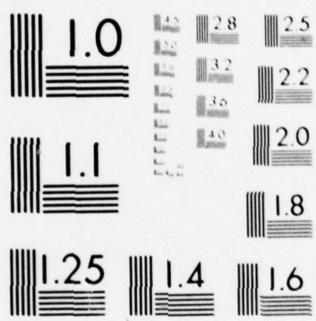
AD-A055 515 TEXAS TECH UNIV LUBBOCK DEPT OF OPHTHALMOLOGY AND VI--ETC F/G 6/16
SPATIAL RESOLUTION THRESHOLDS DURING THE COURSE OF DARK ADAPTAT--ETC(U)
MAR 78 P SPEROS DAMD17-77-C-7007

UNCLASSIFIED NL

1 OF 1

AD
A055 515

END
DATE
FILMED
8-78
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

AD ________

SPATIAL RESOLUTION THRESHOLDS DURING THE COURSE OF DARK ADAPTATION: An evaluation of the recovery of visual function following failure of optical image intensifiers

ANNUAL REPORT

PERRY SPEROS

MARCH, 1978

Supported by:

U.S. Army
MEDICAL RESEARCH AND DEVELOPMENT COMMAND
FORT DETRICK, FREDERICK, MARYLAND 21701

Contract No. DAMD17-77-7007

Department of Ophthalmology and Visual Sciences
Texas Tech University School of Medicine
P.O. Box 4569
Lubbock, Texas

Approved for public release; distribution unlimited

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) SPATIAL RESOLUTION THRESHOLDS DURING THE COURSE OF DARK ADAPTATION: AN EVALUATION OF THE RECOVERY OF VISUAL FUNCTION FOLLOWING FAILURE OF OPTICAL IMAGE INTENSIFIERS.	5. TYPE OF REPORT & PERIOD COVERED Annual Report. 1-77/12-77 (Jan - Dec 77)
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Perry Speros	8. CONTRACT OR GRANT NUMBER(s) DAMD 17-77-7007
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Ophthalmology & Visual Sciences, Texas Tech University School of Medicine, Lubbock, Texas 79409	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62773A 3E762773A819.00.023
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Medical Research and Development Command, Fort Detrick, Frederick, Maryland 21701	12. REPORT DATE March, 1978
	13. NUMBER OF PAGES 20 pages (19p.)
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution of document is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Unlimited.

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Vision, modulation transfer function, dark adaptation curve, AN/PVS-5 night vision goggles, performance measurement.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Optical Image Intensifiers serve to aid night vision by amplifying the amount of light reaching the retina. A failure of this device leaves the observer visually handicapped for a period of time equal to the time that it takes the visual system to adapt to the darkened conditions. Important information, which is not now available, is a quantitative estimate of the degree and time course of visual performance impairment in the event of a night vision aid failure.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

410 722

78 06 16 050

Because of the many possible permutations in describing the visual environment, a prediction of the resolution tasks that may confront the user in the field is impractical. However, any complex stimulus can be described in terms of its Fourier components (viz. sinusoids). Therefore, by examining the visual resolution of spatial sine-wave gratings the necessary elementary information for generalization to any stimulus configuration can be obtained.

In the field, the observer will be adapted to the chromaticity and luminance of the optical image intensifier for an indefinite period of time preceding its unexpected failure. The visual recovery time is independent of the duration of exposure to the adaptation source when it is longer than some critical time. For the purposes of the proposed study, it would be most efficient to use the shortest adaptation time possible. But, the exposure time should be long enough to produce adaptation conditions generalizable to indefinitely long exposure durations. The purpose of the first set of experiments is to determine the shortest adaptation time which may be used. This will be accomplished by measuring classical dark adaptation curves following pre-adaptation to different durations of the curves following pre-adaptation to different durations of the conditions simulating the AN/PVS-5 optical image intensifier.

Following the determination of the critical durations, the contrast thresholds for different spatial frequencies will be measured during the period of recovery from adaptation to the simulation of the optical image intensifiers. The results of these experiments will provide definitive information about the visual resolution capabilities of an observer during recovery from light adaptation for different viewing conditions. Since sine-wave gratings will be used, the data may be generalizable, by way of Fourier analysis, to any stimulus pattern.

ABSTRACT

Optical Image Intensifiers serve to aid night vision by amplifying the amount of light reaching the retina. A failure of this device leaves the observer visually handicapped for a period of time equal to the time that it takes the visual system to adapt to the darkened conditions. Important information, which is not now available, is a quantitative estimate of the degree and time course of visual performance impairment in the event of a night vision aid failure.

Because of the many possible permutations in describing the visual environment, a prediction of the resolution tasks that may confront the user in the field is impractical. However, any complex stimulus can be described in terms of its Fourier components (viz. sinusoids). Therefore, by examining the visual resolution of spatial sine-wave gratings the necessary elementary information for generalization to any stimulus configuration can be obtained.

In the field, the observer will be adapted to the chromaticity and luminance of the optical image intensifier for an indefinite period of time preceding its unexpected failure. The visual recovery time is independent of the duration of exposure to the adaptation source when it is longer than some critical time. For the purposes of the proposed study, it would be most efficient to use the shortest adaptation time possible. But, the exposure time should be long enough to produce adaptation conditions generalizable to indefinitely long exposure durations. The purpose of the first set of experiments is to determine the shortest adaptation time which may be used. This will be accomplished by measuring classical dark adaptation curves following pre-adaptation to different durations of the curves following pre-adaptation to different durations of the conditions simulating the AN-PVS-5 optical image intensifier.

