If you have issues viewing or accessing this file, please contact us at NCJRS.gov.

158027

NCJRS

JAN 2 1996

ACQUISITIONS

FINAL REPORT

NIJ Grant award number: 94-IJ-CX-0055

Project title: Tire Deflator System for Use at Law Enforcement Checkpoints.

Completion date: 30 April, 1995 (Demonstration postponed at request of INS)

Project manager: Mr. Bert Soleau

Project manager's telephone number: 703-234-9400

Grantee name and address: Eagle Research Group, Inc.
1110 North Glebe Road, Suite 1090
Arlington, VA 22201

Project Objectives: Design, fabricate, test, and demonstrate a lightweight, remotely actuated, tire deflator system for use at Border Patrol inspection points. The system is to have an independent power supply, deploy and retract in 1-2 seconds, instantly deflate steel-belted radial tires, leave no roadway debris after use, exhibit minimal tendency to displace (kick) when being run over, have a protective sheath for the spikes when in the stowed position, and be easily emplaced by one person. Deliver one prototype deflator system with three deflator bars to the INS customer.

Accomplishments: All project objectives were achieved, except as noted below on page 4, and demonstrated to the INS customer via operating the deliverable prototype.

Discussion: Figures 1 & 2, (all figures attached) depict the functioning of the tire deflator system and its component parts.

The Eagle Tire Deflator (ETD) (patent pending), developed in-house by Eagle Research Group, Inc. was the starting point for this project. The ETD provides a portable system capable of delivering large, hollow spikes into tires with minimum movement (kick) of the bar in which the spikes are mounted. After penetration, the spikes separate from the deflator bar and remain in the tire to provide an unobstructed air path for rapid deflation. To refurbish a deflator after use, the operator merely replaces the spike units removed by the tires.

Twenty 5' deflator bars, fabricated of aluminum, were delivered to the U.S. Customs Service. The weight of the deflator bars (approximately 4# per linear foot of bar) was too great for use in the portable, easily deployable system required by INS/Border Patrol. Such bar weight would require a large electric motor for raising and lowering, and a

158027

U.S. Department of Justice
National Institute of Justice

This document has been reproduced exactly as received from the person or organization originating it. Points of view or opinions stated in this document are those of the authors and do not necessarily represent the official position or policies of the National Institute of Justice.

Permission to reproduce this [redacted] material has been granted by
Public Domain/NIJ
U.S. Department of Justice
to the National Criminal Justice Reference Service (NCJRS).

Further reproduction outside of the NCJRS system requires permission of the [redacted] owner.

relatively massive base to provide stability during cycling. This project had two thrusts; design of a lightweight deflator bar while maintaining assured functioning and, development of a lightweight, remotely operable deployment-retraction mechanism. These issues are discussed in that order.

THE DEFLATOR BAR

Figure 3 depicts the deflator bar and spike support blocks as delivered to Customs. Two factors were addressed to reduce the bar's weight, its width and its materials of construction. Minimum bar width is defined by the dimensions of the spike support blocks contained in the bar. Tests with rolling tires were performed to determine the minimum support block dimensions required to prevent tipping of 2 1/4" X 1/2" OD hollow spikes when impacted by a tire. These tests indicated that the Customs 4" spike support block dimension could be reduced to 2.5" without impairing spike stability upon tire impact. Further reduction to 2" resulted in the spike tipping prior to tire penetration. Spikes with 2 1/2" base block units were fabricated and successfully tested via drive-overs with steel-belted radial tires. The deflator bar for this project was subsequently designed around the 2.5" spike support block.

The materials from which the bar is constructed afforded the second opportunity for weight reduction. Three substitutes for aluminum were considered: 1) a preformed fiberglass channel, 2) injection molded bars, and 3) a fiberglass reinforced epoxy (FRE) layup stiffened with 1/2" aluminum angle.

The first option originally appeared to be the most attractive. Fiberglass channels were available commercially, but would have to be machined to dimensions required for the 2 1/2" support blocks. Their most serious drawback was weight (they were of a solid material) and lack of torsional rigidity in 6' lengths. Six foot lengths of fiberglass bars were evaluated, but demonstrated too much flexure for this application. The addition of aluminum angles to stiffen the bar increased its weight to unacceptable limits.

The second option, injection molded bars, appeared desirable from a low-cost, mass production aspect. Two factors militated against selecting this option. The first was the high cost of making the molds, and the second was that thermoplastic resins are used in injection molding, and these resins would soften at the high temperatures encountered on a summertime highway surface.

The third option, an FRE layup stiffened with 1/2" aluminum angles (Fig. 4), was selected for use in this project. Bars constructed of FRE layups are not solid in cross section, but are comprised of a fiberglass "skin" reinforced with epoxy. This reduced volume of material in the bar achieved a weight saving sufficient to add two 1/2" aluminum angles for stiffening and still have a bar whose unit weight, with spikes, was less than 1# per linear foot. Such bars were run over up to 12 times and show no degradation in performance. This method of construction allows the bars to flex under tire loading and spring back to their original shape afterwards.

