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The University of Michigan, Engineering Research Institute, Vision Research Laboratories, Ann Arbor, Michigan

Report of Project MICHIGAN, Optics and Vision, Blackwell, H. R.

Report No. 2144-85-P, June 1957, 25 pp., 15 illus., Project 2144 (Contract DA-36-039 SC-52654, DA Project NR-3-99-10-024, Sig C No. 102D), UNCLASSIFIED

The progress of the Optics and Vision Program of Project MICHIGAN for the period 1 July 1955 to 31 January 1956 is described. Topics discussed include: (a) field test planning and instrumentation; (b) simulator development and tests; (c) basic studies of the elements of the optical surveillance problem (target and background characteristics, the optical properties of the atmosphere, and the operating characteristics of the eye); and (d) development of tests of optical, electro-optical and illumination aids to vision.

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2144-85-P

Report of Project MICHIGAN

Optics and Vision

Period 1 July 1955 to 31 January 1956

H. Richard Blackwell
Group Head

June 1957

The University of Michigan
Engineering Research Institute
Vision Research Laboratories
Ann Arbor, Michigan

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ABSTRACT

The progress of the Optics and Vision Program of Project MICHIGAN for the period 1 July 1955 to 31 January 1956 is described. Topics discussed include: (a) field test planning and instrumentation; (b) simulator development and tests; (c) basic studies of the elements of the optical surveillance problem (target and background characteristics, the optical properties of the atmosphere, and the operating characteristics of the eye); and (d) development and tests of optical, electro-optical and illumination aids to vision.

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PREFACE

Project MICHIGAN is a Joint Service supported project at the Engineering Research Institute, The University of Michigan. Its general mission is the conduct of research and development of systems and components for combat surveillance. It operates under the cognizance of the Chief Signal Officer, Department of the Army.

The aims of Project MICHIGAN are: to supplement the functions of the Technical Services in the research and development of equipment for surveillance, target detection, target location, and data transmission; to make maximum use of the techniques and equipment developed by the Technical Services and to emphasize their ultimate use in the combat surveillance system; and to engage in such research and development as may be found necessary to fill gaps in the existing programs leading to combat surveillance.

The research program in optics and vision is being conducted in the University's Vision Research Laboratories, with the objectives of assessing present optical capabilities for combat surveillance and developing improved procedures, and optical and illumination aids. This report summarizes the progress in the Optics and Vision Program from 1 July 1955 to 31 January 1956.

1
SUMMARY

Continuing progress has been made in all phases of the Optics and Vision Program of Project MICHIGAN, directed at assessing and improving optical surveillance of the battle area.

Final arrangements are being made for field tests of aerial photographic surveillance, to be conducted during March 1956 at Fort Polk. Aerial photographs of Army target configurations will be taken at various flight altitudes, with various focal-length cameras. The clarity of the atmosphere will be measured photometrically during the tests. Subsequent photo-interpretation will establish the conditions for obtaining maximum surveillance information.

Equipment is being developed for ground surveillance field tests, particularly at night. A standard field test target is being constructed, which may be varied in reflectance from a remote observation post, to assess the reflectance difference between target and background required for detection under various field conditions. A photoelectric illuminometer was developed which measures the illumination falling on any plane of interest, weighting the light coming from various directions accurately in terms of the cosine law of illumination.

The model simulator for ground-to-ground problems is now sufficiently complete so that experimental studies of visual surveillance capabilities can be conducted with it. Model construction of an area 10 by 20 ft is complete. Reasonably satisfactory systems for producing diffuse and collimated illumination were set up. Techniques for measuring target detection and identification were developed. Studies of the effect of illumination geometry upon detection and identification ranges will now be conducted.

Further instrumentation has been developed for photographic photometric studies of target and background characteristics in visible radiation. Development of a scanning photoelectric microphotometer was completed. This instrument can evaluate the transmittance of negative records from point to point; an automatic mechanical scanning feature makes it convenient and accurate for use in assessing the luminance distribution of the targets and backgrounds photographed.

Instrumentation for studying the optical properties of the atmosphere at night was further developed. Refinements were made on the Portable Transmissometer. The electronic components of the Recording Polar Nephelometer were completed. Furthur refinements of this device are necessary for its satisfactory operation, but these should be accomplished in the next few months. Design features of a Spacelight Meter were established, and efforts are being made to locate suitable components.

Research instruments and techniques were further advanced to facilitate study of the operating characteristics of the eye. The Luminosity Meter was calibrated, and various techniques for measuring the color response of the eye are being investigated. The method of coding psychophysical data for analysis on the Michigan Digital Automatic Computer is being improved. Study of phototube characteristics continues, which is preliminary to the development of convenient photoelectric photometers for laboratory use. The electrical technique for indicating eye position and measuring eye movements is being investigated. The technique was validated for use in recording simple eye movements in one orthogonal meridian, but difficulties were encountered in using the technique to record complex eye movements having both horizontal and vertical components. Apparatus is being developed for use in recording the photopupil response.

Eight studies of the sensory and adjustment characteristics of the eye are in progress. The study of target size and shape was continued at zero background luminance, both in the foveal and the peripheral visual field. The general formulation of the effects of target size and shape in terms of an element contribution function continues to be useful. The study of targets with nonuniform luminance was continued, with multiple-spot targets. Considerable progress was made in a study of the relation between the temporal characteristics of the target and its detectability. Single- and double-pulse targets were studied. A number of studies were made of the comparative effectiveness of visual identification along various meridians (axes) of the visual field. A tentative formulation of the data is being made in terms of preferred time-space sequences for presentation of target information. Comparative visual detection capabilities were measured, with monocular and binocular vision. Binocular vision was superior in all cases investigated, but the extent of superiority varies among individuals. Progress was made in the development of a general theory of visual detection, in which target and "nontarget" occurrences are being conceptualized as sets of neural states. Studies of the ocular convergence mechanism are being made, during accommodation and during disruption of binocular fusion. These studies exhibit hitherto unknown characteristics of the convergence mechanism.

An analysis is being made of the effectiveness of various visual scanning procedures for use in aerial surveillance. This analysis is based upon isoprobability contours computed from the geometry of the air-to-ground situation, and the experimental relation between detectability and target position in the visual field.

Terminal experiments were completed to assess the effectiveness of visual detection training methods. It was found that the forced-choice technique is reasonably effective as a training aid. Experimental studies of the alleged improvement in night vision produced by electrical stimulation of the eyeball continue to exhibit the absence of an effect.

The development of the Oxy-Aluminum Torch for possible use in battle-area illumination continued. Temple University demonstrated that the oxy-aluminum flame can be burned at the top of a 70-ft tower, with all control equipment on the ground. The flame luminance was increased to 125 c/mm^2 by the use of an improved feed mechanism and finer powder. The elimination of smoke has not yet been accomplished satisfactorily.

Telespectacles for night use are being developed for field evaluation by military agencies. Kollmorgen Galilean elements, of 1.7 power, were mounted in four ways and the most satisfactory mounts determined. Fifty prototype units of each of two designs will be produced and delivered to the military probably by spring of 1956.

Work continued on a helmet-mounted binocular for ground use at night, based upon the principle of optional use. The design for a helmet-mounted, counterbalanced assembly for use of an antivibration unit in ground surveillance from a light aircraft was completed. Development of a 15-60 power jeep-mounted monocular telescope for night use is still in the early stages. The suitability of wide-angle Galilean telescopes based upon contact-lens oculars is being studied. Further experimental tests of an experimental stereo-enhancer failed to reveal any practical value of the device.

A concept of an electro-optical device to restore target contrast lost due to the light-scatter in the atmosphere was developed. Variable voltage cutoff and gain adjustments can, in principle, compensate for the effects of the atmosphere and restore target contrast. A mathematical model of the device is complete. Assessment of the concept must await development of suitable research equipment.

2
INTRODUCTION

The Optics and Vision Program of Project MICHIGAN has the objectives of assessing present capabilities for optical surveillance of the battle area, and of improving them in all possible ways. Optical surveillance includes the use of all devices which operate in the visible spectrum, the most important of which is the human eye. The scientific problems involved in visual surveillance include the determination of the physical characteristics of targets and their backgrounds in visible radiation, the optical properties of the atmosphere, and the sensory and adjustment characteristics of the eye. In cases where a photographic or electro-optical device is interposed between the eye and the battlefield target, the input-output characteristics of the device must also be studied.

The present capabilities of optical surveillance were studied by direct field tests, in which all the variables are involved in their usual way. A model simulator was developed, to "freeze" field conditions in the laboratory for systematic study. In addition to these direct approaches to the problem, a broad program of research into the basic elements of the optical surveillance problem was initiated. The studies of target and background characteristics, and of the optical properties of the atmosphere are physical. The studies of the operating characteristics of the eye are psychological and physiological.

The systematic study of visual surveillance capabilities by field test, simulator test, and basic studies of the elements of the problem has apparently not been attempted previously. For this reason, considerable effort was required to develop suitable research apparatus and techniques. This development program is progressing satisfactorily, and the tempo of experimentation is steadily increasing. It is anticipated that the next few years will witness great advances in our quantitative understanding of the characteristics of visual surveillance.

The development of aids to optical surveillance appears to be a fruitful technological field where comparatively little effort has previously been concentrated. The technology of nonelectric light sources promises considerable advances in means of battle-area illumination. Principles for the design of some optical aids to vision were reasonably well established and can guide the development of devices for use in the immediate future. Effort is required to develop further principles of optical instrument design for future use. This effort has not yet been organized at a satisfactory level but it is hoped that the Optics and Vision Program can soon include it.

3
FIELD TESTS OF OPTICAL SURVEILLANCE

The original program of field tests (Ref. 1) revealed the difficulties encountered in conducting such tests with the intention of obtaining quantitative data. Not only is exceptional logistic control of Army targets necessary, but complex physical instrumentation is also required to document the environmental conditions encountered during the tests. Consequently, rather than attempt to conduct a number of inconclusive tests, efforts during the present report period have been devoted to preparation of general equipment for use in field tests, and to detailed planning for a field test of aerial photographic surveillance.