Following the determination of the critical durations, the contrast thresholds for different spatial frequencies will be measured during the period of recovery from adaptation to the simulation of the optical image intensifiers. The results of these experiments will provide definitive information about the visual resolution capabilities of an observer during recovery from light adaptation for different viewing conditions. Since sine-wave gratings will be used, the data may be generalizable, by way of Fourier analysis, to any stimulus pattern.

FOREWORD

This research program is sponsored by the U.S. Army Medical Research and Development Command under Contract No. DAMD 17-77-7007. Major Roger Hula is project monitor. The principal investigator is Perry Speros.

This report covers the period of 1 February 1977 to 31 January 1978. The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

TABLE OF CONTENTS

INTRODUCTION

Historically major military operations have been conducted during periods of adequate illumination, e.g. daytime. This is because it is through vision, man's principle sensory modality, that he gathers information from the external world in order to function effectively.

Recently, though, military experiences and modern tactical considerations have placed emphasis on sustained operations with future military deployment. These sustained operations require continuous activity by military personnel extending well into conditions (periods) of darkness. Performance during this period of reduced illumination have placed new physiological and perceptual demands on the human side of the man-machine system. Some military tasks during reduced illumination demand more visual information than the scotopic system (night-time vision) of the visual system can provide.

Man is equipped with a visual system with a dynamic range in response to light which surpasses any other known photodetection system. To achieve this sensitivity range some physiological compromises had to be made particularly, at lower light levels. Eventhough, scotopic (night-vision) sensitivity extends down to the detection of a few photons, spatial resolution, color information and temporal processing are severely reduced. This restricts the capability of the observer to effectively perform his military duty during periods of reduced illumination.

Major technological advances in light amplification have been made during the last 10 years. In particular, the development of the AN/PVS-5 night vision goggle by the U.S. Army Night Vision Laboratory has been offered as an effective interim solution to allow U.S. Army aviators to perform military duties during periods of reduced illumination.

Optical image intensifiers (e.g. AN-PVS-5) serve to aid night vision by amplifying the amount of light reaching the retina. The result is an improvement of the spatial resolving capabilities of the observer employing such a device (Meeteren and Boogaard, 1973). However, since image intensifiers operate by increasing the mean retinal illuminance, they also serve to increase the adaptation level of the operator's visual system. If the device suddenly fails, as they occasionally do without warning or if removal of the goggle is needed, the operator will suddenly find himself visually impaired because of his elevated adaptation level. The time to full recovery of dark-adapted vision may vary from one to three minutes, depending upon the mean luminance preceeding the device failure (Wiley, personal communication). The critical question is what is the visual capability of the operator at different times during recovery from image intensifier adaptation?

Visual capability is best described as spatial resolution contrast thresholds. In other words, for a given image size, how much contrast is required to resolve it from the background? In the natural world, image size and contrast are not the only parameters, the gradient of the contrast change must also be considered.

All of the necessary parameters for describing and predicting spatial resolution are embodied in the Visual Modulation Transfer Function (VMTF) (Campbell and Green, 1965). The VMTF is simply the spatial sine-wave contrast sensitivity function, or theoretically, the Fourier transform of the convolution of the optical spread function with the retina-brain spread function (Campbell, 1968). By employing the Fourier transform of any image and using the VMTF, a prediction can be made of the likelihood of the operator's ability to resolve the particular image.

The VMTF is known to change with mean image luminance level (Ness and Bouman, 1967), and therefore, it is anticipated that it will also be dependent on adaptation level. The specific experimental question which must be asked is, what is the shape of the spatial sine-wave contrast sensitivity function as different adaptation levels? These data will provide the basic information needed to describe the resolving capabilities of an observer during the recovery of dark adaptation after the failure of an optical image intensifier. By examining the acceleration of contrast threshold versus adaptation time curves for different spatial frequencies, some statement can be made about which aspects of visual resolution recover the fastest and which recover the slowest.

Optical image intensifiers are an important aid to night vision; however, they operate at the expense of the user's adaptation level. A failure of the device will leave the user visually handicapped for a period of time during which his visual system adapts to the darkened conditions. Important information, which is not now available, is a quantitative estimate of the degree and time course of visual performance impairment in the event of a night vision aid failure.

Because of the many possible permutations in describing the visual environment, a prediction of the resolution tasks that may confront the user in the field is impractical. However, any complex stimulus can be described in terms of its Fourier components (viz. sinusoids). Therefore, by examining the visual resolution of spatial sine-wave gratings the necessary elementary information for generalization to any stimulus configuration can be obtained.

In the field, the observer will be adapted to the chromaticity and luminance of the optical image intensifier for an indefinite period of time preceeding its unexpected failure. The visual recovery time is independent of the duration of exposure to the adaptation source when it is longer than some critical time.

For the purposes of the proposed study, it would be most efficient to use the shortest adaptation time possible. But, the exposure time should be long enough to produce adaptation conditions generalizable to indefinitely long exposure durations. The purpose of the first set of experiments is to determine the shortest adaptation time which may be used. This will be accomplished by measuring classical dark adaptation curves following preadaptation to different durations of the conditions simulating the AN/PVS-5 optical image intensifier.

Following the determination of the critical durations, the contrast thresholds for different spatial frequencies will be measured during the period of recovery from adaptation to the simulation of the optical image intensifiers. The results of these experiments will provide definitive information about the visual resolution capabilities of an observer during recovery from light adaptation for different viewing conditions. Since sine-wave gratings will be used, the data may be generalizable, by way of Fourier analysis, to any stimulus pattern.