A number of FRE bars, as depicted in Figure 3, were fabricated and successfully tested. Not one failure to flatten steel-belted radial tires was experienced in over 20 tests. These bars, however, had spacer blocks integral with the bar. This posed added difficulty, and expense, in fabricating the molds in which the bars were formed. A design eliminating these integral spacer blocks was generated (Fig. 5), fabricated and successfully tested. Squares of closed-cell plastic foam were glued into the bar to act as spacer blocks. Such design improvements will result in economies of manufacturing in production runs. The modification was successfully tested and was used in the final demonstration to INS representatives.

SPIKES & SUPPORT BLOCKS

As previously mentioned, low speed roll-over tests indicated that the support block width could be reduced from the 4" used in the Customs version to 2 1/2". Support blocks of these dimensions were fabricated and used exclusively in all testing and demonstrations of the tire deflator developed under this grant. There were no failures to deflate steel-belted radial tires during testing or demonstrations. A number of minor shortcomings with the Customs spike design were noted and rectified. The problems and solutions are as follows:

Spikes were originally press fitted into support block holes 0.001" smaller in diameter than the spikes. This arrangement was satisfactory most of the time, but occasionally the support block would separate from its spike as they rotated with the tire after penetration. This was unacceptable in that INS specified that no flying debris be generated that might be hazardous to law enforcement officers or bystanders. The design was therefore changed by cutting a circumferential groove on the base of the spike and affixing a clip ring in the groove (Fig. 6a). The base block was countersunk to provide a flat base for installation in the deflator bar. This arrangement provides a high degree of assurance that support blocks will not separate from spikes as they rotate with the tire. Testing verified this, and the delivered units were so equipped.

Although an effective design, the addition of the clip ring involves costly and time consuming machining steps. In follow-on and/or production efforts, it is recommended that an alternative method of retaining support blocks on spikes be implemented. A prime candidate is to flare the base of the spike, before hardening, and press fit as was originally done (Fig. 6b). The enlarged base cross section should absolutely prevent any separations.

A second problem was identified during testing. Plugs of tire rubber were sometimes found lodged in the holes of the hollow spikes. These plugs did not completely obstruct the orifice, but did retard the rate of deflation to the extent that the vehicle could travel 50 feet or so prior to the tire going completely flat, i.e., running on its rim. Because this deflator is advertized to provide instant deflation, this phenomenon was deemed

unacceptable. The culprit was identified as the sharp edge of the hole in the spike. This edge acted as a cookie cutter, removing plugs of rubber and retaining them in the orifice. The solution was to dull (grind down) the bottom section of this edge to eliminate its cutting action. This modification was tested with no instance of plugging observed. The delivered systems have the modification, as will all subsequent deflator units.

Late in the project, a problem arose with the magnetic attachment of the spike and support block to the deflator bar. The magnetic attachment worked very well during run-overs by a tire, but failed to retain the spikes in the deflator bar during deployment and retraction. Stronger magnets were procured and incorporated into the bar. These appeared to remedy the problem, but toward the end of the project, they too sometimes failed to retain the spikes during bar deployment, i.e., when the deflator bar strikes the pavement at the end of its swing-down deployment. This problem remained unresolved at the end of this effort, but a design solution as depicted in Figure 7 will be tested for use in all follow-on work. This remedy consists of placing a spring-steel strap over the spike and support block, which locks in a detent in the sides of the deflator bar base. It is thought that such an arrangement will provide more than enough force to hold the spikes and support blocks in place, but will release the spike support block from the detent in the sides of the deflator bar as the spike and support block rotate with the tire.

In the continuing effort to reduce system weight, alternative materials for the aluminum used as support blocks were considered. The first tried was birch plywood which combines great strength, for wood, with light weight. Support blocks were fabricated and 1/2" spikes epoxied in place. Drive-over tests were successful in that the tires were deflated, but the wood shattered upon tire impact permitting the base of the spike to move downward and damage the deflator bar. No traces of wood were noted on the spikes after penetrating the tire, indicating that the epoxy bond had failed as well. The shattered base blocks also remained on the roadway as debris, something specifically prohibited by the INS sponsor. No further consideration was given to wood as a base block material. Considering the failure of the epoxy bond, and the fact that none of the other materials being considered, e.g., fiberglass, hard rubber, etc., were amenable to a good press fit, the aluminum base blocks were retained in the design.

RAISING & LOWERING MECHANISM

The raising and lowering mechanism for the deflator bar was designed, fabricated, and demonstrated to the INS customer (Fig. 8). Two requirements were that it be portable and raise or lower the deflator bar in 1-2 seconds. Portability was attained via use of a 12V battery capable of cycling the system 75 times without recharging. Total system weight is 35 pounds, sufficiently light to be emplaced by one person.

