



DTIC FILE COPY

2

Laboratory Note No. 90-81

AD-A232 777

# Issues in the Development of the AIDMAN VISION SCREENER

J.D. Gunzenhauser

Division of Ocular Hazards

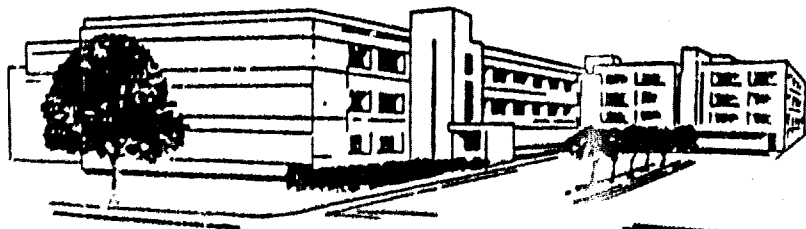
**BEST  
AVAILABLE COPY**

DTIC  
ELECTE  
MAR 14 1991  
S B D

DISTRIBUTION STATEMENT A

Approved for public release;  
Distribution Unlimited

December 1990



LETTERMAN ARMY INSTITUTE OF RESEARCH PRESIDIO OF SAN FRANCISCO CALIFORNIA 94129

91 3 11 084

This document has been approved for public release and sale; its distribution is unlimited.

Destroy this report when it is no longer needed. Do not return to the originator.

Citation of trade names in this report does not constitute an official endorsement or approval of the use of such items.

This material has been reviewed by Letterman Army Institute of Research and there is no objection to its presentation and/or publication. The opinions or assertions contained herein are the private views of the author(s) and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense. (AR 360-5)

  
DONALD R. CORBY  
COL, MC  
Commanding

  
(date)

## REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                            |                                                                                                    |                                   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|----------------------------------------------------------------------------------------------------|-----------------------------------|
| a. REPORT SECURITY CLASSIFICATION<br>UNCLASSIFIED                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            | 1b. RESTRICTIVE MARKINGS                                                                           |                                   |
| a. SECURITY CLASSIFICATION AUTHORITY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                            | 3. DISTRIBUTION/AVAILABILITY OF REPORT<br>Unlimited Distribution                                   |                                   |
| b. DECLASSIFICATION/DOWNGRADING SCHEDULE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                            |                                                                                                    |                                   |
| 1. PERFORMING ORGANIZATION REPORT NUMBER(S)<br>LABORATORY REPORT NO. 90-81                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                            | 5. MONITORING ORGANIZATION REPORT NUMBER(S)                                                        |                                   |
| 6a. NAME OF PERFORMING ORGANIZATION<br>Letterman Army Institute of Research                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 6b. OFFICE SYMBOL<br>(If applicable)       | 7a. NAME OF MONITORING ORGANIZATION<br>United States Army Medical Research and Development Command |                                   |
| 6c. ADDRESS (City, State, and ZIP Code)<br>Letterman Army Institute of Research<br>Division of Ocular Hazards<br>Presidio of San Francisco, CA 94129-6800                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                            | 7b. ADDRESS (City, State, and ZIP Code)<br>Fort Detrick,<br>Frederick, MD 21701-5012               |                                   |
| 8a. NAME OF FUNDING/SPONSORING ORGANIZATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 8b. OFFICE SYMBOL<br>(If applicable)       | 9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER                                                    |                                   |
| 6c. ADDRESS (City, State, and ZIP Code)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                            | 10. SOURCE OF FUNDING NUMBERS                                                                      |                                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                            | PROGRAM<br>ELEMENT NO.<br>62787                                                                    | PROJECT<br>NO.<br>A878            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                            | TASK<br>NO.<br>878/BA                                                                              | WORK UNIT<br>ACCESSION NO.<br>163 |
| 11. TITLE (Include Security Classification)<br>Issues in the Development of the AIDMAN VISION SCREENER                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                            |                                                                                                    |                                   |
| 12. PERSONAL AUTHOR(S)<br>Jeffrey D. Gunzenhauser                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            |                                                                                                    |                                   |
| 13a. TYPE OF REPORT<br>Laboratory Report                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 13b. TIME COVERED<br>FROM Nov 90 TO Nov 90 | 14. DATE OF REPORT (Year, Month, Day)<br>90, December                                              | 15. PAGE COUNT<br>18              |
| 16. SUPPLEMENTARY NOTATION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                            |                                                                                                    |                                   |
| 17. COSATI CODES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                            | 18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)                  |                                   |
| FIELD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | GROUP                                      | SUB-GROUP                                                                                          |                                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                            | Eye injuries, laser injuries, screening, vision screening, military medicine.                      |                                   |
| 19. ABSTRACT (Continue on reverse if necessary and identify by block number)<br>The potential threat of laser-induced eye injuries on the modern battlefield is both real and significant. The response of the Army Medical Department to perceived or actual use of laser devices will derive from the tools available to its personnel and from the training which they have received. The recent publication of Field Manual 8-50 "Prevention and Medical Management of Laser Injuries" represents a significant step in the Army's efforts to educate medical personnel about ocular laser injuries. Nonetheless, there is still a large need to develop screening devices and doctrine which will facilitate the prompt and accurate evaluation of potential laser casualties. The AIDMAN VISION SCREENER was developed to partially fill this void. This report summarizes both the design of the device and the primary issues which have been considered in its development. These considerations include a review of fundamental issues associated with the employment any screening device and unique issues associated with the assessment of retinal injuries resulting from laser exposure. Suggestions are made for future improvements of the device and for the need to develop other related devices. |                                            |                                                                                                    |                                   |
| 20. DISTRIBUTION/AVAILABILITY OF ABSTRACT<br><input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                            | 21. ABSTRACT SECURITY CLASSIFICATION<br>UNCLASSIFIED                                               |                                   |
| 22a. NAME OF RESPONSIBLE INDIVIDUAL<br>Donald G. Corby, COL, MC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                            | 22b. TELEPHONE (Include Area Code)<br>(415) 561-6300                                               | 22c. OFFICE SYMBOL<br>SGRD-ULE-Z  |

## Abstract

The potential threat of laser -induced eye injuries on the modern battlefield is both real and significant. The response of the Army Medical Department to perceived or actual use of laser devices will derive from the tools available to its personnel and from the training which they have received. The recent publication of Field Manual 8-50 "Prevention and Medical Management of Laser Injuries" represents a significant step in the Army's efforts to educate medical personnel about ocular laser injuries. Nonetheless, there is still a large need to develop screening devices and doctrine which will facilitate the prompt and accurate evaluation of potential laser casualties. The AIDMAN VISION SCREENER was developed to partially fill this void. This report summarizes both the design of the device and the primary issues which have been considered in its development. These considerations include a review of fundamental issues associated with the employment of any screening device and unique issues associated with the assessment of retinal injuries resulting from laser exposure. Suggestions are made for future improvements of the device and for the need to develop other, related devices.

