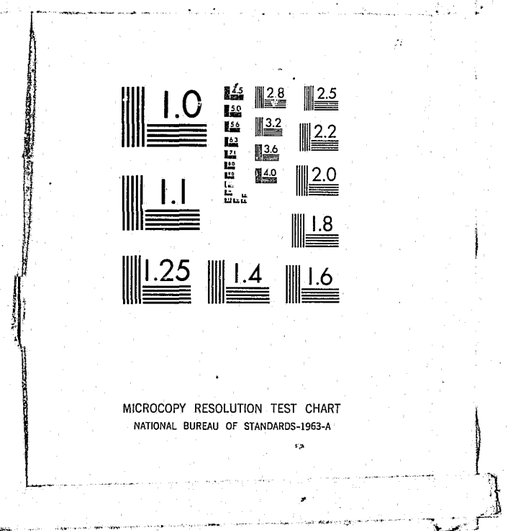

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

EVALUATION OF NIGHT-VISION EQUIPMENT FOR LAW ENFORCEMENT APPLICATIONS

EVALUATION OF NIGHT-VISION EQUIPMENT FOR LAW ENFORCEMENT APPLICATIONS

This project was supported by Grant No. NI-70-065-PG-5 awarded by the Law Enforcement Assistance Administration, U.S. Department of Justice, under the Omnibus Crime Control and Safe Streets Act of 1968, as amended. Points of view or opinions stated in this document are those of the author(s) and do not necessarily represent the official position or policies of the U.S. Department of Justice.

Prepared Under

Pilot Grant Award No. NI 70-065-PG-5

"Study of Techniques for Using Night Vision Equipment"

by

William F. Quinn

Chief of Police
Newton Police Department
Newton, Massachusetts

SUMMARY

This report presents the results of an engineering and operational analysis of the suitability of night-vision equipment for law enforcement applications. Most of the scopes evaluated are of military origin except one specifically designed for police application and are passive devices which operate on an electronic light intensification principle to present a visible presentation of a low-light-level target. On the basis of manufacturer's engineering specifications, field trials, simulated tactical missions, and equipment demonstrations by manufacturer's technical sales representatives, it is concluded that these devices, at their present stage of development, can play an important role as an aid in combatting crime. Considering the element of officer safety and the psychological advantage of surprise, plus ability to obtain photographic and videotaped evidence under the cover of darkness at a safe distance, these devices offer a definite advantage to law enforcement agencies as an aid to combatting crime during hours of darkness. The cost-effectiveness, however, must be directly related to the night-time criminal incident rate for any agency. In the area of search and rescue plus disaster recovery under night-time operations, cost-effectiveness can never be considered as a criteria.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

1. INTRODUCTION

The City of Newton Police Department contracted the Analytic Sciences Corporation (TASC) of Reading, Massachusetts, to provide professional services in connection with the technical aspects of the City's Pilot Grant Award No. NI 70-065-PG-5 entitled, "Study of Techniques for Using Night-Vision Equipment." Under the direction of the City of Newton's Police Chief William F. Quinn and the Project Coordinator Timothy C. Coogan, an engineering and operational analysis of the suitability of low-light-level direct view devices for law enforcement applications was investigated, based upon examination and field trials of the following equipment:

General Ordnance Equipment Corporation: Star-Tron Mk 202 and MK 505 Passive Night-Vision Systems (on loan) Fig. 1-1 & 1-2

Astrophysics Research Corporation L^3V Systems Division (formerly Aerojet-Delft): Owl Eye Model 50AT Low-Light-Level Viewing System (purchased) Fig. 1-3

Sylvania (General Telephone and Electronics): Model 221 Night-Viewing Device (on loan) Fig. 1-4

Machlett (Raytheon): Model 25-135 Low-Level Scope (on loan) Fig 1-5

Astrophysics Research Corporation L^3V Systems Division Owlette Model 60AT (on loan) Fig. 1-6

This equipment is a selection from the new class of night-vision aids for law enforcement. Unlike earlier electronic night-vision aids, these scopes are passive devices, operating on an electronic light intensification principle: weak light from the subject is gathered by a lens (as in a camera), converted into an electron beam and amplified, and finally converted back into a light image of much greater brightness (10,000 to 50,000 times brighter than the source). Depending on the particular device, the intensified image may