3.1 DEVELOPMENT OF RESEARCH INSTRUMENTS AND TECHNIQUES

3.1.1 Standard Field-Test Target

To determine visual detection capabilities under various field conditions, it is desirable to have a target which can be conveniently varied in visibility to the point where it can just barely be seen against a natural background. A standard field test-target, shown in Figure 1, was developed. It consists of two white grills mounted in front of a black plate. One of the white grills can be moved up and down with respect to the other, so that the ratio of black-

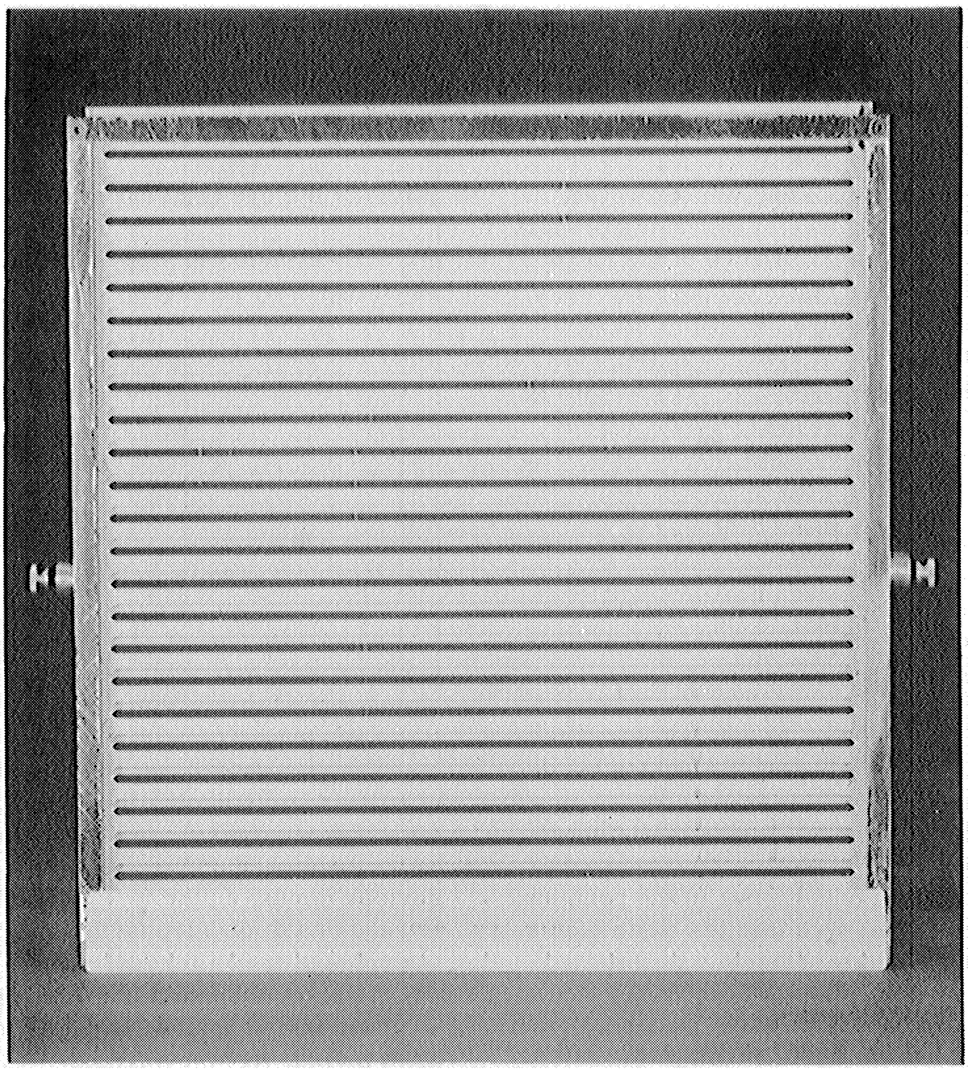

FIG. 1 STANDARD FIELD - TEST TARGET
Target Set for Integrated Reflectance of 75% White, 25% Black

to-white can be varied between 0 and 50 per cent. When viewed from more than 50 ft at night (150 ft by day), the details of the target cannot be resolved and the target appears a uniform gray whose reflectance depends on the relative white and black areas. The less the reflectance difference between the target and its background required for detection, the better are the detection capabilities of the visual surveillance subsystem being evaluated.

The field-test target was completed except for a remote control box and connecting cables.

3.1.2 Photoelectric Illuminometer

In order to document natural illumination conditions encountered during field tests, a photoelectric photometer was developed which weights illumination falling upon it in accordance with the cosine law. The device consists of a phototube photometer with a diffusing plate. A pot opal disc with a sandblasted surface was found most suitable, the angular response departing by less than 2 per cent from the cosine relation at any angle.

3.2 FIELD TESTS IN PROGRESS

3.2.1 Aerial Photographic Surveillance Tests (Planned for March, 1956)

Preparations are nearing completion for a field test to establish the photo-scale for vertical aerial photographs which will provide the maximum information about battlefield targets of tactical size. Photo-interpretation aids and procedures will also be evaluated (Sec. 6.4.1).

Two K-17C aerial cameras, equipped with lens cones of 6-, 12-, and 24-in. focal lengths, have been installed and tested in an RB-26 aircraft. The different focal lengths will provide the same scale photos at different altitudes. Two cameras will permit the simultaneous exposure of two different types of film. After study of a number of techniques for securing large-scale photo-coverage of ground areas the size of a tactical target, we have selected overlapping, low oblique photography with a rapid cycling 35 mm camera directed through the side window of a low flying L-19 aircraft. Atmospheric clarity of the air-paths involved in the photography is to be documented with the photometric camera equipment (Ref. 1). Flight tests have revealed an intermittent failure of this equipment; continuing efforts are being made to rectify the difficulty.

The Continental Army Command has assigned a test site at Fort Polk, Louisiana for the period 15-31 March 1956, and sufficient troops and equipment to stage a realistic target of Battalion Combat Team size. To inform interested agencies, and to solicit their criticism and assistance, liaison has been maintained with the following: Army Photo Intelligence Center at Fort Holabird, Maryland; Photo and Television Division, Battlefield Surveillance Department, Fort Huachuca; Air Force Contract personnel of the Boston University Optical Research Laboratories.

4

SIMULATOR STUDIES OF OPTICAL SURVEILLANCE

Effort in this area was devoted to further development of a model simulator for ground-to-ground use, study of techniques for determining detection and identification distances for battlefield targets, and preliminary evaluation of the effects of some field variables upon visual surveillance capabilities.

4.1 DEVELOPMENT OF GROUND-TO-GROUND MODEL SIMULATOR

A model simulator was developed for use in studying optical surveillance along ground paths. The total completed model now covers an area 10 × 20 ft, at a scale of 108:1. The general

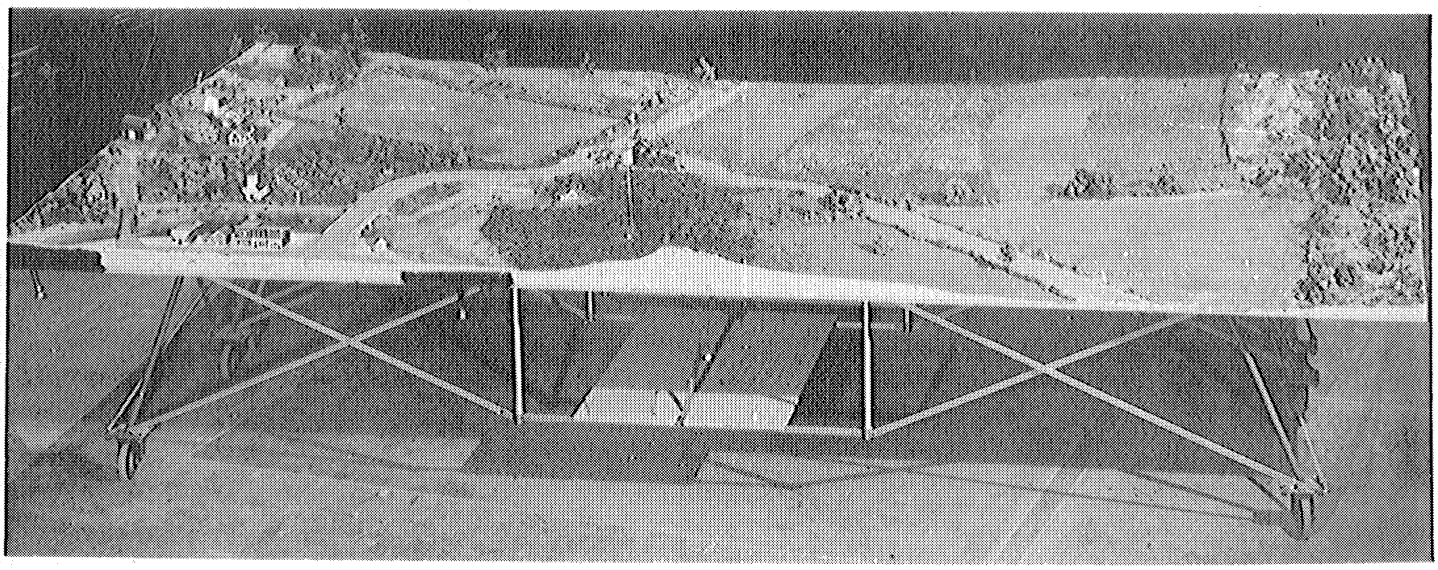

FIG. 2 MODEL SIMULATOR FOR GROUND-TO-GROUND OPTICAL SURVEILLANCE

appearance of the model is apparent from Figure 2. Further foreground areas will be constructed to complete the simulator, but the present model is suitable for preliminary experiments. To aid model craftsmen in preparing the difficult transitional areas bordering woods, fields, streams, etc., a library of terrain photographs was assembled, many of which were obtained in the field.