|                      |                                            |
|----------------------|--------------------------------------------|
| <b>Accession For</b> |                                            |
| NTIS GRA&I           | <input checked="checked" type="checkbox"/> |
| DTIC TAB             | <input type="checkbox"/>                   |
| Unannounced          | <input type="checkbox"/>                   |
| Justification        |                                            |
| By                   |                                            |
| Distribution/        |                                            |
| Availability Codes   |                                            |
| Dist                 | Avail and/or<br>Special                    |
| A-1                  |                                            |



# Issues in the Development of the AIDMAN VISION SCREENER

Jeffrey D. Gunzenhauser, MD

## Introduction

The potential for laser-induced ocular injuries on the modern battlefield presents a significant challenge to the Army Medical Department (AMEDD). The identification and characterization of an injury restricted to the posterior pole of the retina may be difficult under the best of circumstances. In the Combat Zone, where rapid and accurate assessment of fitness is crucial in keeping healthy soldiers on the front line, this difficulty will be enhanced. Normally, medical assets with advanced diagnostic and therapeutic capabilities are located in the Communications Zone, at a considerable distance from those soldiers at greatest risk of injury. The time-critical nature of certain laser-induced injuries dictates prompt evacuation to the rear, while the high likelihood of "losing" soldiers who are inappropriately evacuated warrants restraint in the evacuation of those with borderline findings. Considerations such as these underlie current efforts to develop doctrine and screening tools which will support the AMEDD mission of conserving the fighting strength.

Historically, the AMEDD has taken two approaches to enhance the availability of optimal medical care for forward soldiers. The first is to place advanced therapeutic tools in the hands of medical assets organic (i.e., assigned) to combat units so that care can be provided "as far forward as possible". The second is to develop and maintain an efficient system of evacuation so that casualties can be rapidly brought to rear medical elements. The success of the second approach is largely dependent upon the ability of medical personnel to employ simple, accurate triage criteria and to minimize morbidity during the evacuation process. Therapeutic modalities which can treat laser injuries on the front line are not expected in the near future. Therefore, current efforts to optimize laser casualty management should focus on the second approach. Although adjuncts to minimize morbidity during evacuation of laser eye injuries deserve serious consideration, the primary concern of this discussion is the method by which potential injuries will be assessed and triaged.

The evaluation of soldiers who report exposure to a potential laser emission requires unique skills and knowledge. The purpose of this evaluation is to substantiate symptoms with some type of objective finding so that appropriate triage can be accomplished. Unlike most combat-associated injuries and disease, isolated retinal injuries which produce significant visual loss may manifest no signs which can be easily recognized by the forward medic or unit surgeon. Soldiers who report total blindness in one or both eyes may appear otherwise healthy. The findings upon external examination of severely injured eyes will most likely be entirely normal. Internal examination of the eye will require topical cycloplegic agents, a darkened chamber, and an ophthalmoscope. Such materiel and conditions may not be available in the Combat Zone. Even if available, certain types of laser-induced injury may be difficult for any but a skilled ophthalmologist to recognize. As a result, Combat Zone medical personnel are likely to find no evidence of injury when examining soldiers with significant visual loss. Appropriate assessment must, therefore, rely upon measures of visual function rather than upon discovery of abnormal physical findings. As such, the current challenge is to develop and field an appropriate diagnostic tool which aids forward medical personnel in their efforts to identify "significant" laser eye injuries.

The newly fielded Army Field Manual 8-50, "Prevention and Medical Management of Laser Injuries,"<sup>1</sup> represents a major milestone in the Army's efforts to educate medical personnel about ocular laser injuries. Scientists here at LAIR made a significant effort to support the Academy of the Health Sciences in producing this work (see Acknowledgement). As the final version of the document went to press, specific evaluation procedures for an aidman or other medical person at the Division level were still in debate. In response, we developed the "AIDMAN VISION SCREENER". The term "AIDMAN" is included in the title to emphasize the important role of first echelon medical screeners in the management of potential laser eye injuries. The vision screener is currently under development; we hope a product will be fielded within the next year. The purpose of this paper is to consolidate in a single document key considerations in this developmental effort.

### Background Considerations

Before any effort can be made to develop appropriate diagnostic procedures, we should be clear on the purposes and limitations associated with attempts to develop and field a screening device for combat laser injuries. Clarity on these issues at this time will help us to evaluate whatever incremental improvements we may consider in the future. First, we must establish the ends to which the particular screening test will be used. Second, we should consider those limitations which are inherent in any application of clinical screening tests. Third, I will review what I consider to be unique difficulties inherent in the diagnosis of laser-induced ocular injuries. Finally, with these caveats in mind, the characteristics of the proposed AIDMAN VISION SCREENER will be discussed.

Two primary reasons exist for the expeditious evaluation and management of combat casualties. The first is to ensure that optimal medical care is provided to injured personnel. Table I is a modification of a table published in "A report of the working group of experts on battlefield laser weapons"<sup>2</sup>, a report prepared under the guidance of the International Committee of the Red Cross and hereafter referred to as the "Red Cross report". A "Medical Treatment" column has been included to emphasize that no form of medical treatment is currently recommended in the management of these injuries. Nonetheless, certain surgical procedures are indicated for management of vitreous hemorrhages. Furthermore, other treatment options (surgical or medical) may become available within a few years. Figure 1 (also extracted from the Red Cross report) indicates that a certain degree of time urgency is associated with the management of these injuries. Currently, the urgency required is on the order of days, not minutes or hours. This must be borne in mind when considering that laser injuries are but one of many types of injury which may be encountered on the modern battlefield, and that some of these injuries will demand more immediate medical attention. Nonetheless, expeditious evaluation of potential laser-induced injuries does represent state-of-the-art medical care.

The second reason to rapidly identify and evacuate soldiers with significant eye injuries is so that military units supported by the medics can continue their assigned mission. Ensuring the medical fitness of those called upon to fight has always been one of the key functions of the AMEDD. A soldier in the front line whose visual function has been compromised is not only at increased risk of further injury to him/herself, but also represents a significant liability to his/her unit. Reading, driving, and identifying targets are among the many military tasks which laser-injured soldiers may be unable to perform.

The capability of individuals and units to survive on the battlefield relies upon the preservation of these abilities. Therefore, to prevent further harm, the "medics" must rapidly identify and evacuate soldiers with significant laser-induced eye injuries, thereby allowing other medically fit troops to be brought in as replacements.

Each of the reasons discussed above justifies the need for a screening device which will aid medics on the front line in the evaluation of soldiers with potential laser-induced eye injuries. The specific purpose of this device is to accurately categorize the presence or absence of "significant" injury in individuals presenting for evaluation. Further refinement of this purpose must include a specific definition of those findings which are "significant" and necessarily involves the enumeration of the medical outcomes which can be anticipated in any battlefield environment that includes lasers. Furthermore, the performance criteria of any such device must be considered within the context of the entire evacuation system, evaluating how it (i.e., the device) contributes to the whole in the management of individual casualties. The first step in such a consideration is to define how well the particular device performs. At this point, it is therefore appropriate to review certain fundamental aspects of clinical screening tests.