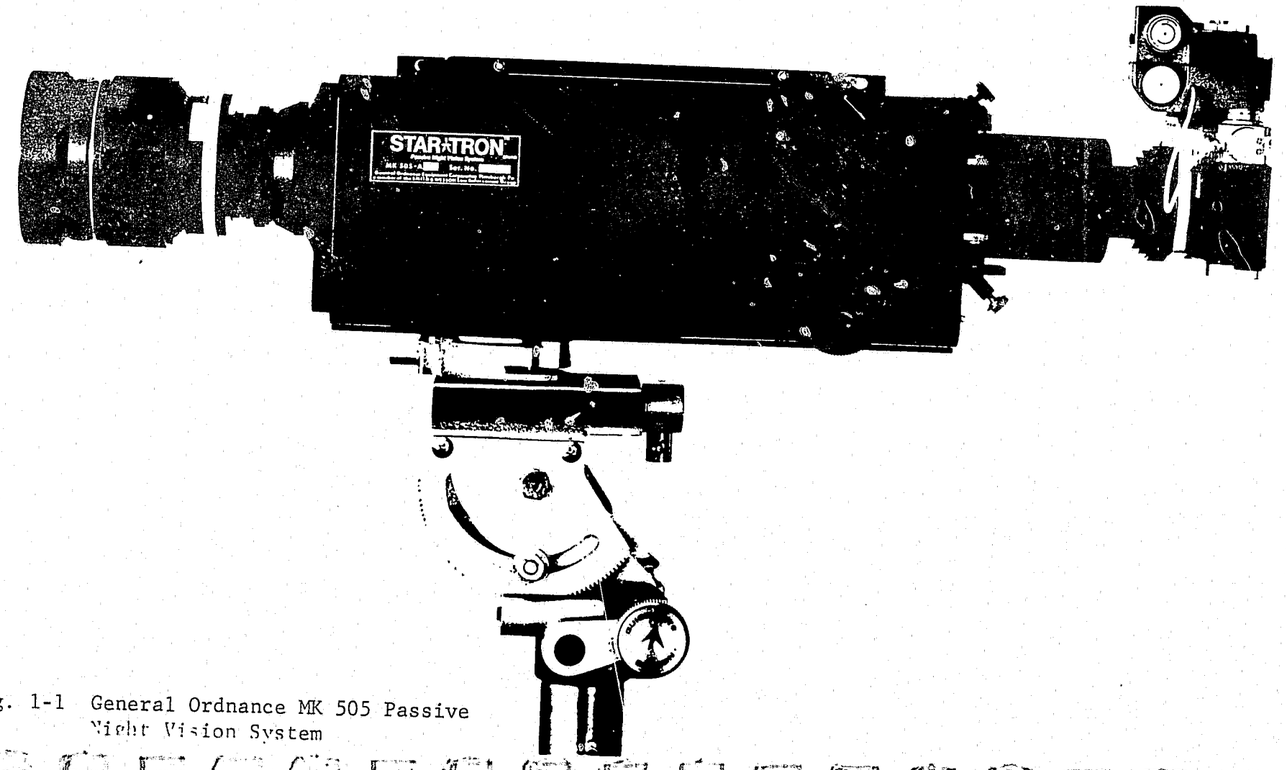

Fig. 1-1 General Ordnance MK 505 Passive Night Vision System

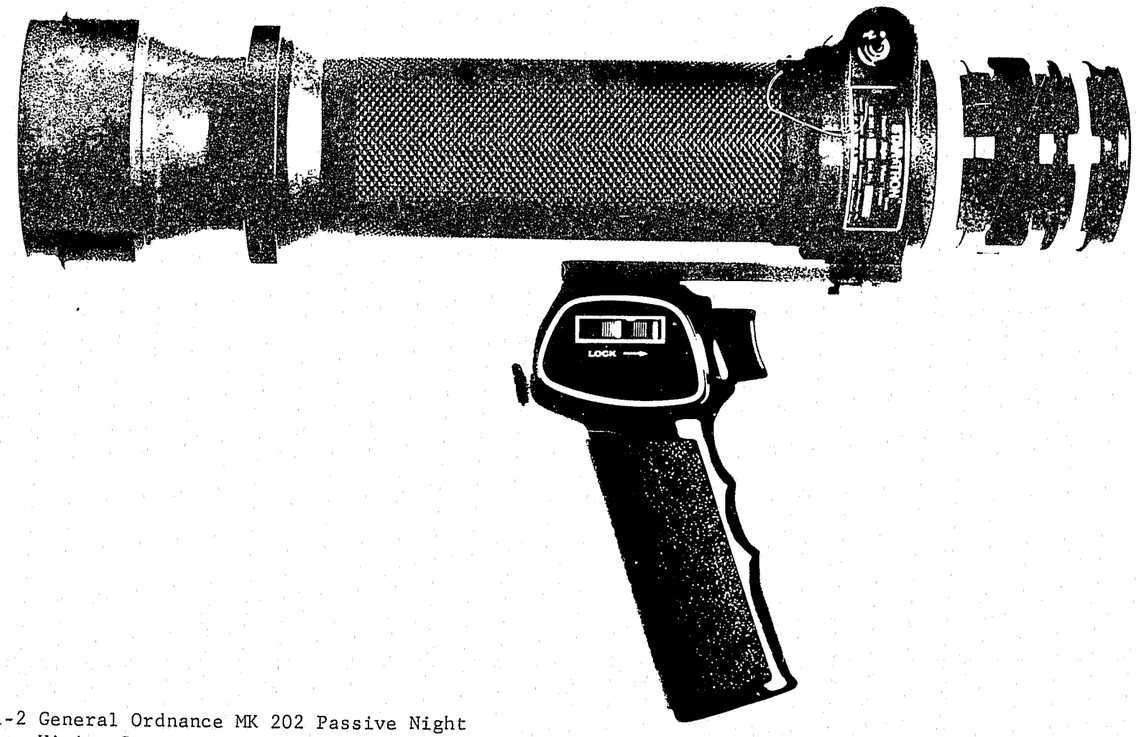

Fig. 1-2 General Ordnance MK 202 Passive Night Vision System

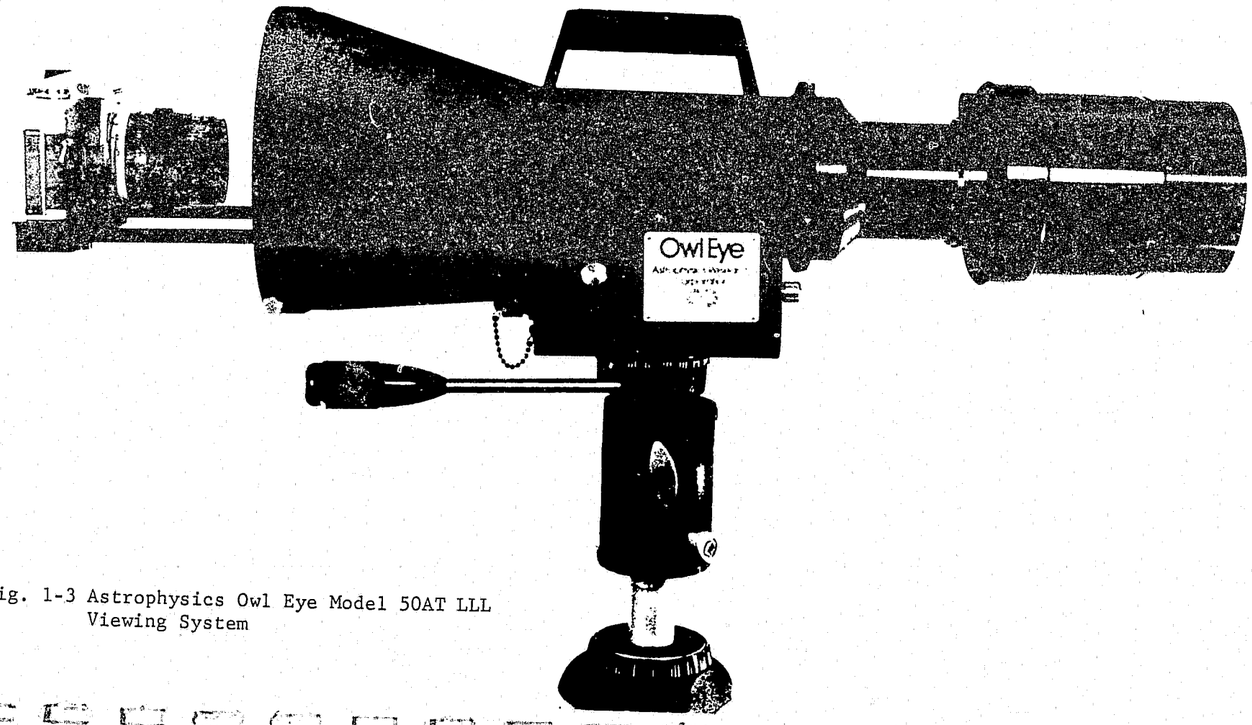

Fig. 1-3 Astrophysics Owl Eye Model 50AT LLL Viewing System

Fig. 1-4 Sylvania Model 221 Night Viewing Device

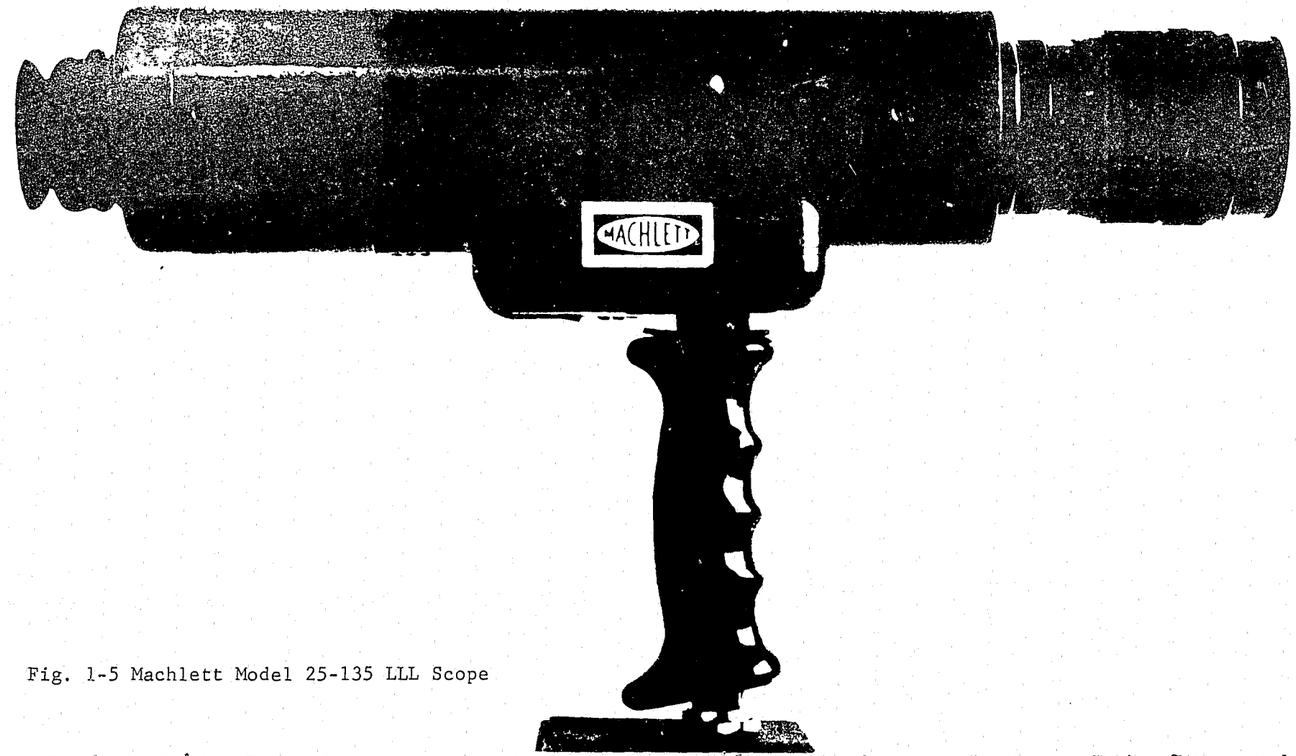

Fig. 1-5 Machlett Model 25-135 LLL Scope

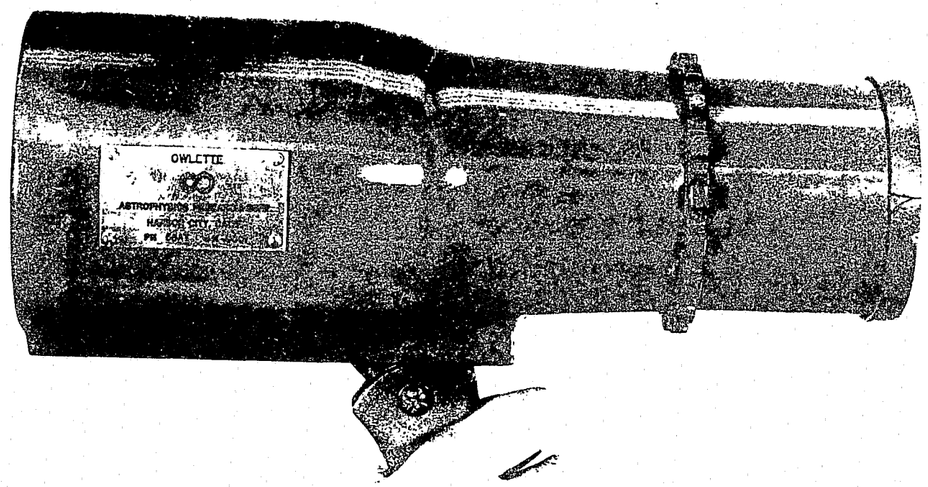

Fig. 1-6 Astrophysics Owlette Model 58AT LLL
Viewing System

be viewed directly on an image intensifier display tube, an eyepiece, a biocular viewer or indirectly by a camera, a movie camera, or remote television monitor. Inherent advantages of these low-light-level scopes include great range and resolution even at extremely low illumination (starlight); portability and low power requirements due to compact solid-state circuitry; compatibility with ordinary cameras and lenses including zoom lenses; and passivity, allowing discreet observation without risk of detection.