A reasonably adequate illuminating system simulating the effects of natural starlight and moonlight was developed. The starlit sky is simulated by illuminating large areas of the walls and ceiling, with an indirect light. Moonlight is simulated by a light beam with a variable density filter to provide uniform and controlled illumination over the entire model. A backdrop provides controlled luminance to simulate the night sky. Consideration was given to an improved "light plenum" system, involving a false ceiling of translucent plastic sheeting below luminaires to produce uniform sky illumination.

Because the average distance of 2.5 in. between the eyes corresponds to a simulated distance of 22.5 ft on the model, a "Cyclops" viewing device was designed to permit both eyes to view the model while eliminating all depth perception resulting from binocular disparity. The device consists of a double beam-splitting cube and a pair of mirrors. When the model is viewed through this system it will appear much like distant terrain seen through an aperture. Until this device is completed, observations of the model will be made monocularly.

Psychophysical methods are being developed for use in establishing detection distances for typical battlefield targets. It appears now that the percentages of target presentations in which the observer reports detecting a target, and can correctly identify its location in the model for each of a number of viewing distance, will be determined. Then, the distance can be computed at which the target is detected some fixed percentage of the time. A similar procedure can be used to establish target identification distances.

4.2 SIMULATOR STUDIES IN PROGRESS

Some general observations may be made concerning the apparent importance of two field variables encountered in working with the model:

a. Vegetation. Vegetation affects visibility less than had been expected. At distances where a tank target could be detected, soil and vegetation blended to a uniform surface.

b. Ground Slope. At a moon elevation of 10 degrees, ground sloping away from the beam at angles greater than 10 degrees passed from light to shadow. Visibility is markedly affected on such slopes.

Systematic studies of the relation between visual detection and identification distances and the position of directional illuminants such as the moon, searchlights, or flares may now be started. Preliminary studies suggest that the position of a directional illuminant can vary surveillance distances by several hundred per cent.

5
BASIC STUDIES OF ELEMENTS OF THE OPTICAL SURVEILLANCE PROBLEM

Efforts in this area were devoted to all three basic elements of optical surveillance: target and background characteristics, optical properties of the atmosphere, and operating characteristics of the eye.

5.1 STUDIES OF TARGET AND BACKGROUND CHARACTERISTICS

5.1.1 Development of Scanning Microphotometer

A scanning microphotometer, designed primarily to measure the point-to-point optical densities of transilluminated negative records obtained by photographing targets and their backgrounds with our photometric camera equipment was completed during the present report period, and is shown in Figure 3. (The device is suitable, moreover, for evaluating any spatial distribution of radiance or luminance from point-to-point.) It consists of two units: a microscopic head attached to a moving carriage, and electrical control and recording equipment. The microscopic head was constructed by modifying a commercial microscope. Light from the object entering the objective lens strikes a photo-multiplier producing an electrical signal proportional to the radiance or luminance of the object being viewed. The microscope can be moved

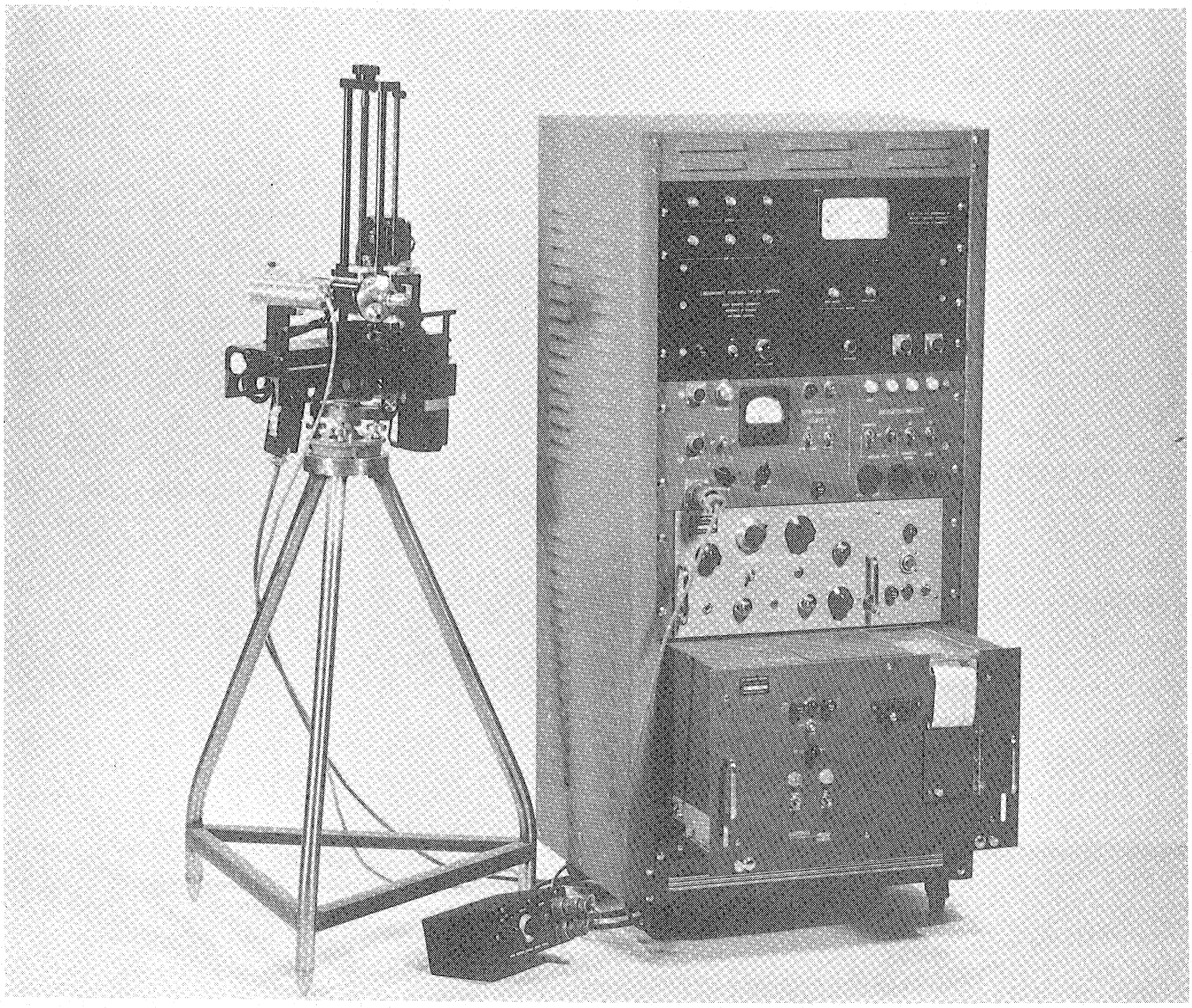

FIG. 3 SCANNING MICROPHOTOMETER
Scanning Microscopic Head on Left, Electronic Components on Right

so as to scan the object and the electrical signal is recorded simultaneously.

The maximum scanning area is a 9 in. square. Various lenses available for the microscope yield fields of view between 0.002 and 0.023 in. diameter.

The electrical equipment associated with the microphotometer is contained in a 4-ft mobile rack. The recording apparatus uses a hot stylus rather than ink, and the coordinates are purely rectangular, thus easing the task of data reduction.

The scanning microphotometer will be used for primary analysis of all photographic photometric records of target and background characteristics.

5.2 STUDIES OF THE OPTICAL PROPERTIES OF THE ATMOSPHERE

5.2.1 Development of Research Instruments

5.2.1.1 Portable Transmissometer for Night Use

A Portable Transmissometer was developed, consisting of two identical optical systems mounted parallel to two surveyor's transits; one device projects a 0.5 degree beam of light, the other receives this light on a photoelectric photometer. The percentage of the projector output which reaches the receiver indicates the transmittance of the atmosphere to visible radiation.

The reticles used in the transit telescopes for aligning the projector and the receiver were improved by the addition of double cross-hairs. The square enclosed by the double cross-hairs defines the 0.5 degree field of view of the receiver and the projector. The new reticles facilitate accurate alignment of the two systems.

Control equipment for monitoring the output of the projection unit was also improved. The output of the projector is now governed by control of the current through the lamps, adjusted by variable resistances and accurately measured by a null bridge-circuit. The current to the control circuits is supplied by a storage battery. The current from the photomultiplier is measured with an Aminco photoelectric photometer (100 v a-c) or a battery photometer (self-contained batteries).

Calibration of the device was accomplished by using the device at short distances indoors.

It was found that the Portable Transmissometer may be used as a giant Polar Nephelometer (Sec. 5.2.1.2) at night if the projector beam and receiver field of view are made to intersect in a common air volume and at an angle such that none of the incident light can reach the receiver directly. Due to its small beamspread, the Portable Transmissometer can be used to extend the polar scattering diagram to angles below 10 degrees and above 170 degrees, which the Recording Polar Nephelometer is unable to measure.

5.2.1.2 Recording Polar Nephelometer for Night Use

A Recording Polar Nephelometer to measure the volume-scattering function of natural air was developed. The device consists basically of a beam of light which is used to illuminate an air sample drawn into a light-tight box, and a photoelectric photometer which measures the light scattered in various directions with respect to the angle of illumination. Refinements were made in the optical system, the fan system, and the light-tight cover. More importantly, the electronic components of the device were completed. The photometer is now automatically driven "around the compass," and the photometer reading is recorded on a Speedomax recorder. At the end of each sweep, the nephelometer makes a return sweep during which the volume scattering function is recorded in reverse. The record indicates the amount of light scattered for each angle from 10 degrees to 170 degrees from the angle of incident illumination. The instrument may now be calibrated by substituting for the air sample, an opal plate with known reflectance characteristics, hence substituting a substance with known "scattering" properties for the air sample of unknown scattering properties. Polarizers may be inserted in both projector and receiver beams so that the polarization phenomenon of light scatter may be studied.

The Recording Polar Nephelometer was mounted in a station wagon and a jeep trailer. The installation is shown in Figure 4. A close-up view of the control panel is shown in Figure 5. The station wagon is equipped with racks containing shortwave radio, control circuits, recorder, amplifier, and voltage regulator. The Polar Nephelometer is mounted on the roof of the station wagon when taking data or stored in the back of the station wagon. The jeep trailer contains a 100 v a-c generator driven by a gasoline motor. Polar Nephelometer data can be obtained with the station wagon stopped, or with it moving at a slow rate of speed.