It is common knowledge that no medical test is perfect. A screening device for laser eye injuries will certainly not be an exception to this rule. Performance characteristics of screening or diagnostic medical tests are summarized in Figure 2. The items listed under the heading of "Screening Test 'Jargon'" are those typically considered as measures of test performance. Ideally, we desire a test with perfect sensitivity and specificity. For each patient who presents with a potential laser eye injury, we would like to state accurately that "You have a significant eye injury" or "You do not have a significant eye injury." In the real world, however, any screening test will incorrectly categorize the "disease" or "injury" status of at least some individuals. This is particularly clear considering that among experts there is no current consensus concerning "significant" eye injury. Our current ability to evaluate potential laser-injury screening devices is severely limited by the paucity of injury cases in whom the performance criteria of each particular test could be evaluated. This means that not only are we unable to develop a perfect test, but also we are unable to determine the degree of imprecision of any particular test. These limitations should not, however, prevent us from using our best judgment.

In the battlefield environment, test inaccuracy means that on some occasions we will incorrectly label someone who has a significant laser eye injury as having "no injury" (i.e., a false negative). This individual will be returned to duty, perhaps leading to further harm to the individual or compromising to some degree the effectiveness of his or her unit. In other situations, we will incorrectly indicate that individuals without a significant eye injury have a serious injury (i.e., a "false positive"). In this case, we will evacuate an individual to the rear who could have been returned to duty. The costs to the medical and personnel systems with recycling incorrectly diagnosed soldiers and replacing evacuees with "fresh" replacements are not trivial. Therefore, our efforts to correctly categorize patients are important.

With these fundamental characteristics of screening tests in mind, the next step in developing any particular device is to enumerate the types of conditions which can be expected in the population of soldiers who may present as potential laser injuries. In the Red Cross report, ocular reactions to radiation are classified as either "temporary" or "permanent" (see Table II). There are several significant features of this classification

systems which deserve emphasis. First, there is a clear recognition of a threshold below which ocular reactions are only temporary in nature. In an environment where lasers are of low or medium power; where soldiers may be using various protective devices; and where the exposure received by any particular individual is a function of distance, location, and atmospheric conditions, it is easy to imagine that sub-threshold exposures will occur. If the lasers in use operate in the visible spectrum, then these exposures will result in flashblindness and dazzle effects. In a typical engagement in which lasers may be used in an anti-personnel mode, a unit in which a few individuals sustain serious ocular damage is likely to have at least as many others who sustain off-axis or sub-threshold exposures. The ratio of permanent to temporary reactions in any particular battle may vary. In some situations permanent effects may predominate, in others the reverse may be true.

The variability in the permanent-temporary reaction ratio (P-T ratio) has significant implications for any screening test which we may devise. If the P-T ratio is high, then the actual prevalence of significant injury among those reporting some type of exposure will be high. If the P-T ratio is low, then the injury prevalence will be low. In other words, there is a direct relationship between the P-T ratio and disease prevalence. As indicated in the bottom portion of Figure 2, the predictive value of any screening test is dependent upon the prevalence of injury in the population. Thus, even if we devise a test with acceptable sensitivity and specificity, its ability to accurately categorize patients will vary depending upon the prevalence of true laser eye injuries in the population. Hence, the variability of the P-T ratio will confound any effort to devise an "optimal" screening test.

A second important point inherent in Table II is the great diversity among the permanent effects of radiation exposure. Whether or not a soldier can be returned to duty is a function not only of whether one of these types of reactions has occurred, but also how large the injury is and where on the retina it is located. In addition, Type B vitreous hemorrhages (i.e., those in which the blood diffuses throughout the vitreous) may take time to evolve. Most research on the ocular effects of laser eye injuries has been performed in animal models. The distinction between Type A and Type B vitreous hemorrhages has not been previously emphasized. From the information contained in the Red Cross report, it appears that Type B vitreous hemorrhages may occur with greater frequency among humans than among animals. Therefore, our strategies to correctly diagnose and manage potential laser eye injuries must consider the possibility that injuries may evolve over time.

As previously mentioned, one of the key challenges in developing a laser injury vision screener is to define the types of injury which are significant. Table III, which is derived from a listing in the Red Cross report, emphasizes the variability of the injury spectrum which can be anticipated among blind, self-reporting casualties. The report states that with the exception of "central thermal burns," these conditions are "easy to see for field station staff using only an ophthalmoscope." While the difficulty inherent in correctly identifying cases of "central thermal burn" (presumable small- or medium-sized lesions) is recognized, it is not as clear that all of the other conditions are "easy to see." The recognition of obscurants or objects not located on the surface of the retina (such as a vitreous hemorrhage) demands more than a modicum of skill from the examining clinician. Furthermore, Type B vitreous hemorrhages may require time to develop, so that incipient forms may be easily missed, especially if the source lesion is located in the retinal periphery.



The approach to triage in the Red Cross report is diagnosis-based. The burden is placed upon the clinician in the field to specifically identify the presence and nature of the injury which the soldier has sustained so that appropriate management and treatment algorithms can be employed. This approach requires that the front-line medic or battalion surgeon (who in the US Army is likely to be a Physician Assistant) look into the soldier's eye with an ophthalmoscope and correctly identify the type of pathology, if any, that is present. The primary advantage of this method is that once an injury is visualized, there is little doubt that an injury has occurred. An inherent disadvantage, however, is that unless one intends to evacuate all soldiers with any degree of injury, someone still must decide which soldiers require evacuation. What are the criteria, for example, by which one distinguishes "small" from "large" and "central" from "non-central" foveal burns? The zealous approach of evacuating all injuries would most certainly result in a costly, high "false positive rate." A further disadvantage is that the availability of ophthalmoscopes and the abilities of front-line medical personnel to correctly assess and diagnose categories of laser-induced ocular injuries is assumed. This assumption is far from trivial. The most likely outcome is that many lesions would, in fact, be missed, resulting in a high "false negative rate." In summary, the triage scheme inferred in the Red Cross report does not address a number of important issues and is likely to lead to unacceptably high false positive and false negative rates. I believe its major flaw lies in its reliance upon direct ophthalmoscopy as the primary screening procedure. A different approach is needed.

#### **AIDMAN VISION SCREENER: Design**

Here at the Letterman Army Institute of Research a prototype screening device has been developed. Named the AIDMAN VISION SCREENER, the test was developed with the Army medic in mind. As such, it is a small, portable device which can be used and interpreted by following a few, simple instructions. Although no testing has been conducted to formally evaluate its performance, its form and purpose have been subjectively reviewed by a number of "experts" in the field. This section describes the structure of the device and reviews a number of related developmental issues.

The AIDMAN VISION SCREENER is a function-based test. Rather than assessing for the presence and nature of specific injuries within the orbit, the VISION SCREENER assesses the function of the eye. This approach allows two distinct injury mechanisms to have nearly identical functional outcomes. A corollary is that nearly identical retinal lesions may have grossly different effects on visual function. The primary advantage of the VISION SCREENER is that it is simple to use, providing clear guidance on what is and what is not a "significant" injury. Its main disadvantage is that soldiers can be evacuated without any physical evidence of injury, thereby allowing for the possibility of malingering. Although not addressed further in this report, this last concern is a serious one which deserves thoughtful and thorough analysis so that effective strategies to minimize malbehavior can be implemented.