The motor selected for use is a permanent magnet 28 VDC gearhead motor, made by Dayton Electric of Chicago, with an output of 254 oz-in at 30 rpm. Deflator bar motion

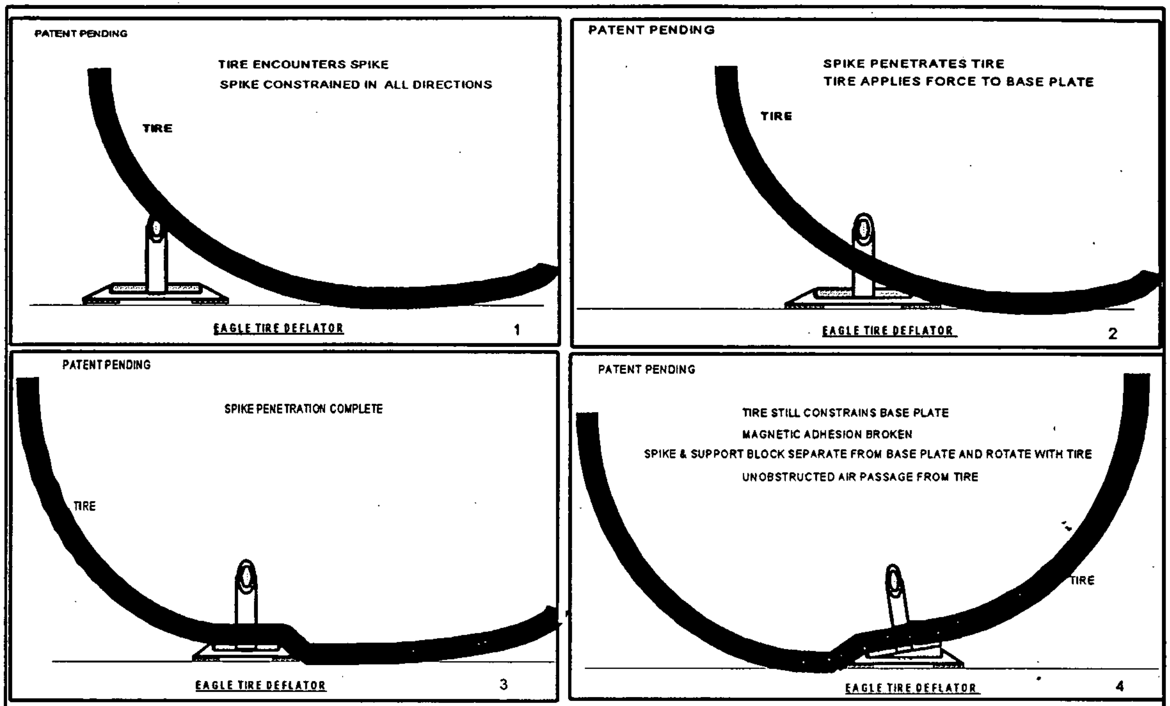
is constrained by an upper and a lower limit switch. These switches are jumpered by back-to-back diodes, resulting in a very simple reversing and motion limiting arrangement that uses no sophisticated electronics (Fig. 9). The motor is powered by the 12 VDC battery referenced above which has 26 amp-hours capacity. Provision is also made for trickle charging the battery, in which mode, the deflator may be cycled indefinitely.

Special attention was given to making the operation of the system simple and user-friendly. A single double-pole, double-throw switch controls deflator bar deployment and retraction. To lower (deploy) the deflator bar, merely push the switch in the direction marked "down", and hold it there until the bar is lowered. Limit switches automatically halt the bar in the horizontal position even if the operator continues to push the switch. To raise (retract) the bar, push the switch in the direction marked "up", and hold until the bar is retracted into its protective sheath. Limit switches automatically stop bar motion when it is positioned in its sheath. Each cycle takes between one and two seconds.

To prevent injuries from accidental contact with the sharp spikes while in the stowed position, sheaths were designed and tested. These sheaths were mounted in a vertical position on the deflator's base plate (Fig. 10). Two designs were tested, one made of PVC pipe and the other, an aluminum frame. The aluminum frame design was selected for implementation based on weight and wind resistance considerations. In the selected design, spike points are shielded from inadvertent contact, but the spikes can be inspected while in the stowed position.

It was considered important that the raising-lowering mechanism remain stationary and undamaged if the deflator bar was accidentally hit by the front end of a car as it was being cycled. Also, under these circumstances, it was desirable the impact minimally damage the vehicle. To this end, the interface between the raising-lowering motor and the deflator bar (the arm lift mechanism) is attached to the motor shaft by an arrangement of pins and magnets. The pins provide an unyielding connection for the raising-lowering torques, while the magnetic connection between the motor shaft and the arm lift mechanism will easily yield if the bar is stuck in the direction normal to rotation. This design has been used in all of the prototype systems and has always functioned as desired.

On May 3rd, 1995, this prototype tire deflator system was successfully demonstrated and delivered to the INS customer. Ensuing discussions have identified the features desired in follow-on models. Follow-on work to further refine the Eagle Tire Deflator for INS and Border Patrol applications is anticipated.