Preliminary data on the volume scattering function under various natural environmental conditions will soon be collected.

5.2.1.3 Spacelight Meter for Night Use

A design for a spacelight meter, which is a device for measuring the spacelight contributed to line-of-sight paths by sky and moon was developed. Spacelight may be measured by photometering the luminance of an extremely black box as viewed through the air path of interest. A black box with a reflectance less than 1×10^{-7} was designed. A design for a spacelight meter which provides sufficient light flux for photometry by ordinary

FIG. 4 STATION WAGON INSTALLATION OF RECORDING POLAR NEPHELOMETER

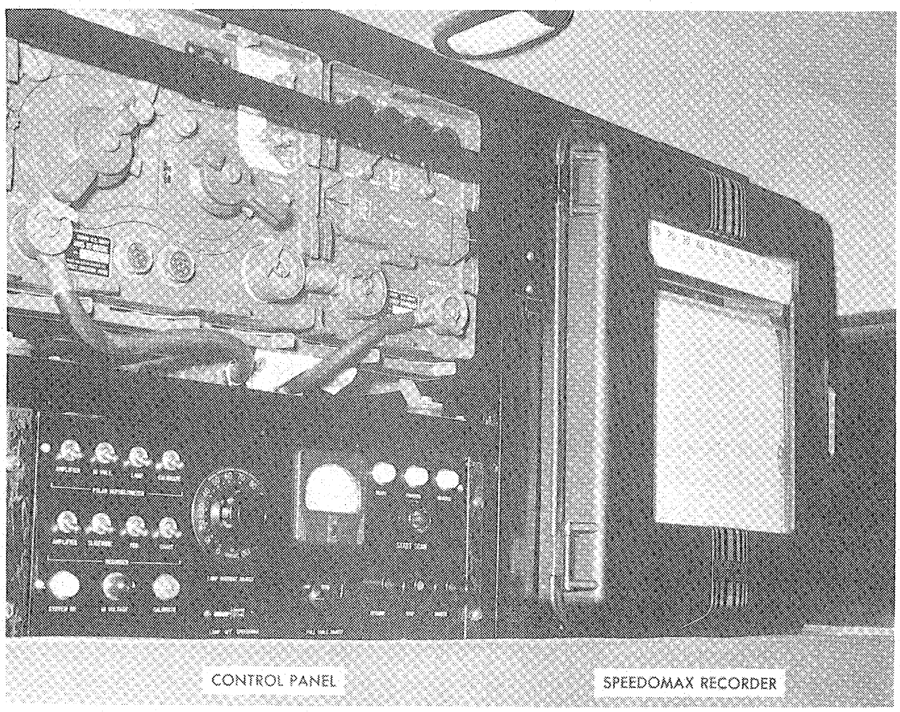

FIG. 5 CONTROL PANEL OF RECORDING POLAR NEPHELOMETER IN STATION WAGON

photoelectric photometers was recently developed. The remaining problem is to reduce spurious light from the sky around the black box which can be reflected diffusely from the objective lens or mirror of the photoelectric photometer. One design which satisfactorily eliminates this source of spurious light reduces the over-all light flux to the point where ordinary photoelectric photometers will not respond. For use with this tentative design, phototubes cooled to reduce thermal noise, and hence of increased sensitivity are being investigated.

5.3 STUDIES OF THE OPERATING CHARACTERISTICS OF THE EYE

5.3.1 Development of Research Instruments and Techniques

5.3.1.1 Psychophysical Data-Reduction Procedures

An analysis technique for evaluating the probabilities of detection and identification (Ref. 1) obtained in research of the sensory characteristics of the eye was studied. This procedure was successfully coded for solution by the Michigan Digital Automatic Computer (MIDAC) and it is now routinely utilized, with a large saving of data analysis time. Currently, this analysis program is being examined and revised to eliminate those desk computations necessary when too large a number appears at some stage of the computation, and when MIDAC fails to obtain a solution after 100 iterative cycles. The revised procedure thus far developed is highly repetitive and thus well adapted to high speed automatic computers.

5.3.1.2 Photometric Devices

Photoelectric photometers were investigated for use in laboratory studies of the sensory characteristics of the eye, to save photometric time. In order to select the best possible phototubes as components, measurements were collected and data analysis is nearly complete on the spectral sensitivity of various photomultiplier phototubes. The noise levels and fatigue rates are to be evaluated to determine the best unit for any given laboratory photometric application.

To insure the linearity of response of various photoelectric photometers, electronic and optical linearity standards were developed. The electronic linearity standard insures that electronic components are responding linearly to imposed currents. The optical linearity standard insures that entire photometers are responding linearly to applied light intensities. A satisfactory calibration of the optical linearity standard was recently achieved. Measurement of the linearity of photometers will now proceed.

5.3.1.3 Luminosity Meter and Luminosity Measurement Procedures

Development of a Luminosity Meter was continued to measure the luminosity function of the human eye, that is, the amount of radiant energy necessary to make one color appear equal in brightness to a standard white, or colored, light. This is accomplished by providing a photometric comparator consisting of a disc of monochromatic (single wave length) light surrounded by a ring of the standard light. The observer adjusts the radiance of the disc until it matches the radiance of the standard.

Radiometric measurements of the energy at each wave length in both the fields of the photometric comparator were completed. These measurements are complicated due principally to the presence of stray light in the prism monochromator, used to provide light of selected wave length.

Comparison of the brightness of a field of one wave length with the brightness of a field of different wave length is a difficult task for an observer, since he must judge equality of brightness while the colors differ. To alleviate this difficulty a "cascade" method was evolved for comparisons of brightness. With this method, color matches are made with each of a series of standards, so that the color differences involved in any particular match are minimized. Data obtained to date agree reasonably well with the 1951 Revised International Commission on Illumination Standard Luminosity Curve except in the short wave length end of the spectrum.

The results obtained with the cascade method will now be compared with the results obtained using a single white standard, where no attempt is made to reduce difficulties due to differences in colors in the photometric comparator. Once the best technique is developed, color responses to targets of varying sizes at various background luminance levels will be studied.

5.3.1.4 Electrical Eye-Position and Eye-Movement Indicator

The use of a bioelectrical phenomenon, the Ocular Rotational Potential (Ref. 1) as an indicator of eye position and eye movements was investigated. The adequacy of the ORP for the measurement and indication of horizontal eye movements was satisfactorily demonstrated. The adequacy of the ORP to measure vertical eye movements and complex eye movements involving both horizontal and vertical components was investigated.

It was found that the ORP is adequate to measure vertical eye movements, although there is more difficulty than was found with horizontal movements, due to irrelevant muscle potentials.

Complex eye movements involving both horizontal and vertical components were studied. If the ORP is to indicate these movements adequately, there must be no vertical ORP component for a purely horizontal movement and vice versa. Unfortunately, clear evidence of "irrelevant" ORP components in complex eye movements was found. Preliminary experiments suggest that the extent to which "irrelevant" ORP components occur depends critically upon electrode placement. The possibility that there is a nonorthogonal array of electrodes which corresponds to axes of electrical zero will be investigated.

5.3.1.5 Technique for Studying the Ocular Convergence Mechanism

The ORP technique (Sec. 5.3.1.4) was found to be ideally suited to measurements of the eye movements which occur during ocular convergence. These movements have only horizontal components. Under these circumstances, a pair of electrodes may be placed to the left and right of each eye. The resulting potential from each eye may be recorded on a separate channel of an ink stylus recorder. The ink stylus records reveal the position of the eyes as a continuous function of time. After calibrations to allow for nonlinearities in the response of the ink styli, these records may be used to indicate the position of the eyes during various phases of ocular convergence movements. This technique is now being routinely used.

5.3.1.6 Techniques for Studying the Photopupil Mechanism

It was recently decided to study the stimulus parameters which contribute to variation in the magnitude of the photopupillary response, that is, the response of the eye pupil to light. To study this under the widest variety of conditions, two separate apparatus setups are required: (a) a device for the study of pupil size under steady-state conditions; and (b) a device for the study of pupil size under rapidly changing conditions.

The design of both of these pieces of apparatus was completed and the apparatus components of (b) were ordered. The components for (a) are currently being assembled and preliminary observations have been made, indicating the general feasibility of this apparatus.

Apparatus (a) consists of an optical stimulation apparatus, and an infrared pupillometer, inside a light-shielded room. The pupillometer is based upon a Snooperscope, modified by the addition of a reticle for calibration purposes. Apparatus (b) utilizes a similar optical stimulation apparatus, but records pupil size by infrared photography using a Grass kymograph camera and a Strobolume infrared flash-apparatus.

5.3.2 Studies in Progress

5.3.2.1 Target Size and Shape

Studies of the effect of target size and shape upon detectability, in relation to a general theory which weights each element of target area in terms of its separation from the target center were continued. Recent experiments confirm the preliminary conclusion that the "element contribution function" falls off more slowly as the element of area is removed from the target center at zero background luminance than at 10 ft L. When targets appear in the peripheral field at zero luminance, all elements of target area receive equal weight. The element contribution theory is even more successful in predicting target detectability at zero luminance than at 10 ft L.

Further studies of the applicability of the element contribution theory will be conducted, since the development of a general formulation of the effects of target size and shape will have great practical significance in visual surveillance problems.

5.3.2.2 Target Luminance Nonuniformity

Attempts were made to extend the element contribution theory (5.3.2.1) to targets consisting of a number of bright spots. The number of spots, their separation from one another, and their configuration was varied, and the effects on target detectability measured. Ten different target configurations were studied in an experimental procedure intended to facilitate internal comparisons. It was found that the addition of a second spot always increases detectability. The addition of more spots continues to improve detectability but the gain decreases as the number of spots increases. Preliminary data suggest that increasing the number of spots from three to five makes a greater difference when the added two spots are located on the line defined by the original three rather than on the perpendicular axis to this original line.

5.3.2.3 Target Location

The effect of target location upon visual detectability was studied. Data were collected for point-source targets, at selected points within $\pm 12^{o}$ of the foveal center. This study is currently inactive but will be reactivated when possible.