The AIDMAN VISION SCREENER consists of two distinct visual function tests. The first is a near visual acuity test (Figure 3). The second is a foveal (AMSLER GRID) visual field test (Figure 4). Both tests are found on opposite sides of an 11 x 18 centimeter card which can be carried easily by any medic performing his/her normal duties. The two tests are applied in sequence. From the point of view of identifying a "significant" laser injury, if the soldier "fails" the near visual acuity test, there is no need to perform the foveal grid

test. If the soldier "passes" the near visual acuity test, then the foveal grid test is administered. The main purpose for including the foveal grid test is to identify soldiers who have normal visual acuity with large visual field defects. It should be clear to everyone that preserved central visual acuity does not necessarily equate with "adequate" visual function. The concept of looking at the world through a straw (though admittedly an extreme case) makes it is easy to grasp the idea that certain injuries which spare central visual function may severely limit the ability of soldiers to perform mission-essential tasks.

The near visual acuity screener could potentially assume a number of forms. Inasmuch as its purpose is to test a specific acuity threshold, a single line of targets would be satisfactory, at least theoretically. If, for example, we define that soldiers with visual acuity worse than 20/50 are to be evacuated, then only the 20/50 line is required. The inclusion of multiple lines of differing acuity levels has many advantages, however. These include the ability to assess changes in visual acuity over time, to down-play a specific threshold so that malingers may be more easily discouraged, and to provide a diversity of targets so that subjects will not be able to simply memorize a single row. We have adopted E's rather than Snellen acuity letters for a number of reasons. First, each "E" in a particular acuity row is an equivalent acuity target; whereas, different Snellen acuity letters in the same row may nominally have slightly different acuity requirements. Second, when a chart full of E's is rotated into any of four positions all of the answers are changed, easily discouraging attempts at memorization. Third, in the event that subjects are unable to speak in English (owing to language or injury), answers can be provided with directional signals. Alternatively, Landolt rings could be employed in lieu of E's and similar results could be expected. An acuity threshold of 20/50 was chosen as we feel that soldiers with this level of acuity can perform virtually all critical military tasks.

In a similar fashion, the design and criteria of evaluation for the foveal (AMSLER) grid test is open to modification. As stated in the instructions printed on the card, it should be held approximately two card-lengths (36 centimeters = 14.2 inches) from the eye. At this distance, a target with a 10-centimeter diameter (i.e., the grid) subtends a visual angle of 15.8°. Each of the small squares on the grid subtends an angle of approximately 0.8 degrees. A schematic diagram showing the region of the retina which is tested by the grid is presented in Figure 5. When used as designed, a "Major Defect" is any lesion which is at least 4 boxes long. This corresponds with a visual field defect approximately 3.2 degrees in length. Obviously, much of a soldier's visual field is not tested by the screener. In certain cases, an individual may have an injury which significantly impairs his/her visual fields but is not detected by the VISION SCREENER. For example, a large vitreous hemorrhage might obscure most of the right visual field, but if it only obscures portions of the retina beyond 7 or 8 degrees from the foveal center, normal results would be obtained for both the near visual acuity and foveal grid tests. This example illustrates the difficulty inherent in developing the "perfect test".

A series of potential test outcomes for a set of arbitrarily selected lesions is demonstrated in Figure 6. A brief review of these lesions and their likely test results is instructive. Lesion #1 represents a 3.0° scotoma centered on the fovea. An individual with such a lesion would fail both the near visual acuity test and the foveal grid tests (i.e., since the lesion covers the center dot). Lesion #2 is a similarly sized lesion, but is eccentrically displaced approximately 3.5° to the right of the foveal center. In this case, the injured soldier would pass the near visual acuity test. Since the diameter of the lesion is nearly 4 boxes long, the foveal grid test would reveal an injury just on the threshold of a

"Major Defect." The series of four 1.5°-diameter scotomas represented by lesion #3 demonstrates that while each lesion itself is nominally under the "Major Defect" criteria, the series as a whole clearly exceeds the limit. In the absence of specific guidance, such results may be interpreted differently by various individuals. Lesion #4 is a 5.0° scotoma which is above and to the right of the foveal center, thereby affecting the lower-left visual field. According to the instructions on the card, lesion #4 exceeds the criteria for a "Major Defect." Some might argue that Lesion #2, which is closer to the fovea, is probably more significant than Lesion #4. However, the simple criteria printed on the card do not allow such an interpretation. These examples illustrate that even with a rather simple set of criteria for defining a "significant" laser-induced injury, debate on the results may be expected.

An alternative foveal visual field test which incorporates certain advantageous characteristics is shown in Figure 7. Here a series of concentric rings and common-centered lines create a webwork structure. The criteria here for a "Major Defect" might be that the longest dimension of the lesion must be at least as long as the "perpendicular line" which connects the three nearest rings. The location at which this distance is determined is equal to the distance at which the lesion center-of-mass lies from the foveal center. Examples of lesions which satisfy threshold levels of this distance criteria are demonstrated in the figure. A particularly attractive feature of this "Web screener" is that it allows for grading of lesions in relation to their distance from the fovea. Small lesions close to the fovea may be considered significant, while more eccentric lesions should be larger before reaching a level of equivalent significance. A major drawback in this approach, however, is that the threshold criteria represents a more complex, abstract concept. Also, determining which rings are the "three nearest" could present some difficulty to some observers. Even in clear-cut situations, medical screeners with limited knowledge and skills are liable to misinterpret results.

A further revision of the foveal field screener which incorporates advantages from both of the previous designs is shown in Figure 8. This is a hybrid screener as it includes both the boxes of the Amsler Grid and the concentric rings of the Web version. The main difference of this screener from the two previous versions is that the area of the lesion, rather than its longest dimension, is used as a measure of significance. The area of any particular lesion is estimated in terms of the "approximate" number of boxes which the lesion covers. The threshold size for a Major Defect is indicated by the numbers associated with the various rings. The ring applying to any particular lesion is the one which lies just inside of the lesion's center of mass. An illustrative lesion has been included in the top right portion of the screener. The center of the lesion lies very nearly on, or perhaps just inside of, the ring labeled "8". If the area of the lesion exceeds 8 boxes, it would therefore meet the "Major Defect" criteria. Clearly six whole or nearly whole boxes are located entirely within the region. Since some portion of an additional twelve boxes also lie within the lesion, it is easy to see that the collective area of these additions exceeds two boxes. Therefore, the lesion exceeds the threshold and a "Major Defect" is present. I believe that the task of estimating the area of a lesion in "number of boxes" is only slightly more difficult than estimating its longest dimension (in number of box-lengths). Similarly, I do not believe that it is difficult to estimate the center-of-mass of the lesion relative to the location of the concentric rings. In particular, I believe that the ability to grade lesions in relation to their distance from the foveal center more than compensates for any disadvantage. In my opinion, then, this version of the foveal visual field tester is superior to the other two.