The objective of this study was to evaluate this night-vision equipment in terms of its usefulness in law enforcement operations. This equipment has been evaluated relative to other night-vision aids and in addition, a comparative analysis has been made of the night scopes themselves. The evaluation, presented in the third section, consist of:

Engineering Analysis:

- A collection of pertinent manufacturer's specifications for each device under study, examining the data for accuracy, internal consistency, and operational requirements for police use.
- An independent evaluation of certain device characteristics, under static and dynamic target conditions and under various degrees of target and ambient illumination.

Operational Analysis:

- Field test evaluation.
- Tactical mission analysis; a definition of police situations where night scopes may be of use, outlining advantages and disadvantages in the performance of required tasks.
- Reliability, maintainability, human factors, and personnel training.

Project activities included interviews with over fifty police detectives and undercover agents in Newton and several other Boston-area cities, and covered the subjects of surveillance, plainclothes operations, stake-out, unmarked vehicle patrol, and police requirements and responsibilities at the scene of on-going crimes. Field trials and simulated police missions were carried out over the year by a staff of six Newton police detectives. Members of the TASC technical staff spent three months of intensive field work with detectives, riding on detective patrol and observing police handling of burglaries, automobile theft, and many other calls for service. In addition, the Newton Police Department arranged for manufacturer's demonstrations, gathered device engineering specifications, monitored field trials, analyzed field evaluation forms and conducted briefings and debriefings of the police field-trial staff. A summary of project activities is presented in Table 1-1.

TABLE 1 -- 1

SUMMARY OF PROJECT ACTIVITIES

	ACTIVITY	RESULTS
FAMILIARIZATION AND PLANNING	Briefing of night detective patrol supervisor of study.	Supervisor prepared to take active role in personnel allocation and project implementations.
	Examination and use of devices at station. Familiarization of detectives with device operation, capabilities, and general principles of operation.	Understanding of individual device capabilities and limitations.
	Technical correspondence . Owl Eye -- Telephone correspondence with P. F. Le Fort, Marketing Vice President. Meeting at Reading, Mass., between The Analytic Sciences Corporation (Electrical Engineering and Instrumentation Specialists) with Astrophysics Research Corporation Chief Engineer R. E. Uehlin and P. F. Le Fort. . Machlett -- Telephone correspondence with M. Jackson of Machlett - Laboratories. . Sylvania -- Telephone and written exchange with D. J. Heckel, Product Manager Night Surveillance Equipment. . GOEC -- Telephone and written correspondence with D. G. Simons, Group Sales Manager Smith & Wesson.	Tabulation and understanding of device characteristics and limitations.
PRELIMINARY OPERATION	Use in simulated stake-outs. Field use by one detective team.	Importance of adequate array of objective lenses. Assessment of limitations imposed by device weight and bulk and by well-lit environment.
	Demonstration by Astrophysics Research Corporation and GOEC . Lens selection . Power supply and other accessories . Camera accessories, special features . General stake-out use . Comparative tests . Readings on resolution chart	Introduction of night scopes to larger cross-section of Newton Police Force under ideal equipment conditions. Further insight into engineering and operational features.
	Experimentation with photography and video camera equipment.	Demonstrated ability to obtain photographic evidence.
REVISION AND REFINEMENT OF PLANNING	Preliminary evaluation of training requirements.	Little formalized indoctrination required because of simplicity of operation.
	Device classification by size as "hand-held" or "tripod-mounted".	Hand-held scopes to be evaluated in a separate program from tripod-mounted, due to functional implications of size, and separate applications.
	Field evaluation to be based on combination of subjective user reaction and limited simulated mission analysis.	Use of comparative crime incidence and clearance data as measure of device effectiveness statistically infeasible and unreliable based on 9 months of use.
	Field trial program planned.	Field use evaluation forms designed.
FIELD OPERATIONS	Project orientation presented to night detectives. Field program and use of evaluation forms explained. Deployment of hand-held scopes by detective teams . General surveillance from moving vehicle . Examination of pedestrians and moving and fixed vehicles . Surveillance of woods and parks . Use inside darkened barn . Use in lighted city areas . Trials on foot in residential areas . Surveillance of industrial park	Determination of field effectiveness of night scopes. Development of operational requirements of night devices for police use.
	Further experimentation with tripod-mounted scopes.	

2.0 PRINCIPLES OF OPERATION

Passive night viewing devices depend upon the light amplification capability of image intensifier tubes for their effective operation. Figure I illustrates how this intensification is accomplished.

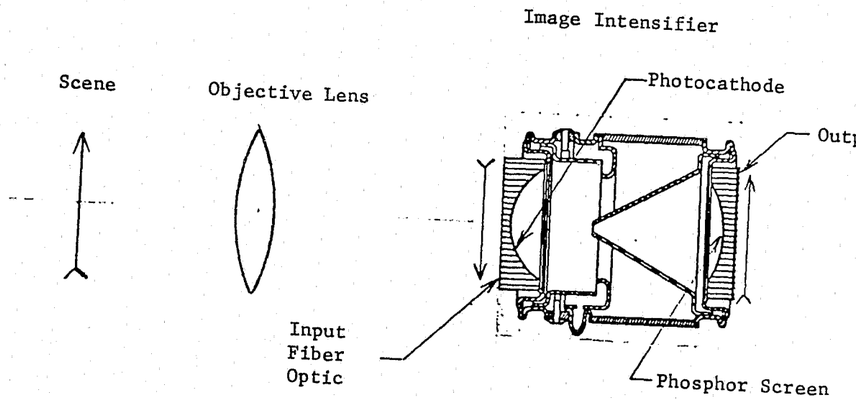

Fig. 2-1- Image Intensifier System Schematic

Light reflected from the scene is imaged onto the face of the input fiber optic plate on the image intensifier. This optical image is then transferred by the fibers of the fiber optic plate to the interior concave surface where a high sensitivity photo cathode transforms the photon image into an electron

image, i.e., photoelectrons are released in direct proportion to the light intensity at each spatial point of the image. The photoelectrons are then accelerated and focused onto the phosphor screen of the output fiber optic plate by an electrostatic lens formed by the potential applied between the anode cone and the photocathode. As the electrons strike the phosphor, kinetic energy acquired from the accelerating voltage is transformed into radiant energy. The intensification factor depends on the accelerating voltage of the tube. If the voltage between the photocathode and the phosphor screen is 15,000 volts, the intensified image is typically 25 to 60 times brighter than the optical image formed on the sensitive surface at the input fiber optic plate. The output fiber optic plate transmits this amplified image from the curved phosphor surface to the flat output surface for direct viewing or coupling to another image tube or display tube.