It is the PURPOSE OF THIS PROJECT to examine the acceleration of contrast threshold versus adaptation time curves for different spatial frequencies. Thus shedding some light as to which aspects of visual resolution recover the fastest and which recover the slowest.

PREVIOUS

The Development of the Night Vision Goggle (AN/PVS-5) is an excellent light amplification device, although it has brought with it several problems for the individual user. Some of these problems have been the subject of investigation for the past several years by visual scientists (mainly at the U.S. Army Aeromedical Research Lab) and their results are summarized below: Wiley and Holly (1976) report that a comparison of system vs. unaided normal vision indicated that: (1) under equivalent illuminance levels of under 5% and 25% moon (1.2×10^{-4} ft-L and 6.0×10^{-4} ft-L) performance with the man-night vision goggle system was superior to that of the unaided vision, (2) under full moon equivalent illuminance levels (2.4×10^{-3} ft-L) unaided vision was superior in performance at high spatial frequencies (spatial frequency used varied from 0.1 to 10 cycles/degree) but slightly poorer than the man-goggle system at low frequencies (lower than 8 cycles/degree), (3) under viewing distances of less than 500 feet, depth discrimination with the man-goggle system is equivalent to the unaided photopic vision; (4) under viewing distances greater than 500 feet, depth discrimination with unaided photopic vision is superior to that of the man-goggle system; (5) the stereopsis threshold (using a modified Howard-Dolman apparatus) with the man-goggle system was inferior to that of the unaided binocular vision showing a degradation of stereopsis using the night vision goggle.

The AN/PVS-5 night vision goggles operates by increasing the mean retinal illuminance and thus increases the adaptation level of the user's visual system. If the device suddenly fails as they occasionally do, without prior warning, or if a pilot needs to remove the night vision goggle, he will find himself visually impaired because of his elevated adaptation level. Glick et al (1974) in a preliminary report on the dark adaptation changes associated with the use of the AN/PVS-5 night vision goggle state that the average recovery time that is, time to return to a fully dark-adapted level was two minutes with a range of 1.5 to 3 minutes after a five minute pre-adaptation of an equivalent goggle luminance level of 4 ftL, and equivalent chromaticity level. This relatively rapid recovery to the fully dark-adapted level (2 minutes instead of the normally expected twenty minutes) is attributed to the chromaticity component of the preadaption source (e.g., the green phosphor used in the AN/PVS-5 night vision goggle). The level of dark adaptation depends upon both the intensity and wavelength of the pre-adaptation source. Thus, although the AN/PVS-5 Night Vision goggle does not fully degrade dark adaptation, it imposes a visual impairment on the operator for a duration of 2 minutes should it be necessary to remove the goggle or should the goggle fail. It should be pointed out here that these results are restricted to the chromaticity output of the AN/PVS-5 goggle and are not generalizable to the development of other image intensifiers with a different chromaticity output since the dark adaptation level is function of wavelength of the source.

The phosphor used in the AN/PVS-5 night vision goggle has a relatively narrow band output around the green region of the visual spectrum. For this reason, the pilot wearing the goggle will be light-adapted to the chromaticity output of the goggle and therefore his color vision will be altered. Glick and Wiley (1975) compared the performance of the man-night goggle system vs. unaided vision with a monochromatic red aircraft light on a standard 1:50,000, transverse mercator projection map and a black background map (Experimental map, by the Defense Mapping Agency Topographic Center) designed to overcome the loss of color information. Their results indicated that (1) the black background map does prevent the loss of information when the night-vision goggle (NVG) is used and when the map is viewed with the unaided eye under monochromatic red aircraft map light. This comparison emphasized the importance of available contrast when the NVG is used. The more contrast with the background, the better the aviator's performance would be.

Sanders et al (1975) evaluated the flight performance of pilots during NOE (nap-of-the-earth) flight (without navigation), low level flight and four standard maneuvers using three configurations of the NVG's (40° field-of-view, 60° and 40° field of view with a 30% bifocal cut) and the dark-adapted unaided eye. Their results showed that (1) the 40° goggles were associated with smoother, more gradual control movements than the 60° goggles and the NVG's were associated with slightly lower flight altitudes during the NOE flight segment; (2) the 40° and 40° with a 30% bifocal cut were also associated with a lower mean altitude relative to the unaided eye during low level flight. This was not true for the 60° goggle and (3) the 40° goggle was favored over the 60° goggle because of the higher resolution angle during the standard manouvers. Sanders et al (1975) concluded that, in some instances, the NVG's can equip the pilot with increased staying power when flying in intermittent light sources due to their light compensatory capabilities. The unaided eye under the same conditions would be adversely affected because of dark adaptation.

Lees et al (1976) compared aviator performance for terrain flight during Low Level (LL) and Nap of the Earth (NOE) profiles under (1) day flight with the unaided eye; (2) night flight with the unaided eye and (3) night flight using NVG's. They demonstrated that for LL flights, the major factors that discriminated day flights from either night flights or NVG's flights were airspeed related variables and the frequency of small corrective control inputs. It was noted that NVG's flights resemble day flight more than the unaided eye night flight. The analysis of the NOE flights demonstrated that performance factors measuring severity of roll angles, and the frequency and magnitude of control input, discriminated best among the three visual conditions.