While the first foveal field screener discussed (i.e., the Amsler Grid) has been in clinical use for some time, the last two have not. They were developed solely for the purpose of illustrating and addressing issues raised in this discussion. Therefore, the optimal design for any particular device which follows the guidelines described above is likely to differ at least somewhat from those shown in the figures. As an example, I believe that more concentric rings are required in the "hybrid" version of the screener than I included in Figure 8. To be considered a Major Defect, a lesion centered outside the largest ring probably should have an area of at least 12 to 15 boxes. Observe, for example, that the center-of-mass of Lesion #4 in Figure 4 would fall just outside of ring-7 in the last version of the screener, yet has an area roughly equivalent to 25 boxes.

#### **AIDMAN VISION SCREENER: Utilization**

The purpose of the AIDMAN VISION SCREENER is to serve as an aid in determining which individuals require evaluation at a higher echelon of medical care. Therefore, an "Evacuation Criteria" table is included on the screener (Figure 3). Only one of the cells in this matrix poses any substantial difficulty in terms of the recommendations provided. When an individual has normal visual acuity but has minor abnormalities on the foveal field test, the individual falls into what I consider a "gray zone". As a first response, it is probably prudent to wait a brief period of time to assess the persistence of the findings. Individuals who have experienced flashblindness may return to a "normal" Amsler Grid result after a brief period of observation and may be safely returned to duty. Other individuals with an evolving Type B vitreous hemorrhage may progress to a Major Defect category and require evacuation. Given that the findings are stable, however, some element of judgment is probably required to assess fitness. For certain individuals whose assigned duties involve demanding visual tasks, it may be prudent to remove this individual from his/her position. For others, the reverse may be true. In some cases, it may suffice to ask the individual whether he/she can perform his/her assigned duties. Such an approach would, however, require an added dimension of training for division medical personnel.

The recommendation to "evacuate" does not necessarily mean that the individual is to be removed from the Combat Zone and lost to the unit. Rather, it means that the medic should evacuate the individual to the Battalion Surgeon or that the Battalion Surgeon should evacuate the individual to the Division Clearing Company. At this level, senior medical personnel may have additional screening tests at their disposal (e.g., may be able to verify the presence of an appropriate lesion through direct ophthalmoscopy) or at least have the authority to "make the tough call" on who should be evacuated. In some situations, Division optometry resources may support the evaluation of potential laser injuries. In many situations, however, this may be either inappropriate or infeasible. Because an ophthalmologist is not likely to be found below the level of an Evacuation Hospital, appropriate expertise may not be available in the Combat Zone. This potential highlights the need for the development of further screening tools which can be utilized within the Division in the assessment of possible laser-induced eye injuries.

My view is that the AIDMAN VISION SCREENER should be one of several screening devices available to medical personnel operating in the Combat Zone. Its design should reflect an orientation toward the front-line medic. As a triage tool, it should function to identify which individuals require evaluation by higher medical echelons within the

Combat Zone, not as a strict indicator of who is unfit for duty. The AIDMAN VISION SCREENER should be of maximal sensitivity, ensuring that soldiers with significant laser-induced eye injuries are not returned to duty. Such a device, when applied alone is likely to have an unacceptably high "false positive rate." However, when considered in conjunction with the more precise assessment which will be made by the unit surgeon upon referral by the medic, the overall performance of this screening mechanism should be reasonable.

Within this context, the need for other screening tools within the Combat Zone is apparent. Some of these could provide more sophisticated measures of function while others may facilitate morphological assessment. Certainly battalion and division surgeons who will be called upon to evaluate soldiers forwarded by the medics should have at their disposal one or two tools which will augment the findings of the AIDMAN VISION SCREENER. A portable, easy-to-operate fundus camera which would provide immediate assessment and documentation of retinal pathology would be a tremendous asset to division medical resources. These and other ideas provide a ripe opportunity for immediate development in the near future.

## Summary

The threat of laser injuries on the battlefield is both real and significant. The response of the Army Medical Department to an actual or perceived use of laser devices will derive from both the tools available to its personnel and the training which they have received. Coupled with the recent printing of FM 8-50, the fielding of the AIDMAN VISION SCREENER will represent a major in-road in the Army's effort to ensure that its response will reflect the most current knowledge and state-of-the-art technology.

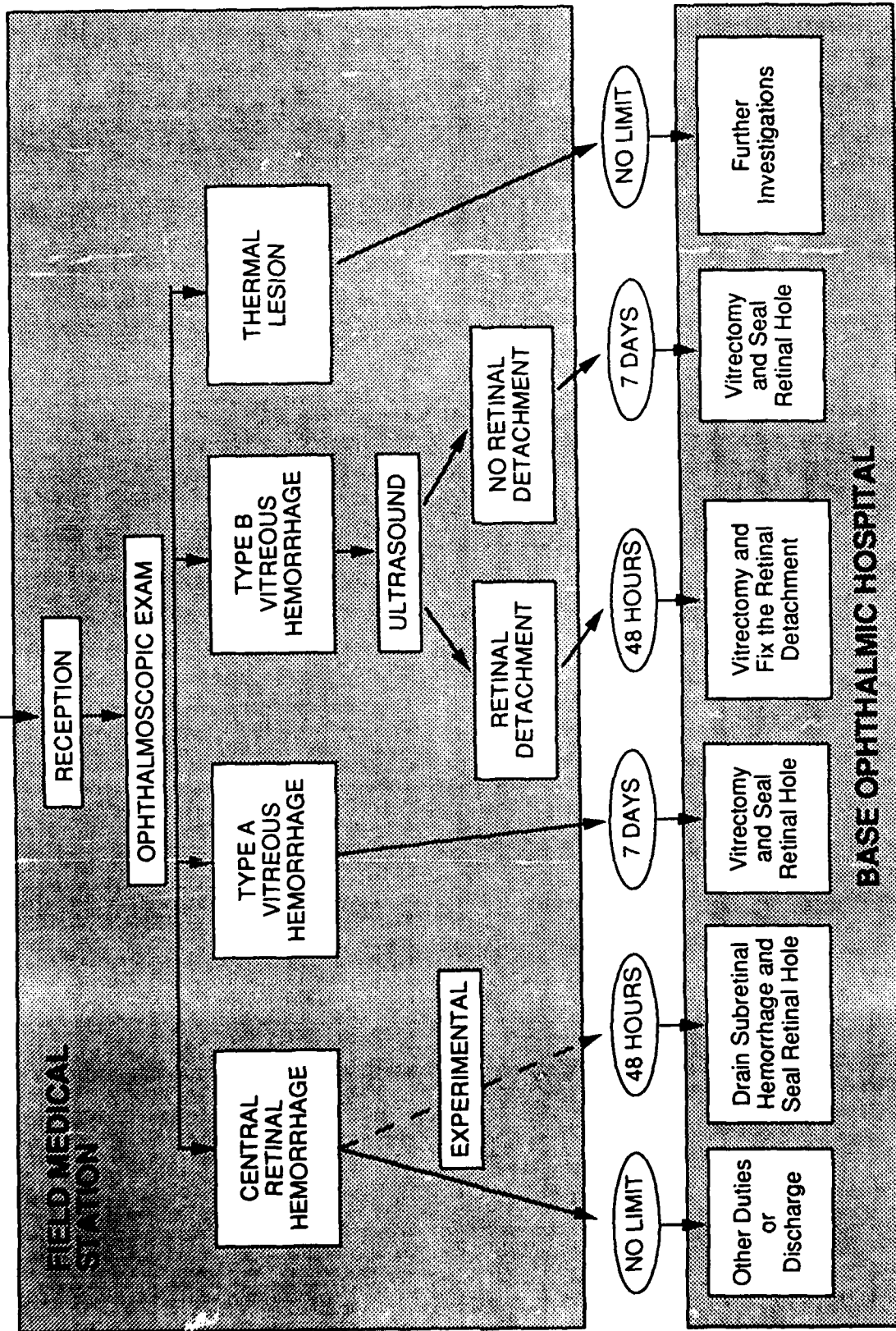
The design of any tool which purports to sort "significant" laser injuries from non-significant conditions encompasses many complex issues. Among these are generic concerns related to the principles of clinical screening and specific issues deriving from the unusual nature and breadth of reactions which may occur when the human retina is exposed to laser radiation. Whatever its form, the AIDMAN VISION SCREENER must be deployed with appropriate training and guidance to ensure that its utilization is compatible with current Army doctrine and structure. Aimed primarily toward the U.S. Army medic, the SCREENER is likely to experience wide application. The need for revision and refinement should be anticipated as additional knowledge and the lessons of experience are compiled. Additional, separate devices which match the needs and capabilities of other highly trained medical assets in the division must also be developed. Collectively, such an effort, when approached comprehensively and conscientiously, will ensure an optimal response to whatever laser threat may be encountered.