An essential component of the image intensifier is the fiber optic faceplate at each end. They allow optimized photocathode curvature and a flat external surface and transmit light without any lateral spread. The input and output fiber optic plates are comprised of more than 10 million glass fibers per square inch. These fibers are light pipes with a core of high index glass and a jacket of low index glass. The fiber optics can transmit a picture from one surface to another with a resolution capability in excess of 80 lp/mm.

3. ANALYSIS AND EVALUATION

In this section the methodology and observations of the engineering and operational analysis of the night-vision devices are presented.

3.1 Engineering Analysis

Tables 3.1-1 and 3.1-2 present a summary of the manufacturer's specifications for the tripod-mounted and hand-held night-vision scopes studied. These specifications give an indication of the suitability of the devices for police operations under various conditions. Analysis of these tables indicates that generally all six devices meet similar specifications, undoubtedly due to their common military ancestry.

The weight, length, and general bulk of a device are major determinants of its ease of use. The ASTROPHYSICS OWL EYE and the GOEC MK 505 (see Table 3.1-1) are large devices requiring a stable base such as a tripod for effective use; deployment in a cruiser or hand-held use are highly impractical. The Machlett, Sylvania, Astrophysics OWLETTE and the GOEC MK 202 (see Table 3 1-2), although equipped with tripod provisions, are all more satisfactory for hand-held or cruiser operation.

A standard reliable power supply is also an important feature to the user. All of the devices are powered by standard, readily-available batteries which will provide adequate service (up to 50 hours of continuous operation) life for most police applications. In addition, the GOEC MK 505 & 202, OWL EYE and OWLETTE have adapters which allow powering from external batteries (car, helicopter, etc.). The OWL EYE is also powered on rechargeable nickel-cadmium batteries or from ordinary 110V line current.

CITY OF NEWTON POLICE DEPARTMENT

TABLE 3.1--1

MANUFACTURER'S SPECIFICATIONS FOR LARGE TRIPOD--MOUNTED NIGHT--VISION DEVICES

CHARACTERISTICS	ASTROPHYSICS OWL EYE MODEL 50 AT LLL VIEWING SYSTEM	GENERAL ORDNANCE MK 505 PASSIVE NIGHT VISION SYSTEM
Primary Use	Direct View Device (DVD) 5" Diameter Picture Screen	Direct View Device (DVD) 4-½" Display Viewer; 25 or 40 mm eyepieces optional
Other Uses	Adapters available from manufacturer for TV and 35 mm camera	Adapters available from manufacturer for TV and 35 mm camera
Mount	Tripod, table, or any flat surface; Dashboard bracket available	Tripod
Weight	11.25 lbs. without objective lens or batteries	14 lbs. with Viewer and 135 mm lens
Length	19" without objective lens	17-3/8" without objective lens
Power Source	3 D-size cells (1.5 V ea.) Rechargeable nickel-cadmium battery, 22-24 hours life, indefinite life with charge 12 VDC external with adapter 110 VAC external with adapter	6.75 V Mercury Battery 50+ hour life
No. of Intensifier Stages	2 + Display Intensifier Tube	3
Light Amplification	15,000 X min spec, 20,000-24,000 typical	45,000 X min spec, 48,000 average
Protection from Bright Light	1. Diode sensor-automatic power supply shut off at 5 footcandles 2. Regulated power supply -- when 1st stage photo-cathode current exceeds threshold, remaining stages off	1. Automatic brightness control 2. Manually controlled field iris
Resolution (minimum)	Input on display tube: 130 lp/mm Output on 5" screen: 28 lp/mm (display system)	32 lp/mm minimum (tube only)
Objective Lens Mount	Quick release bayonet; adapters	Quick change breech lock; adapters available for Nikon, Pentax, Exacta, Cannon lenses
Standard Objective Lens Supplied	135 mm f/1.5 FOV 10.6° 50 mm f/1.4 FOV 30°	135 mm f/1.8
Objective Lens Availability	Limited selection available from manufacturer	
Temp. Range	MIL E 5400 C (Class 2)	-59° C to 68° C
Shock		Not available
Vibration		

MANUFACTURER'S SPECIFICATIONS FOR HAND--HELD NIGHT--VISION DEVICES

CHARACTERISTICS	MACHLETT MODEL 25-135 LLL SCOPE	SYLVANIA MODEL 221 NIGHT VIEWING DEVICE	GENERAL ORDNANCE MK 202 PASSIVE NIGHT VISION SYSTEM	OWLETTE MODEL 60AT
Primary Use	Direct View Device (DVD) Eyepiece	Direct View Device (DVD) Eyepiece; or optional biocular eyepiece	Direct View Device (DVD) 25 mm Eyepiece; 40 mm or biocular eyepiece optional	Direct View Device (DVD) 3" display tube
Other Uses	Adapters available from manufacturer for TV and 35 mm camera	Adapters available from manufacturer for TV and 35 mm camera	Adapters available from manufacturer for TV and 35 mm camera	Adapter available for recording on film or TV
Mount	Hand held (with trigger grip) or tripod	Hand held (with trigger grip) or tripod	Hand held (with trigger grip) tripod, or rifle horesight mount	Hand held (with trigger grip); tripod mount optional
Weight	4.5 lbs complete	7.5 lbs complete	9.5 lbs complete	4 lbs complete
Length	13"	8.5" without objective lens	9-½" (11-¼" with standard lens)	12" with lens
Power Source	6.75 V battery (Mallory TR-175 or Eveready E-133X) 30-60 hour life Spare battery stores in handle	2 A-size cells (1.4 VDC) 25 hour life Spares store in handle (12 VDC external adapter to be available)	2 1.35 VDC mercury cells 45+ hour life 12, 24, 28, and 32 VDC external adapters to be available	Rechargeable Ni Cad (no replacement required). 20 hours continuous use without recharging.
No. of Intensifier Stages	3	3	3	2 stages of amplification and magnifier display
Light Amplification	30,000 X approx min	30,000 X min spec	32,000 X min spec 35,000 average	25,000 minimum
Protection From Bright Light	Automatic cutoff-limiting	1. Automatic Brightness Control 2. Manually controlled field iris	1. Automatic Brightness Control 2. Manually controlled field iris	1. Automatic Brightness Control 2. Manually controlled flare light cutoff
Resolution (minimum)	Not available from manufacturer	Center 32 lp/mm; Edge 30 lp/mm (Tube Only)	35 lp/mm minimum (Tube Only)	35 lp/mm minimum (Complete display system)
Objective Lens Mount	35 mm type thread (Pentax, etc.)	16 mm "C type"	Quick change breech lock; available for Nikon, Pentax, Exacta, Cannon lenses	Quick release bayonet
Standard Objective Lens Supplied	135 mm f/2.8 adj. to f/22 FOV 10°	75 mm f/1.4 adj. to f/22 FOV 6.75°	85 mm f/1.8	100 mm f/1.2 (light weight design)
Objective Lens Availability	Available From Optical Supply Companies	Excellent Selection Available from Manufacturer		
Temp. Range	-54° C to 52° C	-54° C to 68° C	-39° C to 68° C	-54° C to + 68° C
Shock	75G	75G	Data Not Available	Mil. E-5400 Class II
Vibration	1/8" double amplitude at 30 Hz	1/10" double amplitude from 10 to 55 Hz		Mil. E-5400 Class II