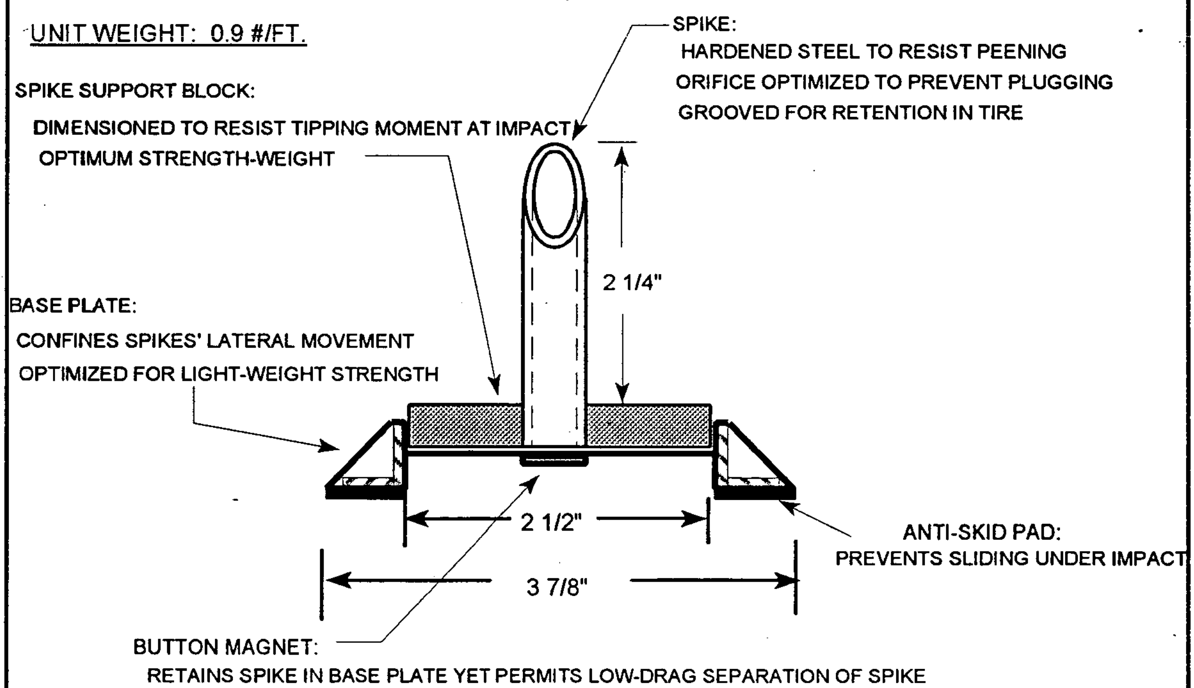


FUNCTIONING OF EAGLE TIRE DEFLATOR

FIGURE 1

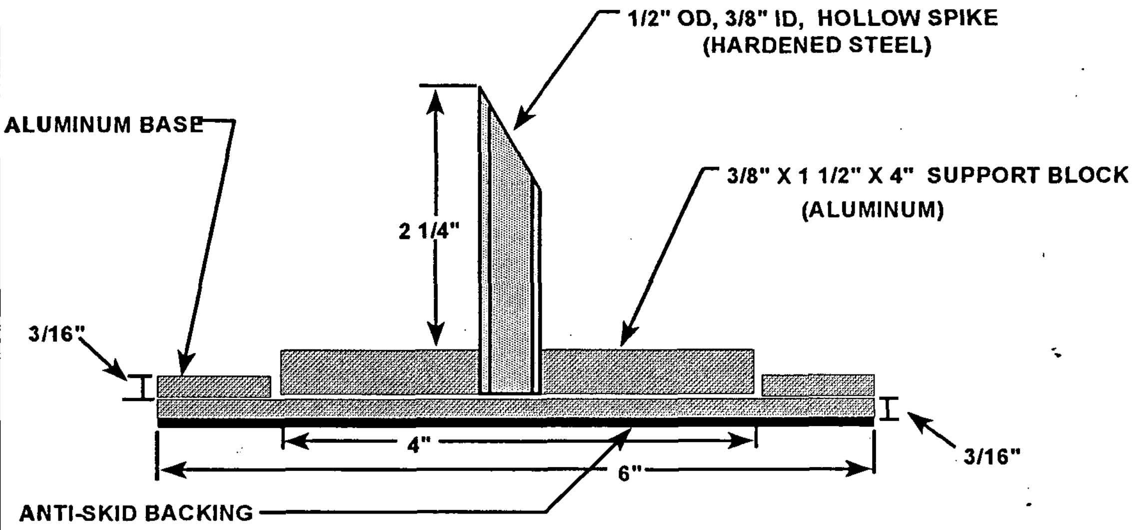
PATENT PENDING; EAGLE RESEARCH GROUP, INC.

UNIT WEIGHT: 0.9 #/FT.