Acknowledgement. The ideas expressed in this paper were derived largely in response to meetings and conversations which occurred during the drafting of FM 8-50. In this regard, I would like to recognize a number of individuals whose participation and support during this period were instrumental in my work. These include: Dr. Robert Mosebar of the Academy of the Health Sciences (Ft. Sam Houston, TX) and Mr. Bruce Stuck, Dr. Harry Zwick, Dr. Dave Randolph, and MAJ Kathryn Knudson of the Division of Ocular Hazard. In addition, I would like to thank Mr. Bruce Stuck, MAJ Thomas Burke, and Mrs. Susan Siefert for their valuable suggestions in the final preparation of this manuscript.

**Reference**

- 1 FM 8-50, Prevention and Medical Management of Laser Injuries. August 1990.
- 2 International Committee of the Red Cross. A report of the Working groups of experts on battlefield laser weapons. Geneva, 31 May - 01 June 1990.

**Figure 1.**  
**EYE-INJURED SOLDIER**



Source: International Red Cross, A Report on the Working Group of Experts on Battlefield Laser Weapons, page 29.

**Figure 2.**  
**Performance Characteristics of**  
**Screening Tests**

|                             |          | Injury/Disease |        |                           |
|-----------------------------|----------|----------------|--------|---------------------------|
|                             |          | Present        | Absent |                           |
| Screening<br>Test<br>Result | Positive | TP             | FP     | TP = "True Positive"      |
|                             | Negative | FN             | TN     | FP = "False Positive"     |
|                             |          |                |        | FN = "False Negative"     |
|                             |          |                |        | TN = "True Negative"      |
|                             |          |                |        | TP + FP + FN + TN = TOTAL |

| Screening Test "Jargon"                                                                                                                                                                                                                                                                       | Lay Interpretation                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\text{Sensitivity} = \frac{TP}{TP + FN} \times 100$ $\text{"False Negative Rate"} = \frac{FN}{TP + FN} \times 100$ $= 1 - \text{Sensitivity}$ $\text{Specificity} = \frac{TN}{TN + FP} \times 100$ $\text{"False Positive Rate"} = \frac{FP}{TN + FP} \times 100$ $= 1 - \text{Specificity}$ | <p>... the probability of having a positive test given you have the disease/injury</p> <p>... the probability of having a negative test given you have the disease/injury</p> <p>... the probability of having a negative test given you do not have the disease/injury</p> <p>... the probability of having a positive test given you do not have the disease/injury</p> |
| $\text{Positive Predictive Value} = \frac{TP}{TP + FP} \times 100$ $\text{Negative Predictive Value} = \frac{TN}{TN + FN} \times 100$ $\text{Yield} = \frac{TP + TN}{\text{TOTAL}} \times 100$                                                                                                | <p>... the probability of having the disease/injury given you have a positive test result</p> <p>... the probability of not having the disease/injury given you have a negative test result</p> <p>... the probability before you administer a test that the result obtained will correctly identify the presence or absence of disease/injury</p>                        |

| The Importance of Disease/Injury Prevalence                                                                                         |                                                                                                          |
|-------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Disease Prevalence = (TP + FN) / TOTAL                                                                                              |                                                                                                          |
| The specificity and sensitivity<br>(and their corresponding inverses)<br>of a given test<br>are not affected by disease prevalence! | The positive and negative<br>predictive values<br>of a given test<br>are affected by disease prevalence! |



# Figure 3

Gunzenhauser - 13

## AIDMAN VISION SCREENER



**Instructions for testing Visual Acuity (VA).** Hold Aidman Vision Screener in good light 14 inches (approx. 2 card lengths) from eye. Test each eye individually. If the soldier normally wears glasses, these should be worn during the examination. Record acuity of the smallest line for which the soldier can identify the direction of at least half of the figures correctly.

**Laser Exposure Evacuation Criteria.** For soldiers who report being exposed to a potential laser source, perform the above test and the test on the reverse side of the card. Use the following table to determine whether the soldier should be evacuated or returned to duty.

### Amsler Grid Results

|               |                                 | Normal         | Minor Defect  | Major Defect |
|---------------|---------------------------------|----------------|---------------|--------------|
| Visual Acuity | 20/70 or worse in one/both eyes | Evacuate       | Evacuate      | Evacuate     |
|               | 20/50 or better in both eyes    | Return to Duty | See footnote* | Evacuate     |

\*Footnote - If soldier says he can do his job, **Return to Duty**. If soldier says his vision is too poor to do his job, **Evacuate**.

### PUPIL GAUGE (mm)



For further instruction on the use of this card, see FM 8-50, "The Prevention and Medical Management of Combat Laser Injuries."