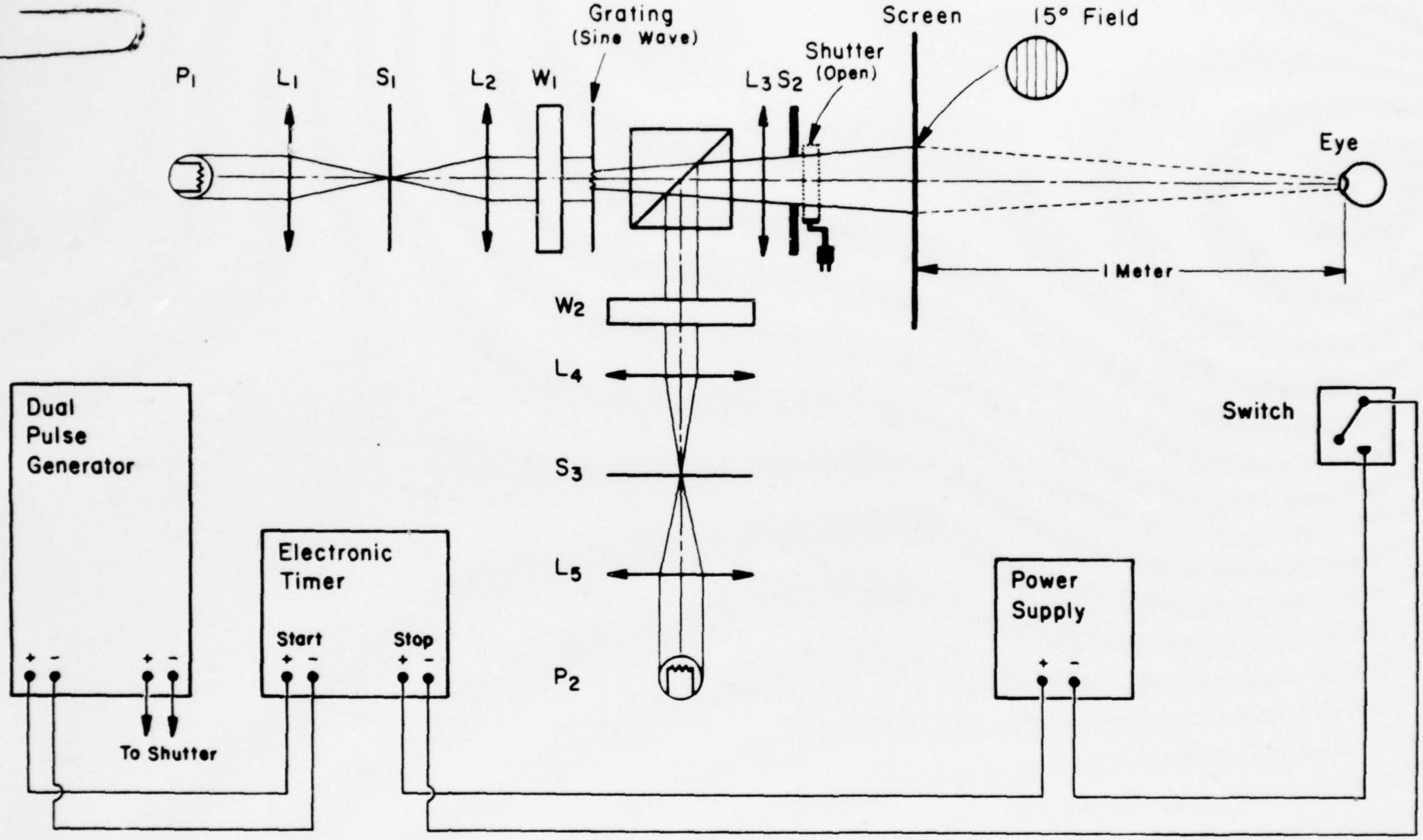
METHODS

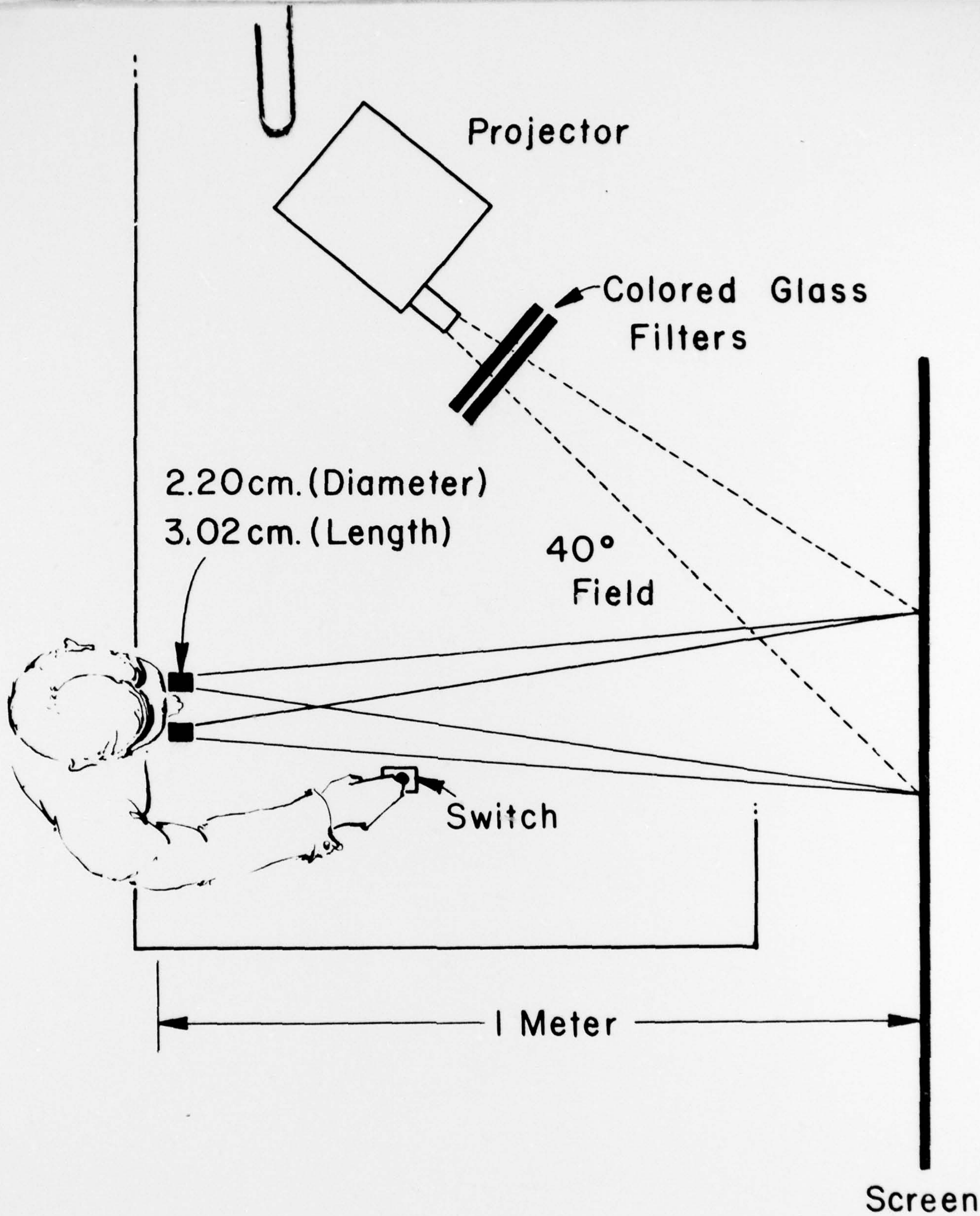
After pre-adaptation to a stimulus of a given luminance and chromaticity, it is desirable to know the amount of contrast required to resolve a spatial sine-wave grating of variable frequency and average luminance as a function of post-adaptation time. This question is raised for (1) natural free fixation and peripheral viewing conditions at optical infinity and (2) foveal fixation conditions at near. Stated in terms of the application of this knowledge, we anticipate shedding some light as to the time it will take an individual to resolve a target with a given angular subtense, luminance and contrast, following a pre-adaptation to a background of a given luminance and chromaticity comparable to the output of an optical image intensifier. This applied knowledge may be gained by performing a Fourier transform of the target of interest by constructing a table of the contrast threshold for each Fourier component.