EAGLE TIRE DEFLATOR, PT-4, INS/BORDER PATROL

FIGURE 2

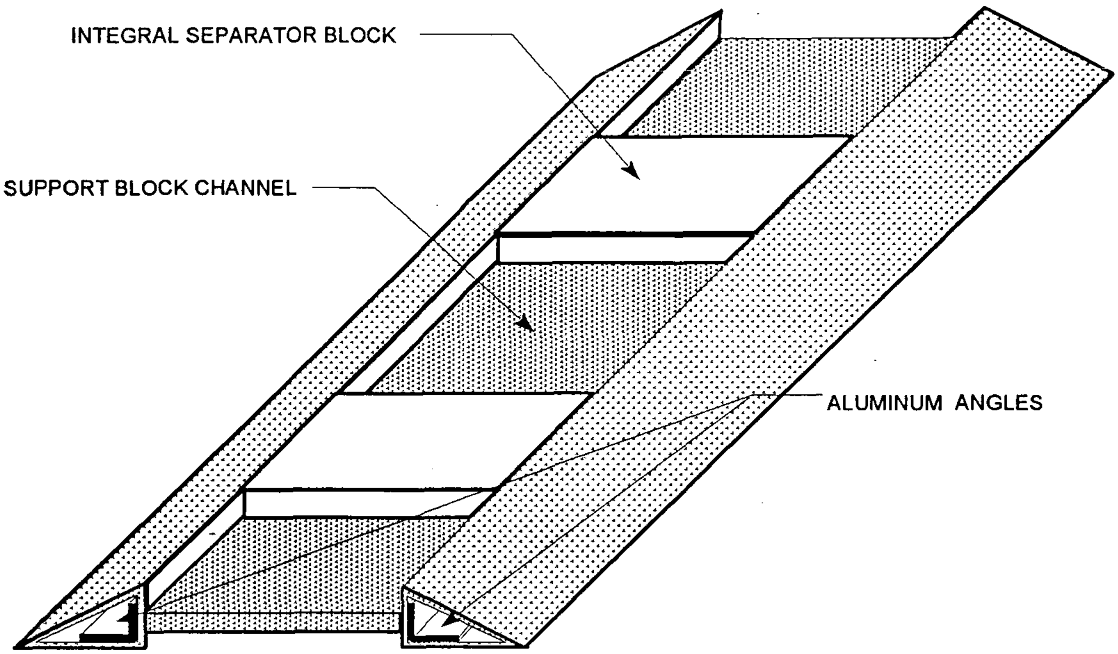


EAGLE PT-1 (ALUMINUM BASE) TIRE DEFLATOR (USCS)