Figure 5

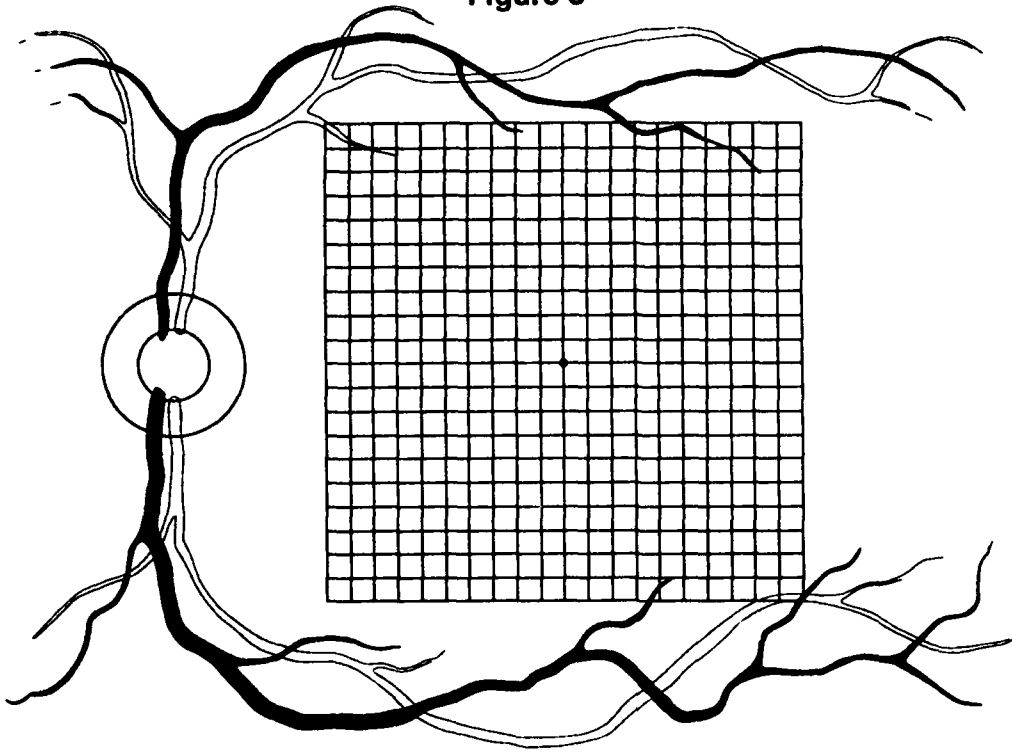
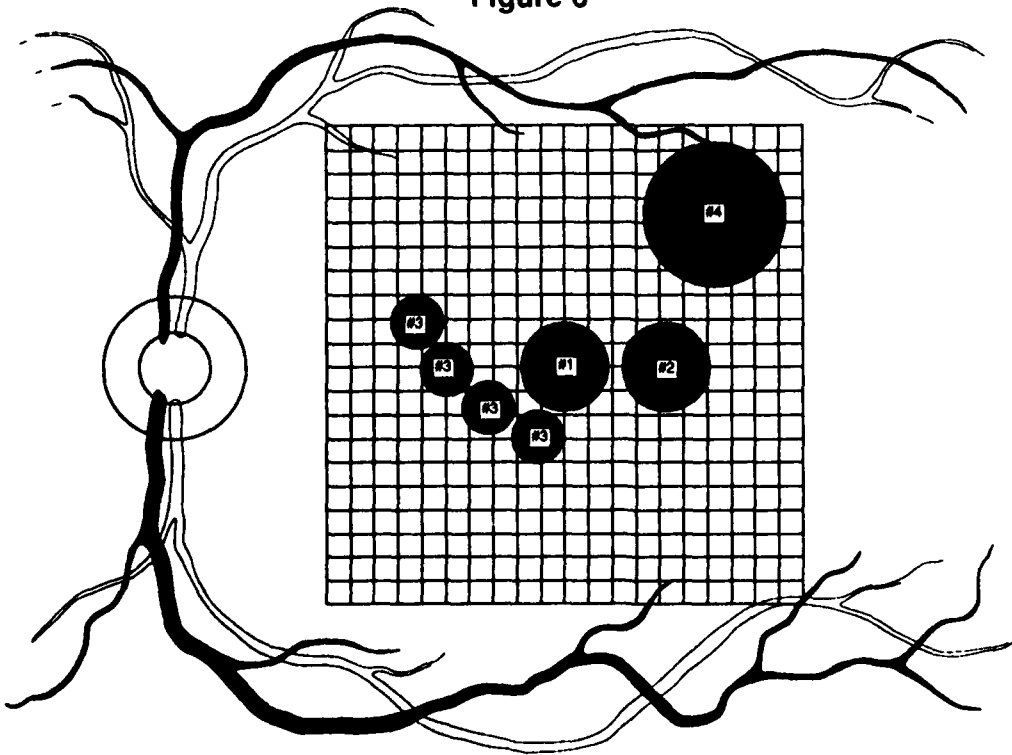
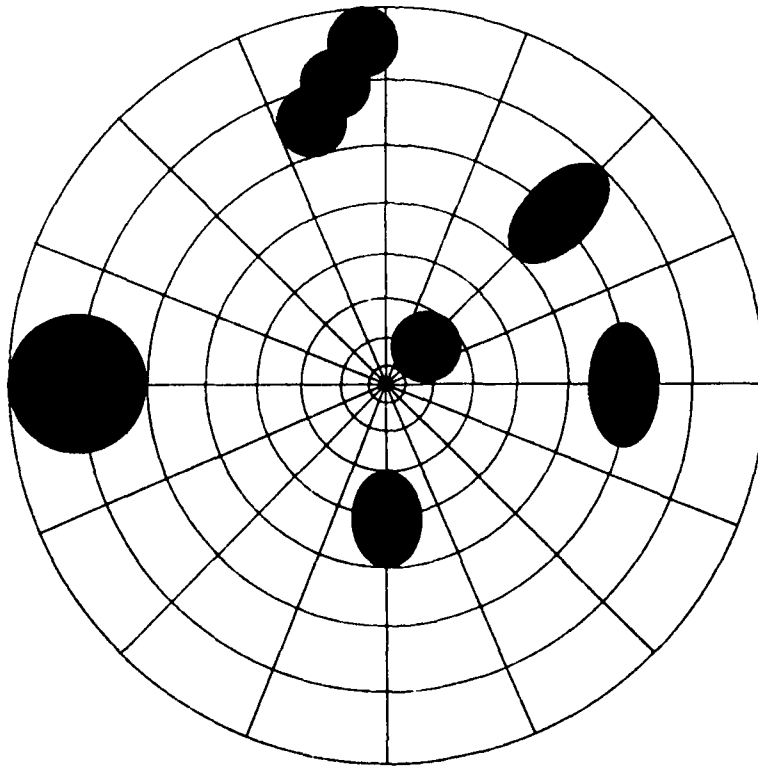