Light amplification-versus-protection characteristics are a key to the usefulness of a night scope in various environments. All low-light-level passive devices require at least starlight level to effectively operate unless supplemented with a covert lighting system. However, in a well-lit urban environment the danger lies in the opposite extreme where too much amplification can cause burn damage to the scope's sensitive amplification and display tubes. Thus, each manufacturer has taken measure to protect its device from light:

- Astrophysics has replaced one intensifier stage with the image intensifier display tube for greater visual accuity and definition, thus requiring lower overall amplification. The OWL EYE is protected by automatic cut-offs which will protect the scope when too much light enters its target field. It also utilizes a manual control for amplification, thus providing greater flexibility for the operator under a variety of conditions.

- GOEC relies on an Automatic Brightness Control (ABC) circuit which reduces device amplification as the average intensity of incident light is increased. In addition, a manually-controlled field iris is provided to block out bright light sources which may be near the desired target; this helps to prevent the ABC from reacting to a streetlamp or headlight which would preclude the observation of a nearby target hidden in shadow.

- Machlett uses an automatic cut-off to shut the device off when incident lighting is too great.

- Sylvania uses an Automatic Brightness Control (ABC) and a manually-controlled field iris.

The protective measures themselves can pose problems to the user by reacting to bright light and shutting the device off or reducing sensitivity to the point where the desired target is obliterated, especially with automatic brightness control; this topic will be discussed further in Section 3.2.

The optical lens system used with a night scope determines the range at which the target can be seen in detail. All of the devices evaluated use lenses with standard mounts, enabling the lenses to be changed readily. Except for Machlett, each of the manufacturers provides a selection of lenses for its scope.

Overall device resolution is a measure of the target detail which can be seen. While the resolution capability of all of the devices exceeds that of the human eye, for photographic and enlarging purposes resolution can be important, especially when detail must be captured for presentation as evidence in court. The definition and contrast of the OWL EYE was superior to the other devices due to the display tube as opposed to a monocular or biocular eyepiece.

The durability of a night scope is important for routine police use. The amplification and display tubes in each device have been built to meet or exceed military specifications for environmental extremes. A scope can withstand a considerable amount of physical abuse while it is stored inside the foam-lined case furnished by the manufacturer. When in operation all night-vision devices are similar in durability as compared to radar, breath analyzing equipment and photographic equipment of which the police are very familiar.

3.2 Operational Analysis

The operational aspects of the night scopes were studied through a combination of field trials by officers of the Newton Detective Bureau, simulated tactical missions, and demonstrations at the Newton Police Headquarters by manufacturers' representatives.* Field trials included use by officers in moving and stationary vehicles as well as by officers on foot.

The trials were conducted both in winter on snow-covered terrain and in summer and over a broad range of lighting conditions. A sample of the field evaluation form is shown in Figure 3.2-1.

*Each of the manufacturers was invited to give a demonstration of its respective equipment; Astrophysics and GOEC gave demonstrations.

Names:_____ Date:_____

_____ Hours Used:____PM to____PM

Scope #_____

Weather and Lighting:

- ☐ Clear
- ☐ Cloudy
- ☐ Raining
- ☐ Foggy
- ☐ Bright Moon
- ☐ Partial Moon
- ☐ No Moon
- ☐ Snow Cover

Remarks:

Figure 3.2-1 **Sample Field Evaluation Form**

Based on preliminary use and extensive field interviews of police and detective and undercover agents, a number of hypothetical missions were developed as an experimental vehicle for operationally evaluating night scopes. These missions are:

Mission A: Stake-Out from Building

When the probability is sufficiently high that criminal activity will occur at a specific place and time and especially when further evidence is needed against a suspected offender, a stake-out may be of value. Stake-out from a building using a night-vision device may provide vital evidence which may be impossible or highly inconvenient to acquire by conventional methods alone. The use of video tape and photographic equipment in conjunction with a night-vision device may permit the compilation of permanent visual records of the identity and actions of persons under surveillance.

Mission B: Stake-Out from an Unmarked Vehicle

In stake-out situations where use of an adjacent building to conceal police observers is impractical, an unmarked car or panel truck might be used as the point of observations. While similar in most respects to stake-out from a building, the limited working space within a vehicle imposes special requirements on a night-vision device.

Mission C: General Surveillance from Moving Patrol Vehicle

In the course of detective patrol it is the officer's responsibility to survey the areas within his sector for signs of suspicious or unusual activity. The night scope can be used to supplement vision, allowing a more thorough examination of dark doorways, buildings, parked vehicles, roofs, shrubbery, and semi-wooded fields and parks without alerting occupants of the target area to police presence. Unfamiliar parked vehicles may be identified without using spots or headlights. Sites of particularly frequent crime (for example, a given warehouse, construction site, etc.) can be approached with patrol car headlights unlighted. Detailed descriptions of suspicious persons can be more easily obtained.