PATENT PENDING

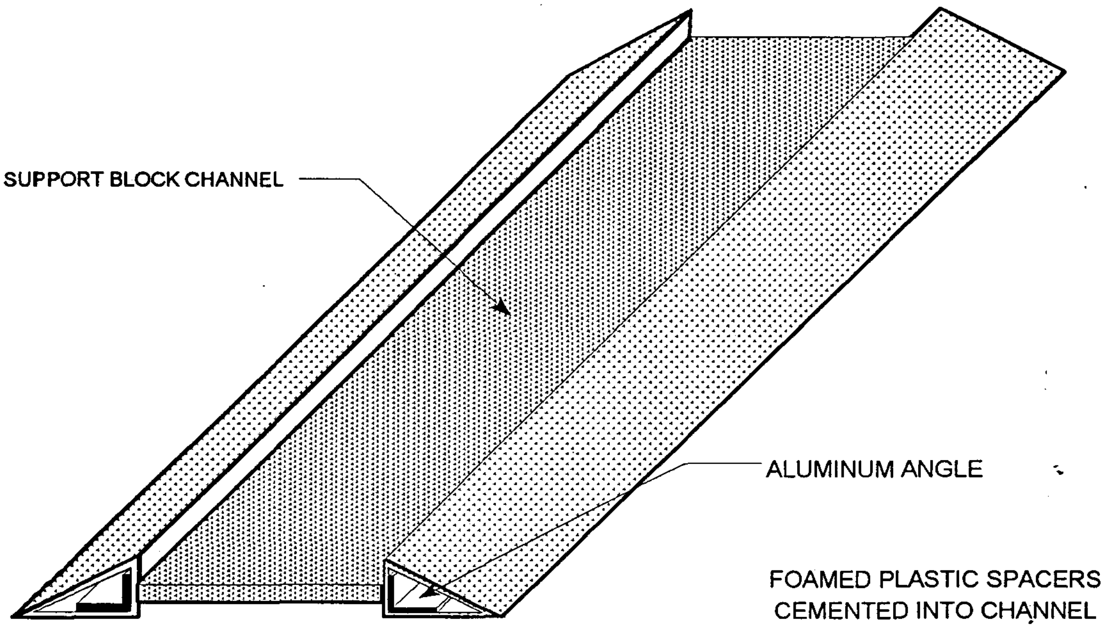
FIGURE 3

BSS: 2/23/94



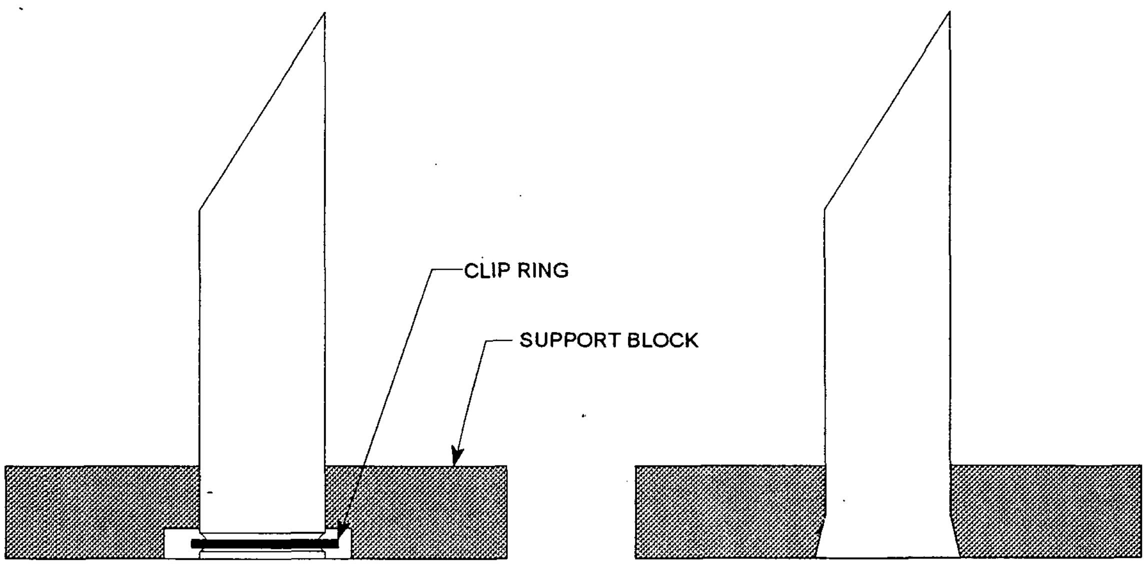
ORIGINAL FIBERGLASS-REINFORCED-EPOXY DEFLATOR BAR

FIGURE 4



NEW BASE FRP BASE PLATE DESIGN USED IN INS DEFLATORS

FIGURE 5



PRESENT DESIGN
SPIKE RETAINED BY CLIPRING IN GROOVE

6 A

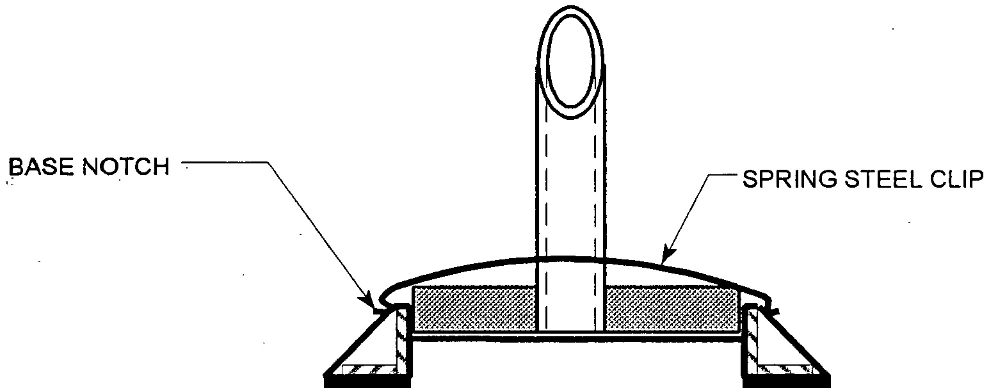
PROPOSED DESIGN
SPIKE BASE FLARED FOR RETENTION

6 B

SPIKE RETENTION MECHANISMS

FIGURES 6 A & B

PATENT PENDING; EAGLE RESEARCH GROUP, INC.



CLIP RELEASES FROM NOTCHES WHEN COMPRESSED BY TIRE

SPRING-STEEL SUPPORT BLOCK RETAINER FOR EAGLE TIRE DEFLATOR

INS MODEL

FIGURE 7

PATENT PENDING; EAGLE RESEARCH GROUP, INC.

EAGLE TIRE DEFLATOR, INS MODEL

STOWED AND DEPLOYED POSITIONS

(PROTECTIVE SHEATH FOR STOWED POSITION NOT SHOWN)