Figure 6

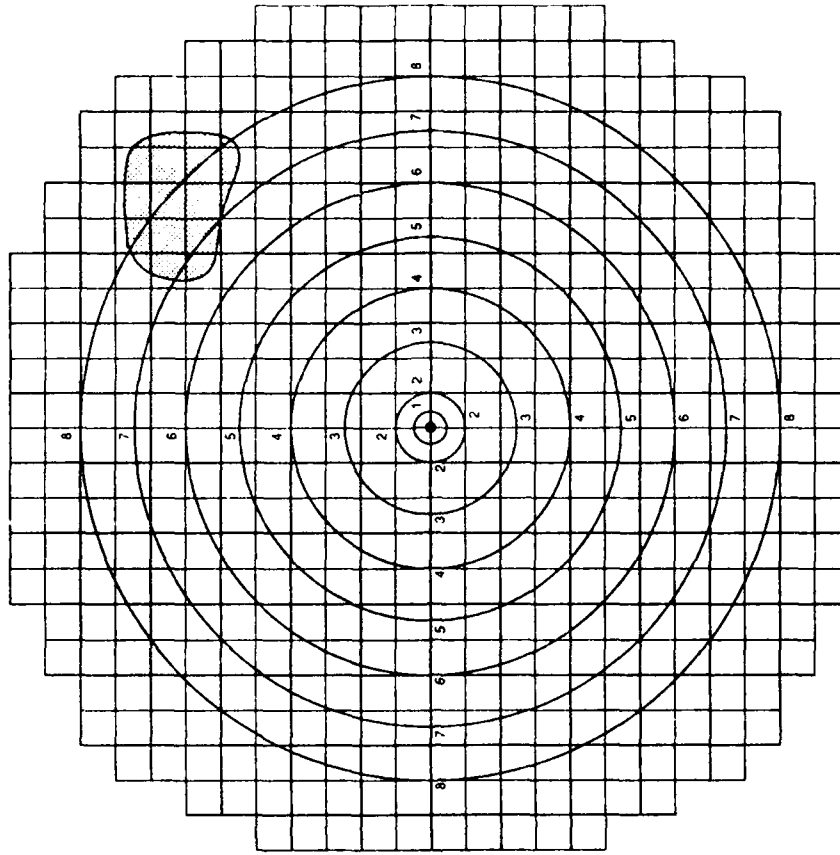


**Figure 7.**  
**Foveal Visual Field Tester: Version 2**



**Major Defect:** Any lesions whose longest dimension exceeds the perpendicular distance between the three closest circles.

**Figure 8.**  
**Foveal Visual Field Tester: Version 3**



**Major Defect:** Any lesion whose area (in boxes) exceeds the number associated with the circle which is just inside the lesion's center-of-mass

**Table I.**  
**SUMMARY OF**  
**TREATMENT OPTIONS**

| Retinal Injury Type          | Medical Treatment | Surgical Treatment  |                      |
|------------------------------|-------------------|---------------------|----------------------|
|                              |                   | Small and Delimited | Large and Extensive  |
| Thermal                      |                   |                     |                      |
| Central                      | None              | None                | None                 |
| Peripheral                   | None              | None                | None                 |
| Hemorrhage                   |                   |                     |                      |
| Subretinal central           | None              | None                | None, try drainage ? |
| Subretinal peripheral        | None              | None                | None                 |
| Vitreous, Type A, central    | None              | None                | Vitrectomy           |
| Vitreous, Type B, peripheral | None              | None                | Vitrectomy           |
| Vitreous, Type B             | None              | N/A                 | Vitrectomy           |

Modified from: International Red Cross, A Report on the  
Working Group of Experts on Battlefield Laser Weapons, page 29.

**Table II. Ocular Reactions to Radiation**

Temporary Effects

Dazzle

Flashblindness

Permanent Effects

Photocoagulation

- Photoreceptor death
- Edema
- Scar tissue (Retina/RPE)

Hemorrhage

- Subretinal
- Intraretinal
- Vitreous Type A
- Vitreous Type B

**Table III. Probable Spectrum of Laser-Induced Injuries Among Self-Reporting Casualties**

- Large foveal thermal lesions
- Central thermal burns
- Parafoveal lesions with subretinal hemorrhage
- Type A vitreous hemorrhage located superior to the fovea
- Type B vitreous hemorrhage

OFFICIAL DISTRIBUTION LIST

Commander  
USAMRDC  
ATTN:SGRD-PLC/MG Russell  
ATTN:SGRD-PLC/COL Lam  
SGRD-RMS/Ms. Madigan  
Fort Detrick, MD 21701-5000

Director  
Defense Technical Information  
ATTN:DTIC-DDA (2 copies)  
Cameron Station  
Alexandria, VA 22314

Commander  
US Army SMO  
ATTN:AMXCM-EO/MAJ Dedmond  
2800 Powder Mill Road  
Adelphi, MD 20783

Commander  
USAMSAA  
ATTN: DRXSY-CSD/P. Baers  
ATTN: DRXST-GWD/F. Campbell  
Aberdeen Proving Ground  
Maryland 21010

Commander  
ATTN: AFWAL/MLPJ/G. Kepple  
Wright Patterson AFB  
Ohio 45433

Commander  
US AEHA  
ATTN: HSHB-RL/D. Sliney  
Aberdeen Proving Ground  
Maryland 21010

Dr. John Ewen  
PO Box 1925  
Washington, DC 20013

Commander  
HQ, USAMMDA  
ATTN: SGRD-UMA/Channing  
Fort Detrick  
Frederick, MD 21701-5012

Commander  
ATTN:AFAMRL/HEF/R. Susnik  
Wright Patterson AFB  
Ohio 45433

Headquarters  
Department of the Army  
ATTN: DASG-TLO  
Washington, DC 20310

Commander  
CACDA/ATZL-OPS-SE  
ATTN: MAJ J.C. Johnson  
Fort Leavenworth  
Kansas 66027

Director  
NADC  
ATTN: Code 601B/Dr. Chisum  
Warminster, PA 18974-5000

Commander  
NMRDC  
ATTN: Code 43  
National Naval Med Center  
Bethesda, MD 20814

Commander  
USAF SAM  
ATTN: RZW/Dr. Farrer  
ATTN: RZW/LTC Cartledge  
Brooks AFB, Texas 78235

Official Distribution List, cont.

Director  
AMSAA  
ATTN: AMXSY-CR/Mr. Brand  
Aberdeen Proving Ground  
Maryland 21005

Commander  
USA Aviation Systems Command  
ATTN: AMCPM-ALSE/H. Lee  
4300 Goodfellow Blvd  
St. Louis, MO 63120

Director  
Defense Intelligence Agency  
ATTN: DT-5A/Hal Rock  
Pentagon  
Washington, DC 20301

Commander  
USA Aeromedical Research Lab  
ATTN: COL La Mothe  
Ft. Rucker, AL 36330-5000

Director  
EWL/RSTA Center  
ATTN: AMSEL-EW-C/J. Allen  
Ft Monmouth, NJ 07703-5303

Director  
USA HEL  
ATTN: AMXHE-IS/D. Giordano  
Aberdeen Proving Ground  
Maryland 21005-5001

Director  
US Army AMMRC  
ATTN: AMXMR-O/Fitzpatrick  
Watertown, MA 02172-0001

Director  
Armed Forces Medical  
Intelligence Center  
ATTN: AFMIC-SA/MAJ Downs  
Fort Detrick  
Maryland 21701-5004

Director  
DTD Directorate  
ATTN: EOGWCM-CCM/Kasperek  
White Sands Missile Range  
New Mexico 88002-5519

Commander  
HQ TRADOC  
ATTN: ATCD-ML/J. Gray  
Ft. Monroe, VA 23651-5000

Commander  
LAIR  
ATTN: SGRD-ULZ (1 copy)  
SGRD-IR (10 copies)  
PSF, CA 94129-6800