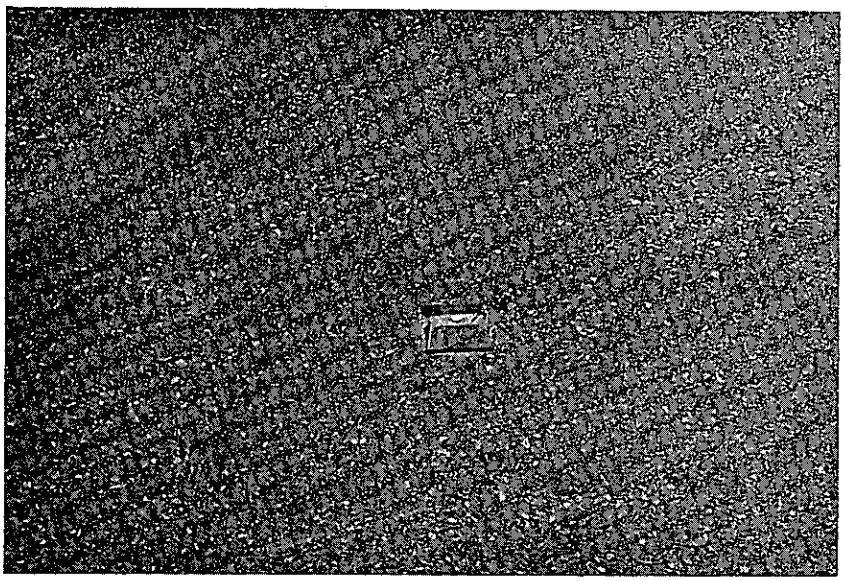
EXHIBIT Q

TWISTING OF MARKER



DISINTEGRATION OF MARKER SURFACE

FAILURE OF STIMSONITE PAVEMENT MARKER

WHEN SECURED BY A NAIL AS TEMPORARY ATTACHMENT

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