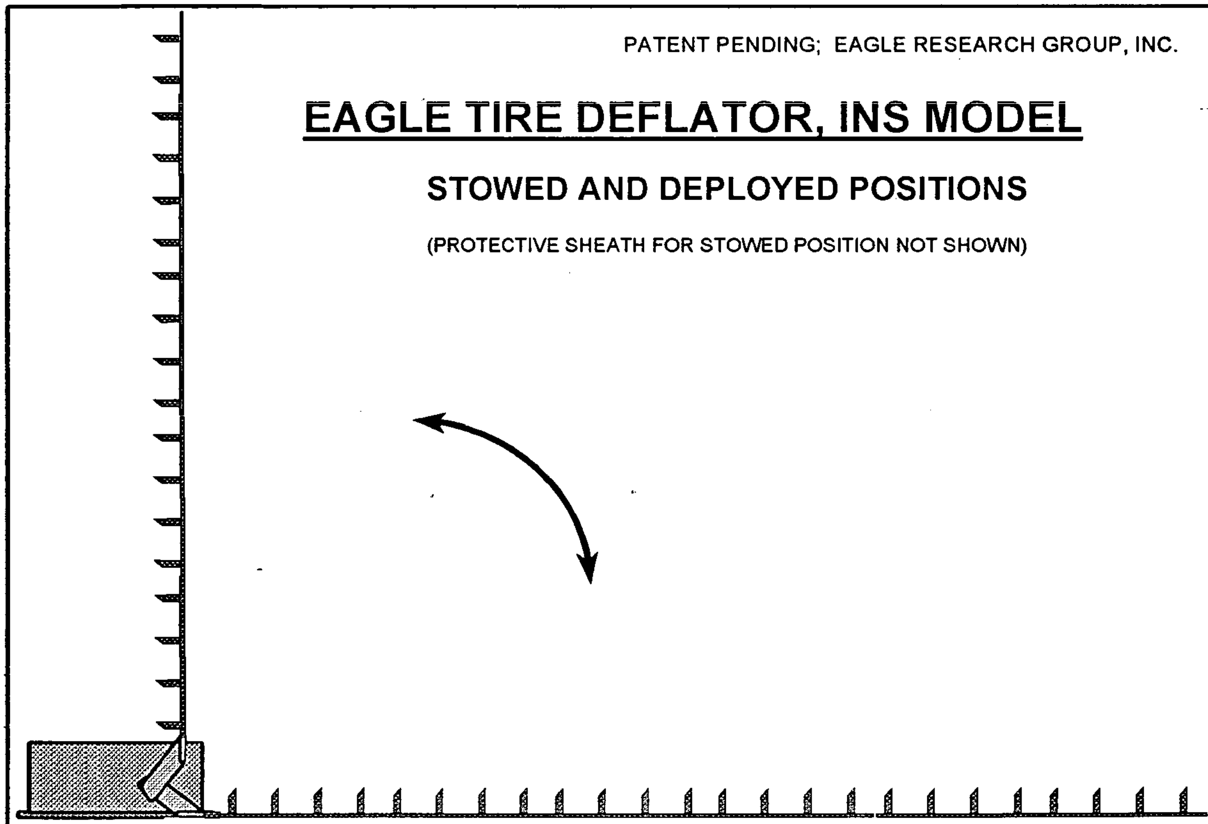
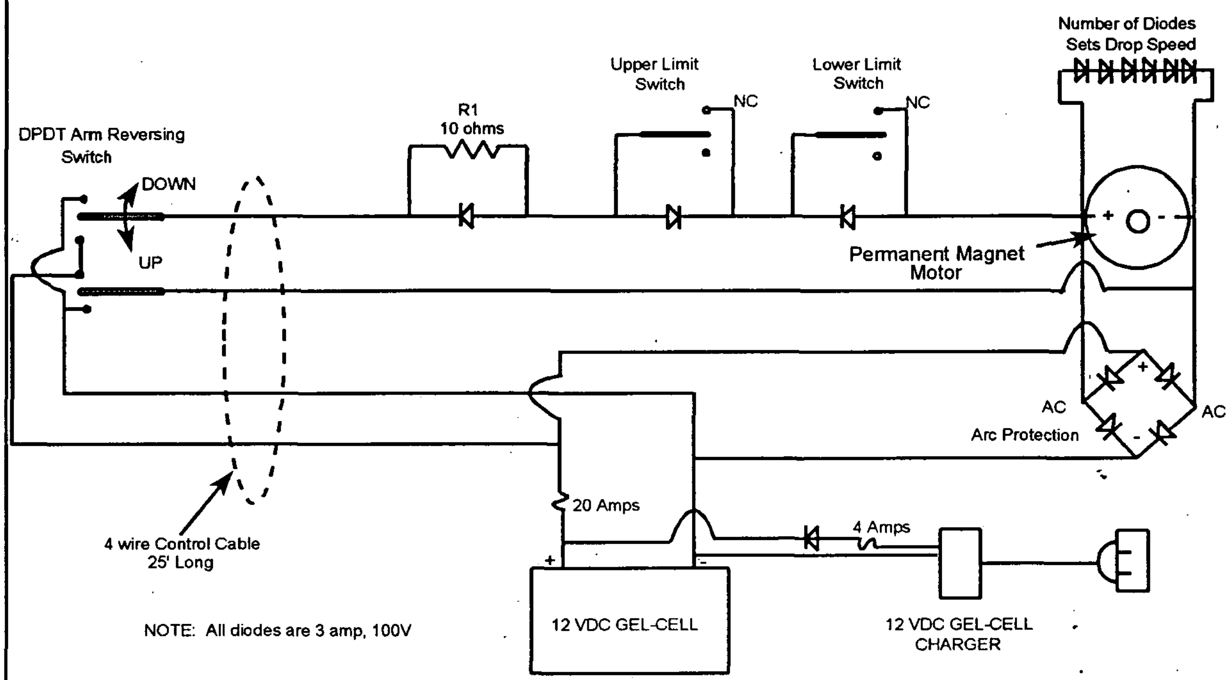