A) Apparatus

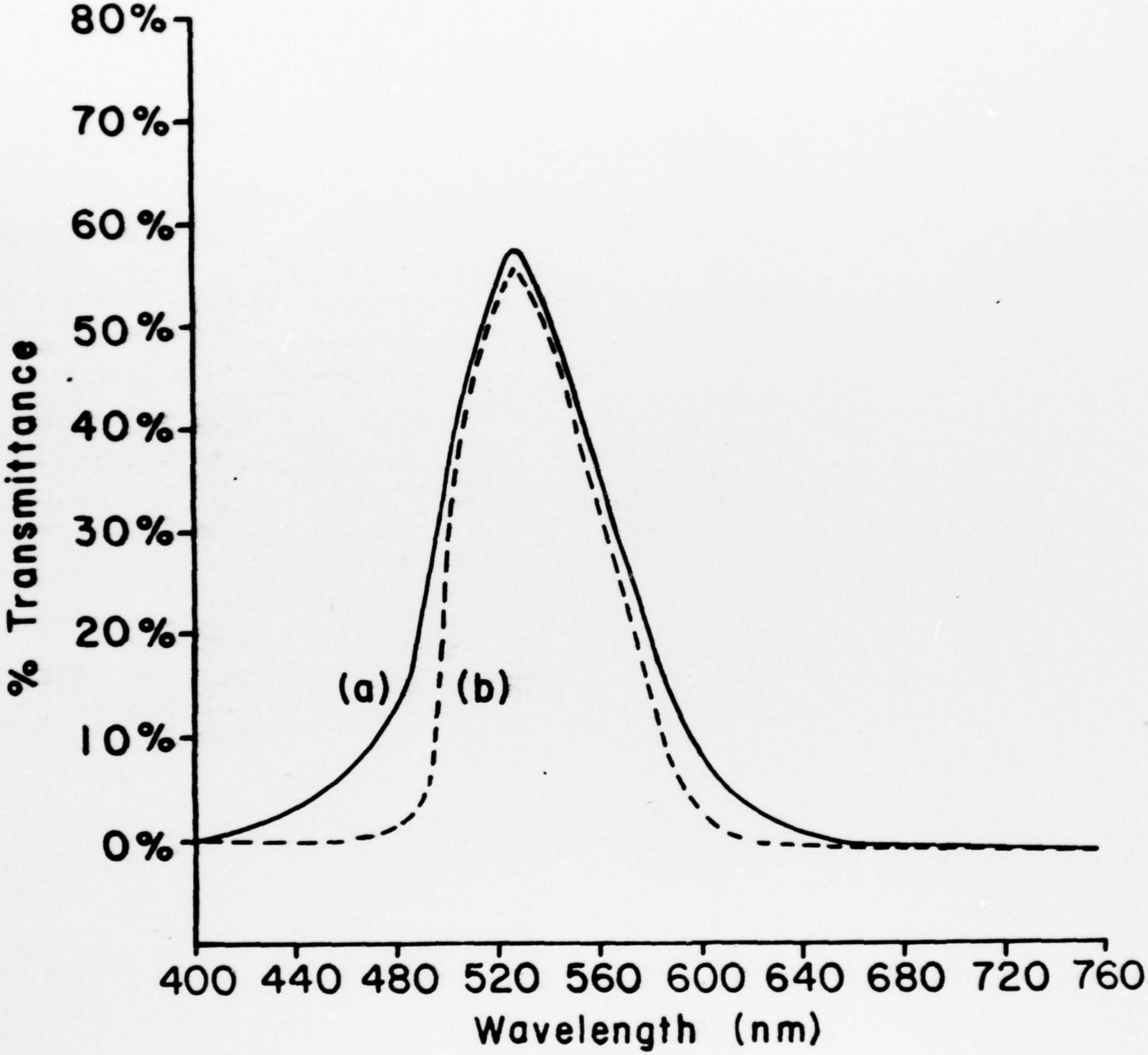
The experimental design for the presentation of sine-wave grating target is illustrated in figure 1. The test target for the contrast threshold experiments is a sine-wave grating generated on a photographic film (Kodak projector # AF2 with ABC conversion by Buhl so uniform field is achieved). A modified projector is used as the light source (P_1). Light form P_1 is collected by a lens (L_1) which focuses the beam of light on a Stop (S_1). Light from S_1 is collected and colimated by a second lens (L_2). A rotary neutral density filter (W_1) is placed at the colimated portion of the light beam and serves as a means of controlling the luminance level of the sine-wave test target grating. The target beam in turn passes through a beam splitter and projected onto a screen. A lens (L_3) positioned after the beam splitter is used in the optical path and serves to focus the target on to the screen. A second stop (S_2) is placed between L_3 and the screen and serves to control the size of the target on the screen and to minimize the unwanted images. The duration of presentation of the test target is controlled by means of an electromagnetic shutter. For our experiments, a field size subtending 15^o was chosen. A field subtending 15^o and centrally fixated yields dark adaptation curves comparable to those obtained with the test target presented to the peripheral retina (say 15^o nasally). The optical system for adjusting the luminance of the projected grating is controlled by the counter-balanced neutral density wedge W_2. The two beams (the test target and the veiling background) are brought together at the beam splitter. The spatial frequency of the grating is regulated by adjusting the magnification by L_3. By adjusting the luminances of the veiling source and the sine-wave grating in counter-phase the contrast of the grating can be changed while the mean luminance is held constant at the screen. To assure that the mean luminance of the target is holding constant, photometric measurements are taken using the Spectra-Pritchard photometer (Model 1980A-PL) each time the contrast of the test target is changed. The duration of presentation of the test target is controlled by a Grass #88 dual pulse generator. One output of the dual generator is used to activate the shutter and thus allowing the test target to be presented to the subject, while the second output is used to trigger the electronic timer and thus marking the onset of the target. When the subject perceives the test pattern, his task is to press a micro-switch which allows an electrical pulse to stop the electronic timer and thus register the time it took the subject to see the test target. The time then is recorded by the experimenter and the timer is reset for the next presentation.

The optical system for the pre-adaptation source is illustrated in figure 2. The light source is a tungsten lamp GE 500czx of a slide projector. Light from the source is passed through a combination of Corning color glass filters (Corning # 3-70 and 4-96) simulating the chromaticity output of an image intensifier (AN/PVS-5). The light beam in turn is projected onto a screen. This system is capable of providing a luminance level up to 10 ftL. The subject's chin is supported by an adjustable chin rest one meter away from the screen. The subject views the pre-adapting field through two 2.20 cm Dx 3.02 cm L tubes placed directly in front of the subjects eyes. This system then simulates the size of the viewing field of the image intensifier (AN/PVS-5) e.g., 40^o field-of-view. A comparison of the spectral power distribution of the combination of the Corning color filters (obtained by


P1
L1
S1
L2
W1
Grating
(Sine Wave)
L3 S2
Shutter
(Open)
Screen
15° Field
Eye
1 Meter
W2
L4
S3
L5
P2
Dual
Pulse
Generator
To Shutter
Electronic
Timer
Start
Stop
Power
Supply
Switch



Projector
Colored Glass
Filters
2.20cm. (Diameter)
3.02cm. (Length)
40°
Field
Switch
1 Meter
Screen


% Transmittance
80%
70%
60%
50%
40%
30%
20%
10%
0%
(a)
(b)
400 440 480 520 560 600 640 680 720 760
Wavelength (nm)

a Curry 14 spectrophotometer) and the spectral power distribution of the AN/PVS-5 image intensifier (obtained by the U.S. Army Night Vision Laboratory) are shown in figure 3. These curves represents our best effort after an exhaustive attempt of different combinations of filters. As can be seen in figure 3, there is a good agreement in the two curves with the exception at the short-end of the spectrum, e.g., at the 440-480nm.

B) Subjects

Five young adults (ranging in age 19-25 years) have agreed to participate in the experiments. All subjects have gone through a complete ophthalmological examination including Goldmann visual fields and Goldmann-Weekers dark adaptation curves. All subjects show a minimum visual acuity of 20/20 and normal dark adaptation curves. All subjects are currently undergoing the pilot studies phase of the experiments in order to determine the optimum values for the fixed parameters of the experiments e.g., (1) mean target luminance (2) target exposure time (3) duration of the interval between exposures and (4) range and spacing of contrast values to be used.