5.3.2.4 Target Exposure Duration

Studies were begun on the relation between target exposure duration and target detectability. Two experiments related target detectability and target exposure duration: one for single light pulses and the other for double pulses.

For a single light pulse the contrast required for detection decreases relatively smoothly as exposure duration increases.

If the time between two light pulses, each of 0.0025 sec duration is short, the contrast required for detection is the same as for one pulse of 0.0050 sec duration. As the time between pulses is lengthened, the amount of contrast required for detection increases until it reaches a value approximately equal to that required for a single pulse of 0.0025 sec duration. At still longer separation between pulses, this threshold contrast drops again somewhat below the level required for the single pulse of 0.0025 sec duration.

Further experiments are planned to verify theoretical descriptions of these relations.

5.3.2.5 Knowledge of Target Difficulty

The effect of knowledge of the ease of detecting targets upon their detectability was studied. Data collection is now complete, and the data are currently being analyzed.

5.3.2.6 Knowledge of Target Location

A preliminary study of the effect of knowledge of target location upon detectability was conducted. Further data collection will be initiated when modifications in the apparatus are complete.

5.3.2.7 Identification Along Various Meridians (Axes)

Studies of the relative accuracy of target identification along various meridian lines of the visual field, using linear arrays of discrete target elements, were continued. The results from two basic experiments suggest that fewer errors are made for elements at the ends of patterns in all meridians. The data also indicate that there is an increase in the number of errors from the North to the South of the N-S meridian, from the NW to the SE of the NW-SE meridian, and from the West to the East of the W-E meridian. To explain these results, it has been speculated that the arrays of information are neurally scanned in one or the other direction along the meridians, and that information scanned first is most successfully identified.

Considerable additional data were collected which are currently undergoing analysis.

5.3.2.8 Monocular and Binocular Sensitivity

The extent to which binocular sensitivity exceeds monocular sensitivity was studied. Recent data reveal that for three observers binocular sensitivity is clearly superior to monocular for all target sizes studied. The extent of difference is, however, different among the observers. The presence of individual differences has obvious implications for observer selection in the use of monocular and binocular optical aids, and attempts will be made to relate the observed differences to other visual capabilities. Two theoretical models have been considered to explain the relations found: in one, the two eyes are considered to add linearly; in the other, the two eyes sum on a probability basis. Neither formulation is entirely adequate for all three observers studied.

5.3.2.9 Chromatic Sensitivity

Studies were made of visual detection when target and background are illuminated by a single chromatic source. In order to isolate the sensory factors, attempts were made to control eye pupil size during the measurements. Preliminary experimental results were highly variable from session to session. The source of trouble has been traced to the system used to control pupil size, which involved mounting a metal aperture in front of the eye by means of a headband support. It was found that minute variations in the position of the apertures introduced variability in our measures of sensitivity. Accordingly, the experiments have been discontinued until a more satisfactory system of controlling pupil size can be developed.

5.3.2.10 Development of General Detection Theory

The development of a general theory of visual detection was started, with the goal of eventually greatly reducing the number of experimental studies needed to define the sensory characteristics of the eye. Once developed, crucial experiments will be conducted to evaluate the adequacy of the theory. The present form of the theory involves defining "neural states" which correspond to the presence of the target and background, and to the presence of the target alone, and defining possible categories by which the target states can be differentiated from the background states.

5.3.2.11 Eye Movements During Accommodation

Studies of ocular convergence movements which occur during optical stimulation were initiated, utilizing the ORP techniques (Sec. 5.3.1.5). Four studies have been completed, the results from which differ significantly from naive expectations.

With one eye shifting in focus from a near to a far object or vice versa, and the other eye masked, the masked eye moves while the seeing eye does not. The movements of the masked eye are smooth, continuous, and much slower than previously reported, and they occur only after long latency. The velocity of this movement is independent of its magnitude.

With both eyes fixated on a far target, both eyes move when refixating to a near target aligned before the right eye. These movements are divided into two components: a fast yoked movement of the two eyes, followed by a slower convergence of the eyes onto the target.

When both eyes are fixated and a prism is suddenly introduced before one eye, both eyes move rapidly together, and then the eyes move slowly by different amounts to reinstate binocular fusion.

When both eyes are focused on a target, no eye movement occurs when a strong minus lens is introduced, or removed, before each eye.

Further studies should suggest optimum design of optical aids to visual sureveillance which require dioptric accommodation from far to near or vice versa, or the use of a prism before the eye.

6

STUDY, DEVELOPMENT & TESTS OF AIDS TO OPTICAL SURVEILLANCE

During the present reporting period, effort was devoted to developing improved procedures for visual surveillance and illumination, optical and electro-optical aids to vision.

6.1 IMPROVED VISUAL SURVEILLANCE PROCEDURES

6.1.1 Evaluation of Visual Search Procedures

An operations analysis of the relative effectiveness of aerial visual surveillance at different flight speeds and altitudes was continued. This analysis involved the simple case of an aerial observer flying over a straight road and looking vertically downward The measure of effectiveness was the probability of detection of a target located on the road. Currently, the more general case, where the observer looks obliquely downward and the target may be anywhere on the ground, is being considered. The relative effectiveness of various methods of visual scanning for assumed values of flight altitude and speed is being determined. The data may also be used subsequently to re-examine the relative effectiveness of various flight speeds and altitudes for assumed visual scanning procedures.

Loci of target positions on the ground for which the detection probability is constant were computed. Incomplete sets of such iso-probability contours are shown in Figures 6 and 7, for two geometries of aerial viewing of the ground. The target was assumed to be a sphere, 10 ft in diameter, making a contrast of 0.5 with the ground, and viewed for 0.05 sec. These contours were computed from data previously collected (Ref. 1) on the effect of target location on visual detection.

These contours represent the situation for one moment in time, with the eye in a fixed position. Evaluation of the composite probability of detecting

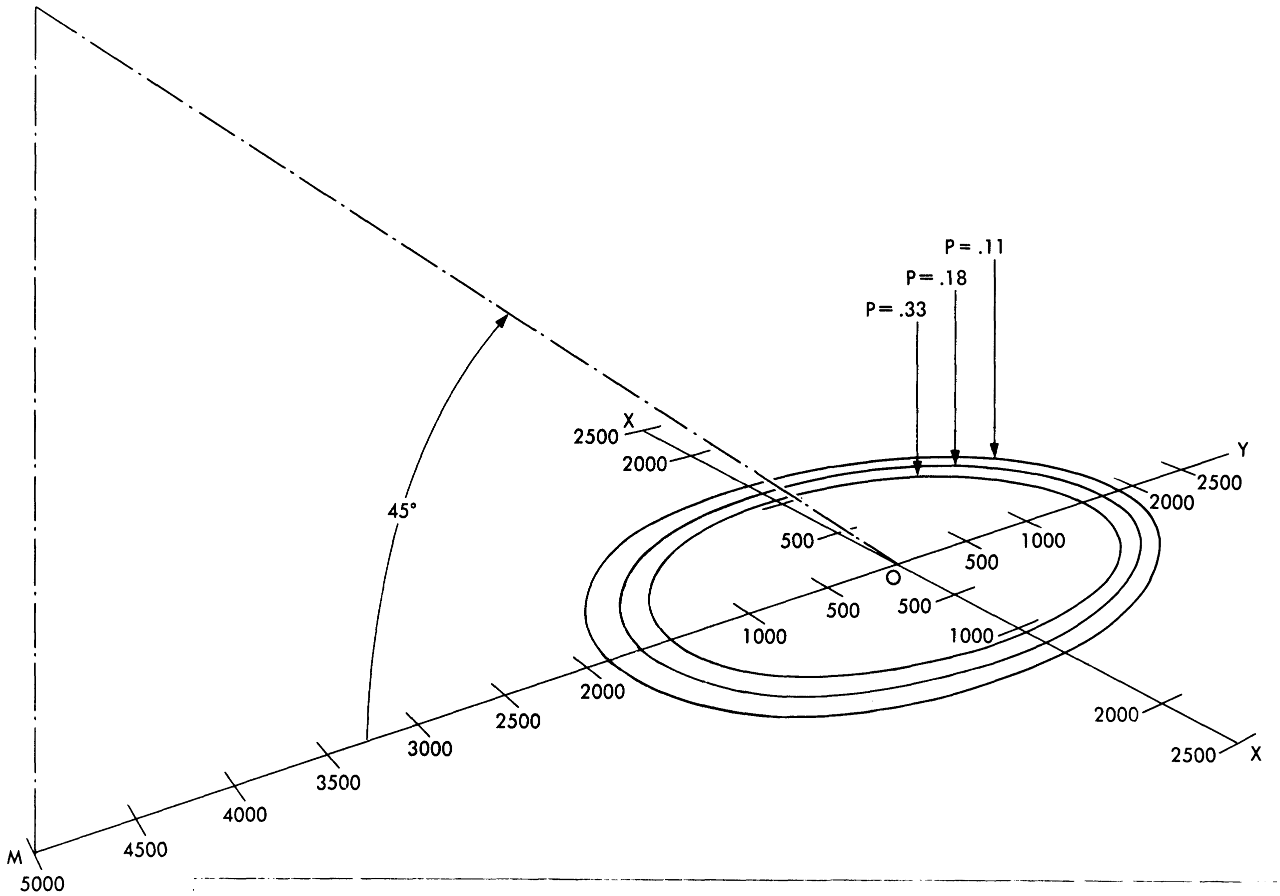

FIG. 6 DETECTION PROBABILITY CONTOURS FOR 5000-FT ALTITUDE
For an Observer Located 5000 Ft Above M and Looking Toward O. The Axes OX and OY are Reference Points for Locating Points on the Ground. Distances Along the Axes are Indicated in Feet.