Mission D: Response to Trouble Call

A trouble call involves potential danger related to the uncertainty of the presence and whereabouts of an armed and belligerent offender. For example, in answering a residential burglar-alarm call at night, the responding police officer may walk into a situation in which a desperate armed burglar is depending upon stealth and darkness to make his escape.

A night-vision device will allow the officer to quickly survey the building area, discover a hiding burglar, and determine whether he is armed. This information could give the officer a great advantage in evaluating the situation and quickly determining his safest course of action.

Mission E: Pursuit of Fleeing Suspects

Police officers responding to trouble calls are frequently called upon to pursue fleeing suspects on foot in the dark. The pursuit terrain may consist of darkened alleyways, backyards, vacant lots, woodlands or swamps. The ability to spot a fleeing suspect nearly as well as in broad daylight would not only increase the chances of apprehension, but also provide increased safety to the pursuing officers.

Mission F: Location and Sighting of Snipers

In recent months police officers all over the nation have become targets of sniper-fire at night. A night-vision device can be used to spot a sniper concealed in the dark, pinpoint his location by detecting muzzle flash, and even obtain a videotape recording of his activities. Some devices can be used as night scopes on rifles to accurately return fire (as the devices were originally employed in military action). Although such incidents have been comparatively rare in police work, they are extremely dangerous to the police and the public. Fig. 3.2-2 shows a night viewing device mounted on a M-16.

In each of the above hypothesized missions, the actual need and worth of supplementary night-vision through use of a night scope depends largely upon the following criteria:

1. Quality of information desired from observation
   - Presence of subject
   - Activity of subject
   - Identification of subject
2. Level of subject illumination
   - Absolute level
   - Subject brightness vs. ambient brightness
3. Degree of unobtrusiveness needed
4. Set-up time available
5. Range of viewing subject
6. Type of observation point available, as dictated by the situation
7. Time span over which surveillance must be maintained.
8. Need for observer mobility

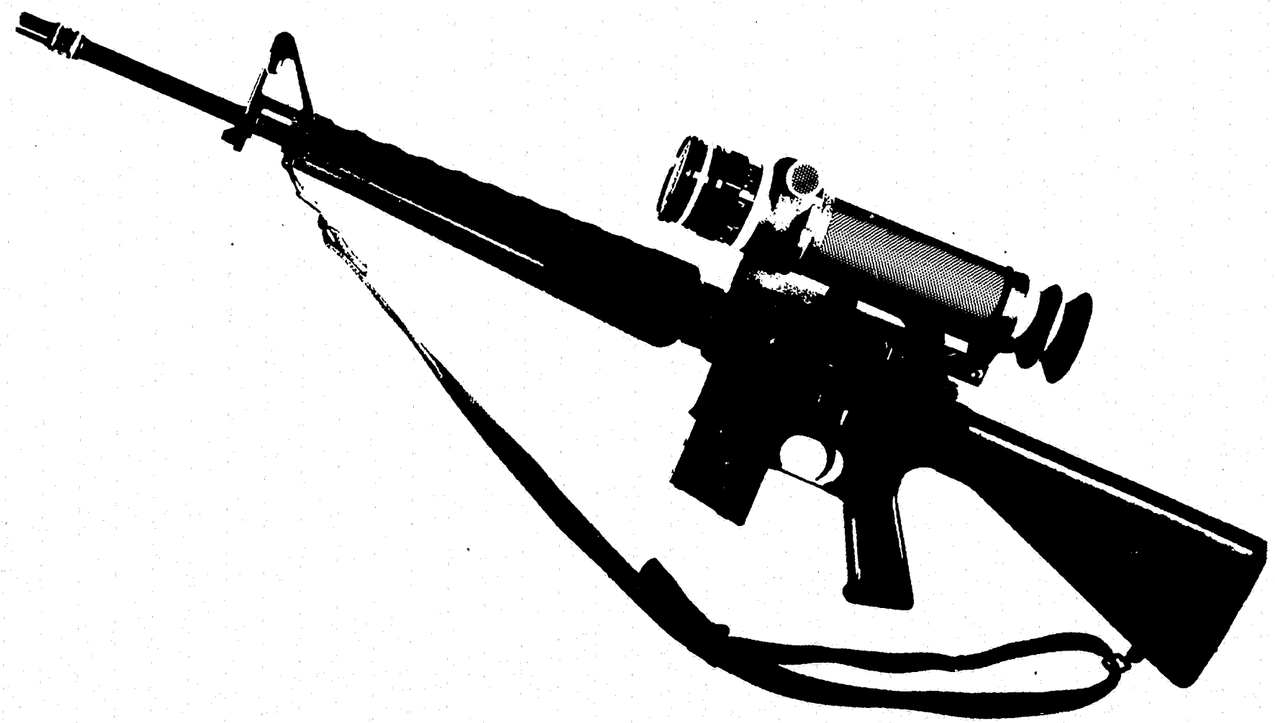

Fig. 3.2-2 GOEC MK 202 Mounted on M-16 Rifle

9. Need for permanent record

   - Still photography
   - Moving photography
   - Video tape

10. Availability and practicality of conventional aids (flashlights, spotlights, etc.)

In general, the night scopes require very little instruction or training prior to field deployment. The basic controls include an on-off switch and focus and brightness adjustments. Lens changes are basically straightforward. Most officers participating in the study felt comfortable with the equipment after only a few minutes instruction and practice.

In the missions outlined above, the direct view tripod-mounted devices proved effective in operations A, B and F. Mission C was best performed with the hand-held units for general surveillance in darkened areas. Missions D and E also favor hand-held devices, especially while viewing from a moving patrol vehicle for search and surveillance.

Except for the Machlett Model 25-135, all of the devices have biocular eyepieces. Biocular viewers have the inherent advantage of permitting the use of both eyes (Fig. 3.2-3) thereby increasing overall resolution and reducing eye fatigue; they have a potential disadvantage however in that if the scope brightness is adjusted too high, the viewer's face is illuminated, which may reveal his presence to a person being observed. The OWL EYE has accessories which reduce the back lighting.

Fig. 3.2-3 Biocular Viewer on Sylvania Model 221 Night Viewing Device

All officers who participated in the field trials complained of eye pain after using hand-held devices for only several minutes that were equipped with only a monocular eyepiece. Further, night vision equipment with monocular viewers caused the user's pupils to contract as in ordinary daylight, thus temporarily blinding him immediately after making observations with the devices.