C) Experimental Procedure

The procedure each subject goes through is as follows: the subject is first seated in front of the screen (1 meter away) and (1) is allowed to view the pre-adaptation field as shown in figure 3 for a duration of 5 minutes. This duration is found sufficient to fully light-adapt the eye to the luminance and chromaticity output range of an image intensifier (AN/PVS-5). Since the luminance output of an image intensifier is variable from .10 to 10ftL, we have chosen three pre-adapting levels at 0.1, 4, and 9ftL, within this range, (2) a set contrast value target (spatial frequency .1 to 10 cycles/degree) is presented to the subject immediately after the termination of the pre-adaptation field, and concurrently the electronic time is triggered. The subject's task is to press a micro-switch when the pattern is first seen. The subject views the target with free fixation. When the subject sees the pattern the session is terminated and the post adaptation time is recorded, (3) the next lower contrast is set in and Step (2) is repeated. The procedure continues until adaptation time is recorded for 5 contrast values. (4) Following the recording of the 5 different contrast values, the procedure is repeated for the 5 different spatial frequencies from 0.1 to 10 cycles/degree). The different spatial frequency targets are presented randomly, while the grating orientation is always vertical, (5) the experimental procedure is then repeated for the following three viewing conditions: (a) free fixation with target projected onto a screen one meter away, (b) free fixation with target 6 meters away and (c) with fixation at 15^{o} temporal to the target at 6 meters away.

WORK ACCOMPLISHED

During the period of this contract we have accomplished the following tasks: (1) all of the equipment needed to carry out the major portion of the research has been acquired. Some unanticipated delays have been encountered in the procurement of (a) the needed sine-wave gratings on photographic film (w) the necessary combination of color filters for the simulation of the chromaticity output of the AN/PVS-5 image intensifier and (c) the modification of the slide projector to achieve uniform light. These problems though have been overcome and the experimental apparatus is thus functional. Our experience with the present experimental design and through personal communication with the U.S. Army Night Vision Laboratory at Fort Ruckers indicated that a more precise way of presenting the sine-waye targets is through electronically-generating it in a CRT.

Toward that end, this author has through Research funds other than U.S. army purchased most of the necessary equipment needed for that purpose: these include a Conrac model 6000 high resolution monitor, a Visual Information Institute sync generator and pedestal generator. We feel that we can carry out the pilot experiments and the training sessions with the present experimental design as illustrated in figures 1, 2 and 3, and carry-out the main experiments of the proposed research with the addition of the above electronic equipment. Our emphasis is on acuracy of obtaining data. After an enormous effort in maintaining identical experimental conditions from subject to subject or even from one set of contrast to the next, the decision to go to an electronic system was made. The difficulty lies on the manipulation of sine-wave gratings on photographic film especially when one relies on magnification for obtaining the appropriate frequencies for the test target, plus the fact that we were unable to purchase values other than 30% and 65% modulation sine-wave target patterns on photographic film. (2) All of the preliminary experiments for this research have been completed: a) our pilot studies indicate that a pre-adaptation of 5 minute duration to the chromaticity and luminance range (up to 10ftL, within the range of the image intensifier AN/PVS-5) is sufficient for our experiments. This duration of exposure to the simulated adaptation source results in the longest post-adaptation time to reach full dark adaptation level as determined using the Goldmann-Weekers threshold measurements. (b) The mean target luminance levels were determined as 1.2×10^{-4} ftL, 6×10^{-4} ftL and 2.5×10^{-3} ftL. These values were chosen for comparison purposes with data obtained by U.S. Army Aeromedical Research Lab. (c) The spatial frequency values to be used in these experiments are .38, .54, .77, 1.3, 3.8, 5.45, 7.52 and 10.20 cycles/degree.

In summary then, the experimental conditions we plan to use in the main experiments for the determination of VMTF's are as follows:

Viewing Distances:	1 meter, 6 meters, 1 meter with 15° temporal fixation
Pre-adaptation:	5 minutes, at .5ftL,4ftL,10ftL simulated AN/PVS-5 output luminance and chromaticity
Size of test pattern:	15°
Pupil:	Natural
Accomodation:	Natural
Kind of test pattern:	Sine-wave pattern, electronically generated
Frequency Range:	.38 - 10 cycles/degree
Luminance Range:	10^{-4}ftL to 10^{-3}ftL
Method:	Threshold measurement
Orientation of Pattern:	Vertical
Presentation time:	Unlimited
Fixation:	Free (1 meter and 6 meter viewing conditions only)
Pre-adaptation time:	5 minutes
Ambient illuminance:	1 red simulating aircraft cockpit illumination, one white at near.

DISCUSSION

The major user of optical image intensifiers, such as the AN/PVS-5, has been the military. These intensifiers extend the limits of visual function far below the normal human scotopic absolute threshold. These devices have demonstrated improved performance and reliability under combat conditions in night flying. That is, observation of processes that must be conducted at extremely low light levels is now possible with the oncoming of optical image intensifiers. As the availability of new and improved performance devices increases, new applications, military, as well as industrial increases. Although these devices are extremely valuable in "total-darkness" operations, they are not immune to failure. Failure of these devices is sudden and with no prior warning.

In the event of optical image intensifier failure, the operator's visual capabilities are impaired. This is because with the device in place, his visual system is light-adapted to a level of luminance compatible to that of the output of the particular optical image intensifier. The higher the performance of the device, the higher the degree of impairment would be in the event of failure. The nature and extent of visual impairment must be known in order to evaluate which functions the operator can perform under these conditions.

This research proposal suggests experiments that can be executed under controlled experimental conditions and could provide information as to the extent and degree of visual performance loss of the operator in the event of AN/PVS-5, as well as other optical image intensifiers, fail.