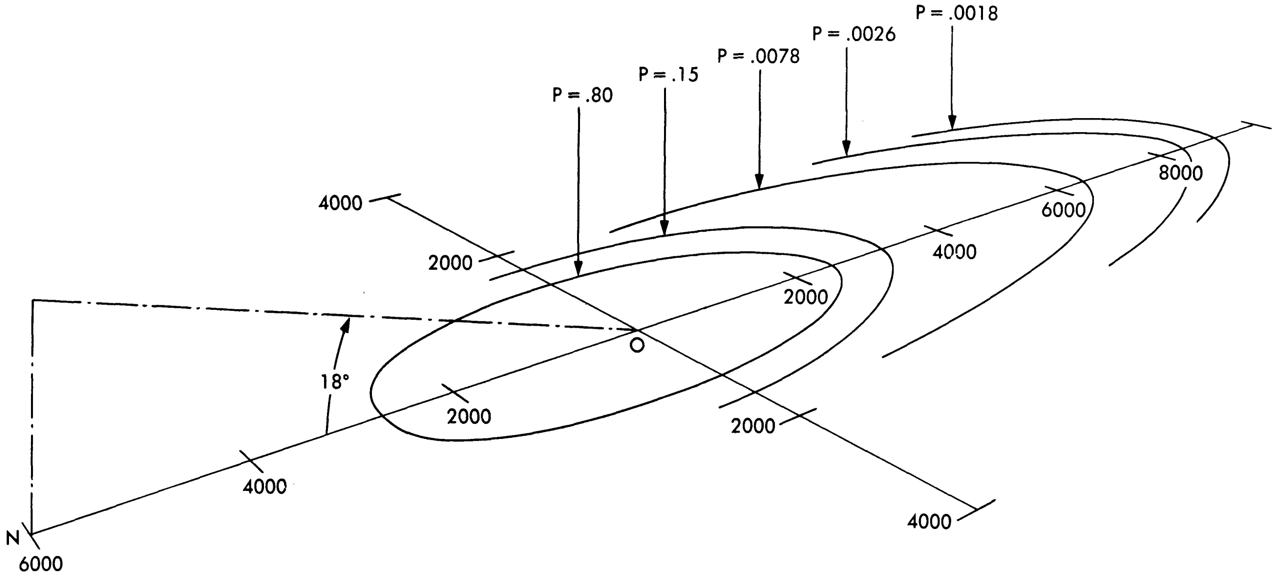

FIG. 7 DETECTION PROBABILITY CONTOURS FOR 2000-FT ALTITUDE
For an Observer Located 2000 Ft Above N and Looking Toward O.
Distances Along the Axes are Indicated in Feet.

a target observed from a moving aircraft and with a scanning eye must be based on such contours.

Computations will be carried out to complete these contours. Then various assumptions will be made with respect to patterns of visual scanning, and the resulting composite probabilities of detection for ground targets will be computed.

6.1.2 Comparative Effectiveness of Various Observer "False Alarm" Rates

A study was made of the extent to which visual detection capabilities could be improved by adoption of an optimal false alarm rate. The results of this study are available in report form (Ref. 3). After further consideration, it was decided that the improvements obtainable by manipulating "false alarm" rate are insufficient to justify further study. This project has, therefore, been terminated.

6.1.3 Effectiveness of Detection Training

The effectiveness of detection training in improving an observer's detection capability was studied. The training procedure is a laboratory method known as forced choice. Two experiments were completed on the extent and duration of improvement in detection capability during practice, and the extent to which this training transfers to a new but similar detection task. Practice of at least eight hours continued to improve detection capability. Evidence was found of the transfer of visual detection training, but the transfer effects were not large. The first experiment was concerned with the transfer of training to a target size different from the one on which the observers were trained. The second experiment was concerned with the transfer of training to a target duration different from the one on which the observers were trained.

Project MICHIGAN does not intend to conduct further studies of detection training methods.

6.1.4 Effectiveness Of Photosensitization by Blue Light

A study was made of the extent to which the dark-adapted eye could be photosensitized by the addition of a dim, unfocused blue light to the entire visual field. Although there was evidence of photosensitization, efforts to determine optimum conditions for the use of blue light were unsuccessful due to the presence of apparently uncontrolled variables in the experiment. Efforts to isolate the uncontrolled variables have not yet been successful.

6.1.5 Effectiveness of Alleged Electrosensitization

The possible improvement of visual capability at night by electrical stimulation of the eyeball was studied. Early results failed to demonstrate any effect on achromatic sensitivity due to d-c stimulation. Recent experiments failed to demonstrate the effects Kravkov and Galochkina (Ref. 2) reportedly found on color sensitivity, using d-c stimulation.

The Russians reported that (a) when the front of the eye is made anodal with respect to an electrically neutral point on the body, the eye becomes sensitive to blue-green and less sensitive to orange-red and (b) cathodal polarization has the opposite effect.

The possible effects of a-c and pulsating d-c upon visual sensitivity were considered. It was decided that a study of the effect of frequency of stimulation on the threshold for "electrical phosphenes" would be in order. (Electrical phosphenes are apparent light flashed produced by intermittent electrical stimulation of the eye.) Presumably, there is a relation between the frequencies effective in eliciting phosphenes and those effective in sensitizing visual response. Preliminary results indicate that different neural components of the visual system are affected by different frequencies of electrical stimulation. Thus, it may be possible to manipulate the sensitivity of the visual system by proper intensities and frequencies of imposed electrical stimulation.

6.2 ILLUMINATION AIDS TO VISUAL SURVEILLANCE

6.2.1 Temple Torches

Studies were made of the possible usefulness of an oxy-aluminum flame, based upon a cutting torch originally developed by Temple University, as a source of battle-area illumination to improve visual and photographic surveillance.

Higher and steadier flame luminance has been achieved by Temple University under subcontract to Project MICHIGAN by adding oxygen jets to the powder-feed screw mechanism to prevent powder from clinging to the screw, thus producing more uniform flow rates. Finer grades of powder have also been used. Best results to date have been achieved with a mixture of 5 per cent R-120 and 95 per cent R-100 aluminum powders. A reasonably steady luminance of 125 c/mm^2 can now be obtained fairly consistently. This represents an increase of 67 per cent over the value originally obtained. Since it is doubtful that further increases in luminance can be achieved easily, further efforts in that direction will cease.

Tests have been conducted at Temple University with the torch placed on a tower 70 ft above the feeder mechanism, as shown in Figure 8. Copper tubing was used to pipe the oxygen-powder mixture, the hydrogen ignitor fuel, and the coolant water to the top of the tower. A spark coil was used to ignite the hydrogen remotely. Tank pressures had to be increased considerably to maintain a normal rate of oxygen flow, but there was apparently no appreciable fall-out of the powder due to the velocity of the mixture flow.

Methods of collecting smoke produced by the flame are being investigated. A large graphite tube has been used to draw the smoke away from the flame, but efforts to collect the smoke at the other end of the smoke-collecting mechanism have not yet been successful.

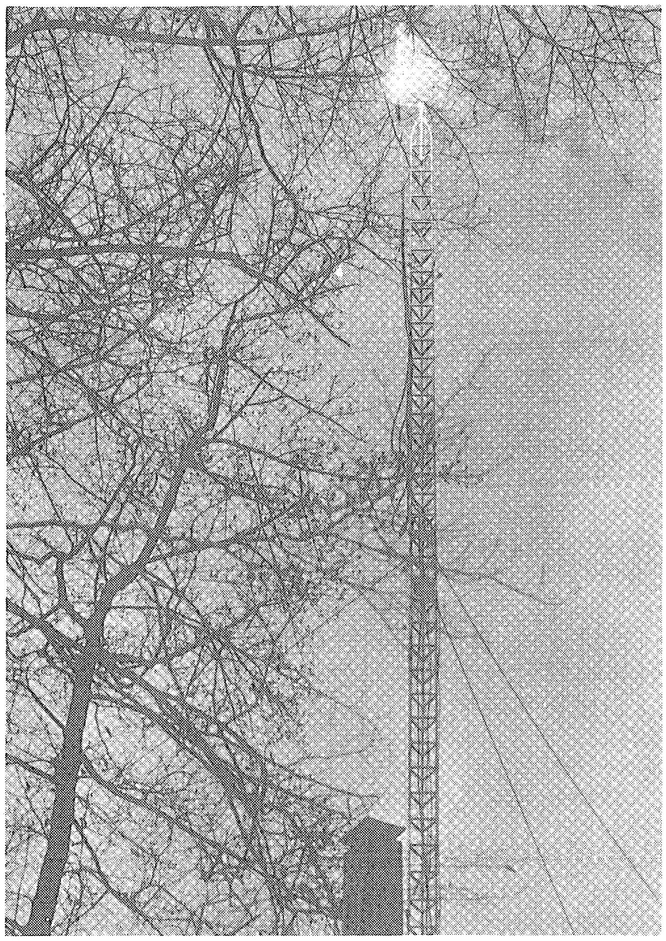

FIG. 8 TEMPLE TORCH ON 70-FT TOWER

6.3 OPTICAL AIDS TO VISUAL SURVEILLANCE

6.3.1 Night Telespectacles

Studies were made of low-power, wide-field Galilean telescopes for use at night for ground surveillance. The most promising binoculars were made by mounting 1.7-power Kollmorgen telespectacle elements in an ordinary ophthalmic trial frame.

Various "mechanical" aspects of these lenses have especially recommended their use as portable aids to night surveillance, capable of "ambulatory" use. Kollmorgen elements are extremely compact, being only seven-eighths inches long and relatively light in weight due to a unique plastic mounting. These elements also have exit pupils 19mm in diameter, of major importance in any optical aid for night use because it allows freedom from alignment problems, even though the eye pupil at night is as large as 9mm. The plastic mounting system is also of interest in that the separate optical elements are optically aligned and then cast as a unit into a precision plastic mold. Another important feature of these elements is their exceptionally large true field of view which allows the user of binoculars made from these elements to walk about freely and maintain relatively good orientation. The true field of view of each element is 19.8 degrees. The only problem has been to find a satisfactory method for mounting these lenses for field use, since an ophthalmic trial frame, which is held to the eyes by hand, seems scarcely practical.