FIGURE 8



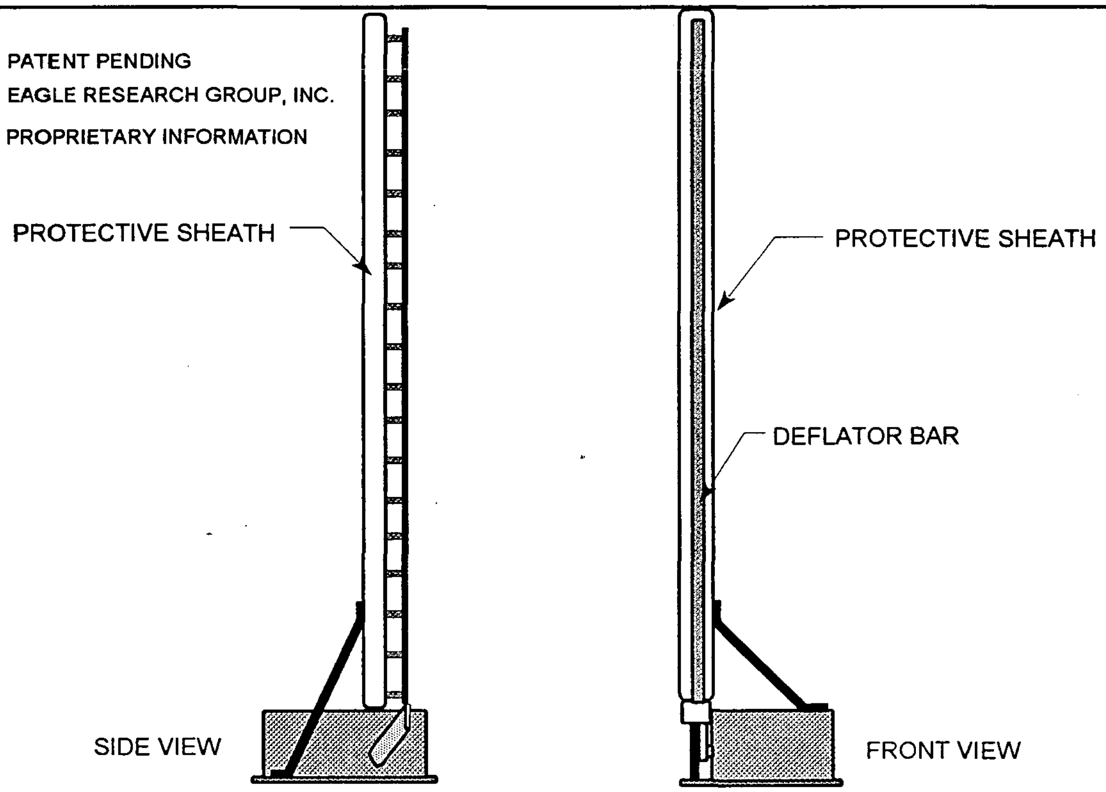
DEFLATOR DEPLOYMENT MECHANISM SCHEMATIC

FIGURE 9

PATENT PENDING

EAGLE RESEARCH GROUP, INC.

PROPRIETARY INFORMATION



EAGLE TIRE DEFLATOR, INS MODEL, STOWED

FIGURE 10

U.S. DEPARTMENT OF JUSTICE
OFFICE OF JUSTICE PROGRAMS
NATIONAL INSTITUTE OF JUSTICE

PROJECT REVIEW FORM

GRANT/CONTRACT #: 94-IJ-CX-0055

GRANT/CONTRACT TITLE:	GRANTEE/CONTRACTOR NAME AND ADDRESS:
Tire Deflator System for Use at Law Enforcement Checkpoints	Eagle Research Group, Inc. 1110 North Glebe Road, Suite 1090 Arlington, VA 22201

PROJECT DIRECTOR AND ADDRESS:	FUNDING LEVEL THIS PHASE:	TOTAL LEVEL
Mr. Bert Soleau (Same as Grantee) Tel 703-234-9400	$ 78,000	Same
	PROJECT PERIOD THIS PHASE: 9/1/94-2/28/95	TOTAL PERIOD: 9/1/94-2/28/95

PRODUCTS

	TITLE AND AUTHOR	DATE SUBMITTED
1.	"Tire Deflator System for Use at Law Enforcement Checkpoints"	4/30/95
2.		
3.		
4.		

PROJECT MONITO[R]

		FROM	TO
1.	David G. Boyd	9/1/94	Present
2.			
3.			

OUTSIDE REVIEWERS

	NAME AND TITLE
1.	
2	
3	

STAFF REVIEWERS

1	Dr. Raymond Downs	3.	
2		4	

	DATE:
PROJECT REVIEWER: David G. Boyd	
DIVISION DIRECTOR:	
OFFICE DIRECTOR: David G. Boyd, NIJ/OST	10/24/95

(CONTINUED ON REVERSE)

I. FINDINGS AND SUBSTANTIVE QUALITY

Grant Manager's Assessment Report

Provide a narrative assessment *not to exceed 200 words* describing the following: problem addressed and major objectives, accomplishments, activities undertaken, principal findings and documents produced. This report will be entered into the Grant Profile System (PROFILE). For further clarification of the requirements, see chapter 7 of the effective edition of OJP HB 4500.2.

The purpose of this project was to design, fabricate and test a lightweight tire deflation device. The device is envisioned for use at law enforcement road blocks to rapidly stop a vehicle that attempts to evade security checkpoints such as those operated by the Border Patrol and U.S. Customs. The device uses relatively large, approximately 0.5 inches, hollow spikes attached to a special bar. The spikes are pulled out of the holder by penetration through the tire and the air in the tire will rapidly escape through the hollow spikes. This bar is mounted in a vertical position by a roadway and is deployable rapidly at a short distance from the checkpoint site by an officer observing an attempted unlawful flight. The deployment is accomplished by remote activation of the device. The system has an independent power supply, deploys and retracts in 1-2 seconds, instantly deflates steel-belted radial tires, leaves no roadway debris after use, exhibits minimal tendency to displace when being run over, has a protective sheath for the spikes when in the stowed position, and is easily emplaced by one person.