REFERENCES

1. Campbell, F. W.: The Human eye as an optical filter. Proc. of Ieee 56: 1009 - 1014, 1968.

2. Campbell, F. W. and Green, D. G.: Optical and retinal factors affecting visual resolution. J. Physiol. 181: 576 - 593, 1965.

3. Chiou, W. C.: Uilization of existing aircraft landing light as an artificial illumination source for AN/PVS-5 night vision goggles training. USAARL Report No. 1-7-1, October 1976. U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL.

4. Glick, D.D. and Moser, C.E.: Afterimages associated with using the AN/PVS-5 night vision goggle. USAAEL Report No. 75-1-7-1, August 1974, U.S. Army Aeromedical Research Laboratory, Fort Rucker, Al.

5. Glick, D.D. and Wiley, R.W.: A visual comparison of standard and experimental maps using the AN/PVS-5 night vision goggle. USAARL Report No. 75-26-7-6, March 1975. U.S. Army Aeromedical Research Laboratory, Fort Rucker, Al.

6. Glick, D.D., Wiley, R.W., Moser, C.E., and Chun, K.P.: Dark adaptation changes associated with use of the AN/PVS-5 night vision goggle. USAARL Report No. 75-2-7-2, August 1974. U.S. Army Aeromedical Research Laboratory, Fort Rucker, Al.

7. Hirsch, M.J. and Weymouth, F.W.: Distance discrimination. I. Theoretic considerations. Arch. Ophthal. 39:210 - 223, 1948.

8. Hirsch, M.J. and Weymouth, F.W.: Distance discrimination. V. Effect of motion and distance targets on monocular and binocular distance discriminating. J. of Aviat Med. 18:594-600, 1947.

9. Lees, M.A., Glick, D.D., Kinball, K.A., and Snow, A.C.: In-flight performance with night vision goggles during reduced illumination. USAAEL Report No. 76-27, August 1976. U.S. Army Aeromedical Research Laboratory, Fort Rucker, Al.

10. Lees, M.A., Kimball, K.A., Hoffman, M.A., and Stone, L.W.: Aviator performance during day and night terrain flight. USAARL Report No. 77-3, December, 1976. U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL.

11. Lewis, C.E., Blakely, W.R., Swarsop, R., Masters, R.L., and McMurty, T.C.: Landing performance by low-time private pilot after sudden loss of binocular vision. Cyclops II. Aerospace Medicine 44: 1241-1245, 1973.

12. Lewis, C.E. and Krier, G.E.: Flight Research Program XVI: Landing Performance in jet aircraft after the loss of binocular vision. Aerospace Medicine 40: 9-11, 1969.

13. van Meeretern, A. and Boogaard, J.: Visual contrast sensitivity with ideal image intensifiers. OPTIK 31: 179-191, 1973.

14. van Meeteren, A. and Vos, J.J.: Resolution and contrast sensitivity at low luminance Vision Res. 12-825-833, 1972.

15. van Ness, F.L. and Bouman, M.A.: Spatial Modulation transfer in the human eye. J. of Optical Soc. of America 57:401 - 406, 1967.

16. Sanders, M.G., Kimball, K.A., Frezell L.L., Hofmann, M.A.: Aviator performance measurement during low altitude rotary using flight with the AN/PVS-5 night vision goggles. USAARL Report No. 76-10, December 1975. U.S. Army Aeromedical Research Laboratory, Fort Rucker, Al.

17. Sanders, M.G., Kimball, K.A., Frezell, T.L., and Hofmann, M.A.: Helicopter flight performance with the AN/PVS-5, night vision goggles. Paper presented at the Aerospace Medical panel meeting, AGARD/NATO, October 1975, Ankara, Turkey.

18. Sloan, L.L. and Attman, A.: Factors involved in several tests of binocular depth perception. Arch. Ophthal. 52: 524-544, 1954.

19. Teichner, W.H., Kobrick, J.L., and Dusek, E.R.: Commonplace viewing and depth discrimination J. of Optic at SOC of America 45:913 - 920, 1955.

20. Teichner, W.H., Kobrick, J.L., and Wehrkamp, R.F.: Effects of terrain and observation distance on depth discrimination Environmental Protection Division, U.S. Army Quartermaster Research and Development Center, Natick, Massachusetts, Report No. 228, May 1954.

21. Teichner, W.H., Kobrick, J.L., and Wehrkamp, R.F.: The effects of terrain and observation distance on relative depth discrimination. American J. of Psychology 68: 193-208, 1955.

22. Wiley, R. W. Glick, D.D., Bucha, C.F., and Park, C.K.: Depth perception with the AN/PVS-5 night vision goggle USAARL Report No. 76 - 25, July 1976. U.S. Army Aeromedical Research Laboratory, Fort Recker, Al.

23. Wiley, R. W. and Holly, F. F.: Vision with the AN/PVS-5 night vision goggle. Paper presented at the Aerospace Medical Panel meeting AGARD/NATO, Nevilly Sue Seine, France, 1976.

DISTRIBUTION LIST

4 copies	HQDA (SGRD-AJ) Fort Detrick Frederick, MD. 21701
12 copies	Defense Documentation Center (DDC) ATTN: DDC-TCA Cameron Station Alexandria, Virginia 22314
1 copy	Dean School of Medicine Uniformed Services University of the Health Sciences 4301 Jones Bridge Road Bethesda, Maryland 20014
1 copy	Superintendent Academy of Health Sciences, US Army ATTN: AHS-COM Fort Sam Houston, Texas 78234