It was decided that one research model of each of several types of mounting should be fabricated. The mounts could then be evaluated for comfort, ease of use, and mechanical simplicity after they had actually been worn. Four research models were fabricated and evaluated. On the basis of the evaluation, prototype models of two of the mountings will be produced and delivered to the military for field test probably during the spring of 1956.

Hand-Held Mount

The hand-held mounting shown in Figure 9 is the simplest of any of the mountings evaluated. The user would have the unit available in a pocket, pull it out for a better look at the terrain of interest, and replace it in the pocket.

A neck lanyard prevents the unit from breaking if dropped from the hands in the event of a surprise move requiring the use of both hands.

FIG. 9 HAND-HELD MOUNT FOR THE NIGHT TELESPECTACLE ELEMENTS

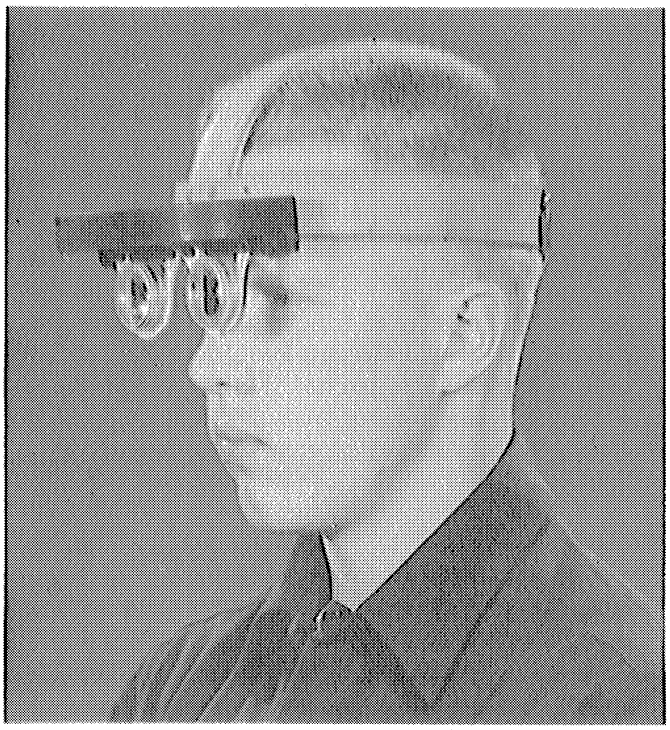

FIG. 10 HEADBAND MOUNT I FOR THE NIGHT TELESPECTACLE ELEMENTS

This model was one of the two models selected for prototype production. Fifty items will be manufactured and delivered to the military for field testing.

It was believed that some cover was necessary in order to protect the lenses from abrasion. The present plan is to assess the merits of a sheath cover, much like the cover used on the old straight razor. The cover would act as a handle extension when in the open position.

Headband Mounts

An alternate principle of mounting involves use of a headband which positions the unit firmly on the head without the need for hand support. The headband principle might well be incorporated into a visor extension on an antishrapnel personnel helmet.

Three headband mounts have been fabricated, as shown in Figures 10, 11, and 12. They differ only in the mechanical means of support and in the mechanism used to bring the lenses into place in front of the eyes when the unit is to be used. After testing these three models, a composite design was decided upon which most closely resembles Mount I, but which incorporates features of Mounts II and III.

6.3.2 Helmet-Mounted Binoculars for Ground Use

A helmet-mounted binocular for optional use at night was designed. The unit would be positioned in front of the eyes and held there, when needed, with a minimum use of the hands. A research model was built to evaluate this concept; the present status of the unit is shown in Figure 13. The binocular mounted in the device is a 2.2-power Galilean. (It should be emphasized that the research model shown is considerably larger and more complicated than it would need to be when adapted to any specific binocular, since it was required that it accommodate any binocular up to 9 x 63 size, with a minimum of modification. The only item to be changed when a different binocular is used is the counterweight attached to the cross-bar at the rear of the helmet.)

The principal feature of the mount is a two-stage mechanism which positions the binoculars close to the eyes for use, then moves them out and up to their position of rest when not in use. A chin cup is the activator.

It is essential to obtain correct alignment between the binoculars and the eyes each time. A football helmet gave excellent skull contact with

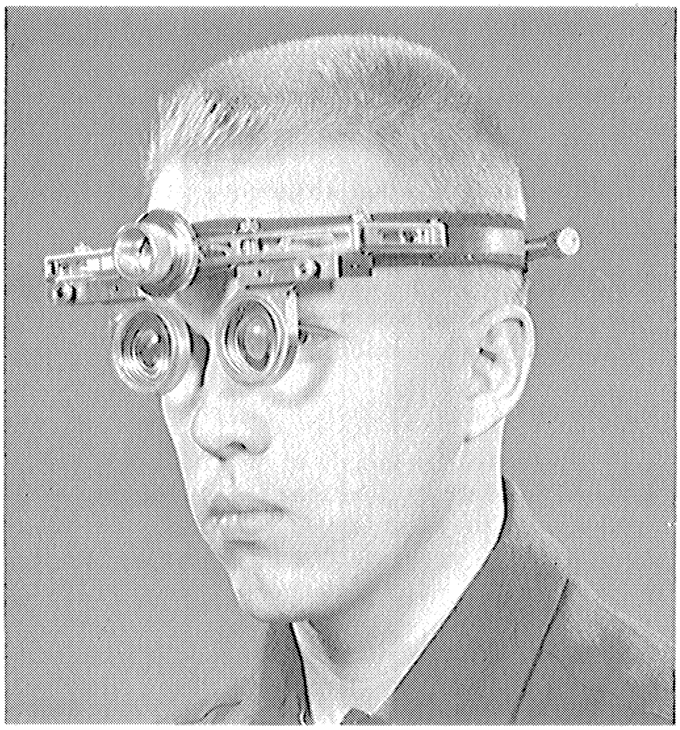

FIG. 11 HEADBAND MOUNT II FOR THE NIGHT TELESPECTACLE ELEMENTS

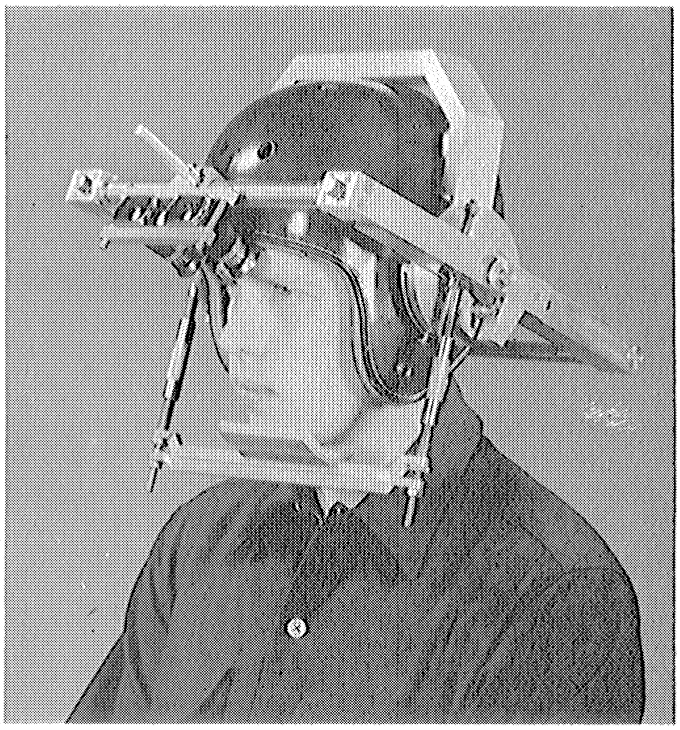

FIG. 13 RESEARCH MODEL OF HELMET-MOUNTED BINOCULAR FOR GROUND USE

FIG. 12 HEADBAND MOUNT III FOR THE NIGHT TELESPECTACLE ELEMENTS

maximum comfort, plus a good stable platform on which to mount the mechanism. Once designed around a specific binocular, the mechanism could be housed in the space between a helmet liner and a specially designed antishrapnel helmet which would also house and protect the binoculars when in the up position. The device at present has several mechanical defects which can be eliminated by a redesign of several of the major bearing surfaces.

The superiority of the present arrangement over a completely hand-held unit rests partially in the freeing of the hands, partially in the convenient storage provided the heavier binoculars, and partially in the reduction in vibration effected by the head-mounting.

6.3.3 Antivibration Binoculars

Various methods for stabilizing the images produced by optical devices mounted in various military vehicles were studied. Although the use of mechanical antivibration mounts appears promising, methods based upon "free floating" optics have the inherent advantages of less bulk and weight. Accordingly, information on present and proposed designs for image-stabilized optical systems is being obtained for systematic study and evaluation.

6.3.4 Helmet-Mounted Binoculars for Aerial Use

A helmet-mounted binocular for aerial use, employing the Rochester prototype antivibration binocular, is being developed. The design of such a device was completed, intended for ground surveillance from liaison-type aircraft. Like the helmet-mounted binoculars for ground use (Sec. 6.3.3), these binoculars are intended for optional use when needed so that the advantages of wide-angle, low-resolution search and narrow-angle, high-resolution search can be combined.

The design for the experimental unit is shown in Figure 14. It is intended for use by an aerial observer, without pilotage responsibility, in an L-19 or similar light aircraft. The design employs a counterbalancing arm attached to the helmet to enable the observer to pull the binoculars down into viewing position or push them up out the way. The entire mounting is supported by a cord running from the top of the helmet, through pulleys at the top center and side of the aircraft cabin, to a counterweight. This makes the entire unit feel weightless and automatically compensates for gravity changes encountered in flight.

Plans were made to construct a unit from this design and evaluate the principle of such a device in flight tests.

6.3.5 Tripod-Mounted, Medium-Power Binoculars

A study was made of the development of a medium-power, tripod-mounted binocular for use in ground surveillance, primarily at night. This device features 15 power, 9mm exit pupils, and an illuminated "alignment reticle." Early field tests revealed the value of such binoculars for increasing the range of visual detection at night. The specifications to be used in developing a prototype model were developed during the report period, and a subcontractor was found who is willing and able to develop the prototype model.

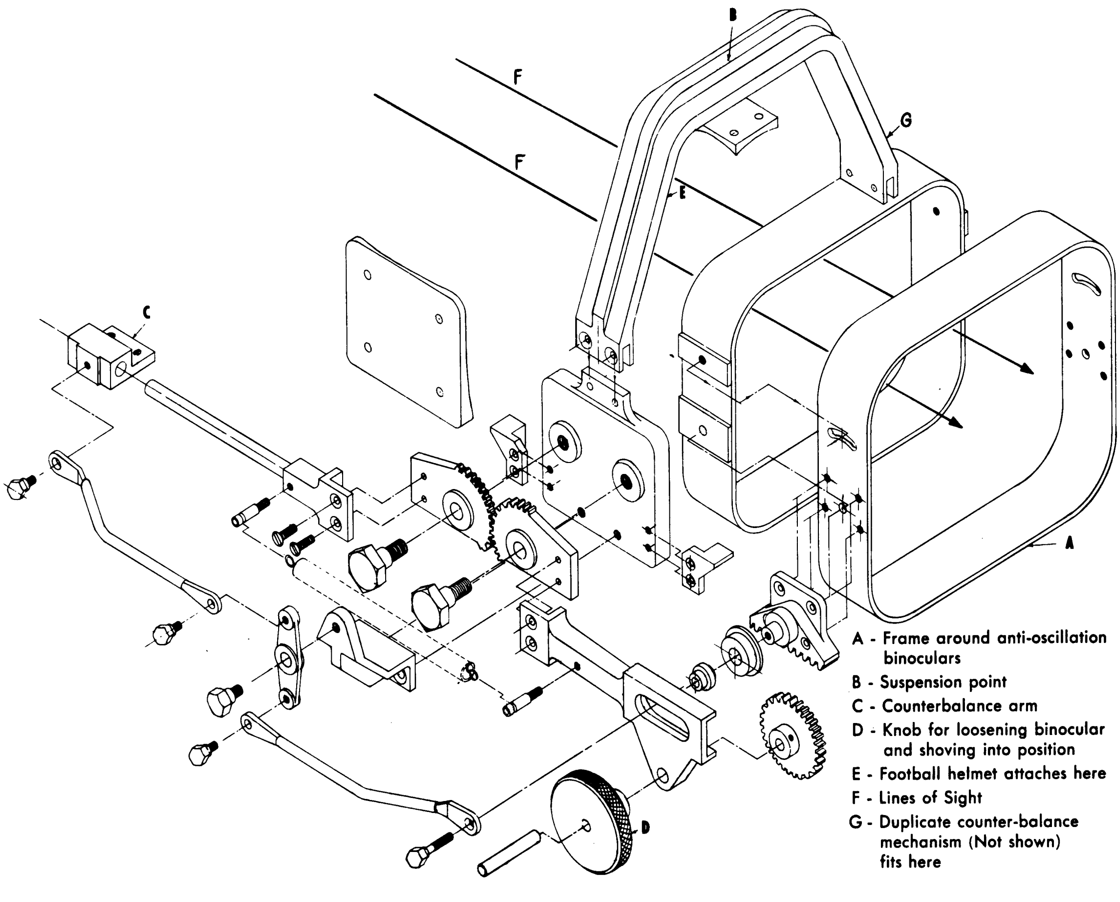

FIG. 14 DRAWING OF HELMET-MOUNT FOR ROCHESTER BINOCULAR

6.3.6 Jeep-Mounted, High-Power Monocular

The development of a large, 60-power monocular for "vantage-point surveillance" of the battle area, involving a 15-power finder telescope and a jeep-transportable mount was considered. Efforts were made to borrow an astronomical mirror for use in a research device to evaluate the concept, but these efforts were finally unsuccessful. Various designs of reflection objectives were considered, and sources of supply investigated. Negotiations were started with the Optical Research Laboratories of Boston University for the design and fabrication of a mirror suitable for use in a Cassegrain system.

6.3.7 Contact-Lens Binoculars for Aerial Use

Studies were made of the development of extremely wide-angle Galilean telescopes utilizing contact-lens elements. The first design involved a contact-lens ocular with a separate objective lens and should be called a Dallos system after its inventor. Recently, studies were made of a telescopic system in which the contact lens serves as an entire Galilean telescope.

This is the Feinbloom system, shown schematically in Figure 15. Negotiations are under way with The Institute of Optics at the University of Rochester. As soon as a subcontract has been arranged, Rochester will study the characteristics of these and other designs for binoculars with contact-lens elements.

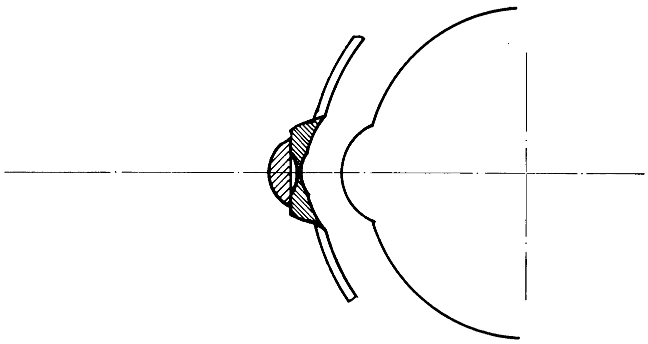

FIG. 15 FEINBLOOM CONTACT-LENS GALILEAN TELESCOPE

A contact-lens element has important special characteristics for use as an ocular in telescopic systems. Light losses are minimized; there is a possibility for high-speed scanning in a fixed large field optical system, as well as the possibility for rapidly switching from one optical system to another.

Two of the problems of using contact lenses over an extended period were partially solved. The formation of Sattler's Veil, which has the visual appearance of a fog and rainbow halos around bright points of light, is delayed considerably, if not prevented entirely, by the use of methyl cellulose in the buffer solution. (Sattler's Veil is due to the absorption of water in the corneal tissues. Methyl cellulose absorbs the excess water from tissues which are hypotonic with respect to the buffer solution.)

Comfort is increased by fenestrating the contact lens properly to admit oxygen to the fluids which bathe the cornea. The cornea's supply of oxygen comes directly from the air. If this is shut off, stinging develops. Furthermore, comfort is increased by adding antihistaminic agents to the buffer solution. Two have been tried with success: pyribenzamine and benedryl.

6.3.8 Aerial Stereo-Enhancer

The possible usefulness of an aerial stereo-enchancer developed by a Mr. Bartow was evaluated. Further flight tests were recently conducted in which the device was altered in various ways. All tests failed to exhibit any marked improvement in depth discrimination with the device. A visit to the inventor failed to establish any way in which the tests wer unfair to the device, even though Mr. Bartow continues to made extremely favorable assertions about the performance of the device.

An analysis was made of the theoretical effectiveness to be expected with the device, based upon the Helmholtz theory and utilizing experimental data published by Langlands in 1926. This analysis provided no basis for expecting the device to work, provided a regular alternation of ortho- and pseudo-stereo pairs is employed. There remain two experimental variations to try: (a) altering the time between ortho- and pseudo-stereoscopic pairs by deleting every other pair, and (b) using magnification to increase the stereoscopic angular disparity.

6.3.9 Visual Sight for a Target Location Subsystem

The usefulness of a simple visual sight for use in target location from Army liaison-type aircraft was studied. A simple ring-and-post sight has been mounted in an L-19 aircraft. Efforts to develop a suitable camera system for recording and evaluating sighting errors in flight tests were continued.

6.4 Aids to Photographic Surveillance

6.4.1 Aids to Photo-Interpretation

The development of optical and illumination aids to photo-interpretation was studied. Film materials suitable for use in evaluating potential aids are not available. A study of optimal photo-scales requires photographs of controlled Army targets suitable for this purpose (Sec. 3.2.1). Accordingly, further work on photo-interpretation aids was set aside until the photographs to be obtained in field tests are available.

6.5 ELECTRO-OPTICAL AIDS TO VISUAL SURVEILLANCE

6.5.1 Concept for a Contrast-Restoring Device

The contrast of targets observed through a given atmospheric path is reduced due to (a) transmittance losses in the atmosphere; and (b) spacelight scattered into the line-of-sight. It is theoretically possible to construct an electro-optical device which can enhance target contrast by suitable adjustment of voltage cutoff and gain within the circuit. The mathematical model for such a circuit was developed.

In an homogeneous atmosphere, the device will theoretically alter the apparent contrasts of targets at various ranges just as though the observer had moved closer to all targets by a fixed distance. In a nonhomogeneous atmosphere, the device can be adjusted to restore the inherent target contrast for targets at one range, but the apparent contrasts of targets at other ranges would be altered in a complex manner, dependent upon the nature of the non-homogeneity.

Based upon the principle indicated above, it should be possible to construct an electro-optical device, that will aid an observer viewing targets through the atmosphere. This device might take the form of an improved television system incorporating adjustable clipping, moderate gain (50-1000), and low noise, since we are concerned with the detection of a difference. Another way of physically realizing this device might involve using a photomultiplier and mechanical optical scanning, then feeding the signal to a scope synchronized to the scanner.

The feasibility of instrumenting this concept will be evaluated.

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63	Directors, Human Resources Res. Office, Attn: Security Officer, George Washington University, P. O. Box 3596, Washington 7, D. C.
64	Fred Thompson, c/o Combat Development Department, General Analysis Corporation, Fort Huachuca, Arizona
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Report of Project MICHIGAN, Optics and Vision, Blackwell, H. R.

Report No. 2144-85-P, June 1957, 25 pp., 15 illus., Project 2144 (Contract DA-36-039 SC-52654, DA Project NR-3-99-10-024, Sig C No. 102D), UNCLASSIFIED

The progress of the Optics and Vision Program of Project MICHIGAN for the period 1 July 1955 to 31 January 1956 is described. Topics discussed include: (a) field test planning and instrumentation; (b) simulator development and tests; (c) basic studies of the elements of the optical surveillance problem (target and background characteristics, the optical properties of the atmosphere, and the operating characteristics of the eye); and (d) development of tests of optical, electro-optical and illumination aids to vision.

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2. Vision
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