The OWL EYE is equipped with a 5" image intensifier display screen which proved the most suitable for group observations. This feature also permitted simultaneous recording with photographic and videotape (Fig. 3.2-4). This method of recording allows uninterrupted direct viewing with the camera in place on the OWL EYE. The GOEC STAR-TRON scopes have provisions for either monocular or biocular eyepieces. The biocular eyepieces of this equipment allows multiple viewing although not to the degree provided by the OWL EYE. The STAR-TRON method for photographic recording was accomplished by a hinged arrangement in which the direct view eyepiece is swung aside and the camera swung into its place (Fig. 3.2-5). This proved to be somewhat cumbersome and not too effective operationally due to the uncooperative motions of the suspect. The time lapse for replacing the eyepiece with the camera presented a loss of activity that could prove important in evidence gathering surveillance missions. The Sylvania Model 221 device is provided with both a monocular eyepiece and a biocular viewer. Photography, however, could be accomplished only through the removal of the eyepiece or viewer and insertion of a relay lens and photographic or videotape camera (Fig. 3.2-6). These operations are somewhat more time consuming than as required for the OWL EYE and GOEC MK 505. The Machlett Model 23-135 scope is also provided with a monocular eyepiece. The manufacturer further states that adapters for cameras are available although they were not tested during this project. Operation of the Owl Eye with a 35mm camera is shown in Figure 3.2-7.

The over-abundance of artificial light in urban environments poses several problems to users of the various scopes. First, is the problem of the protective cut-off feature in all the scopes except the Sylvania 221. In this respect the Machlett scope has the most severe problem, frequently shutting off at the approach of car headlights or when the lights come into view. The OWL EYE and GOEC devices also have this problem, but to a lesser degree. These scopes not only withstood greater exposure to light sources but when they did shut off their recovery time was rapid. Since the Sylvania scope is not protected by an automatic cut-off, the manufacturer cautions using the scope in a well-lit area.

A side-by-side comparison was made of the viewing qualities provided by the large tripod-mountes scopes (Fig. 3.2-7). All light intensifier devices have a problem with bright lights in the field of view, as described above. Peripheral degradation (edge distortion), while common to all scopes, was most noticeable in the GOEC STAR-TRON due to the three-stage amplifier. A magnifier accessory offered by Astrophysics for use on the OWL EYE completely eliminates all of the amplifier distortion effects.

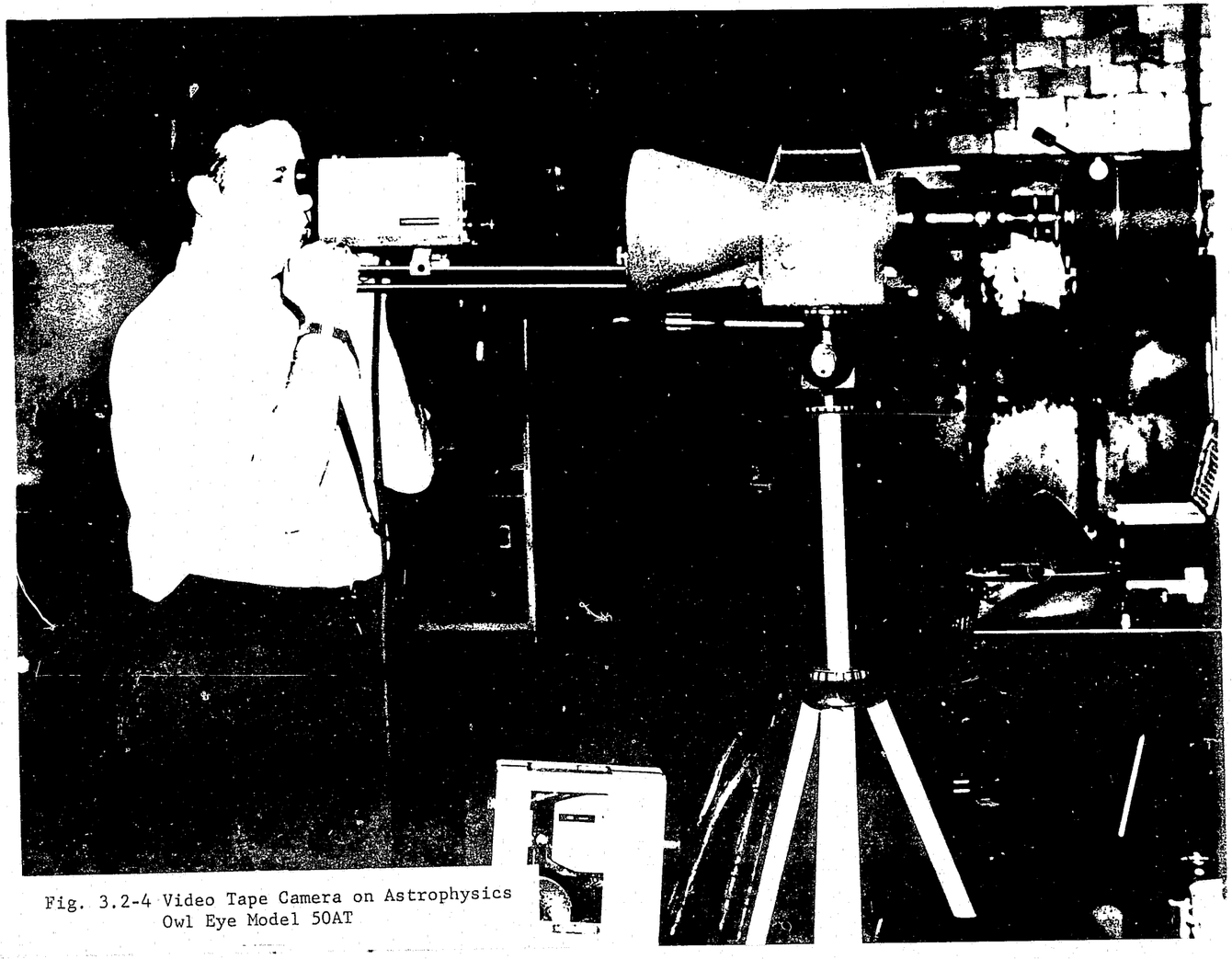

Fig. 3.2-4 Video Tape Camera on Astrophysics
Owl Eye Model 50AT

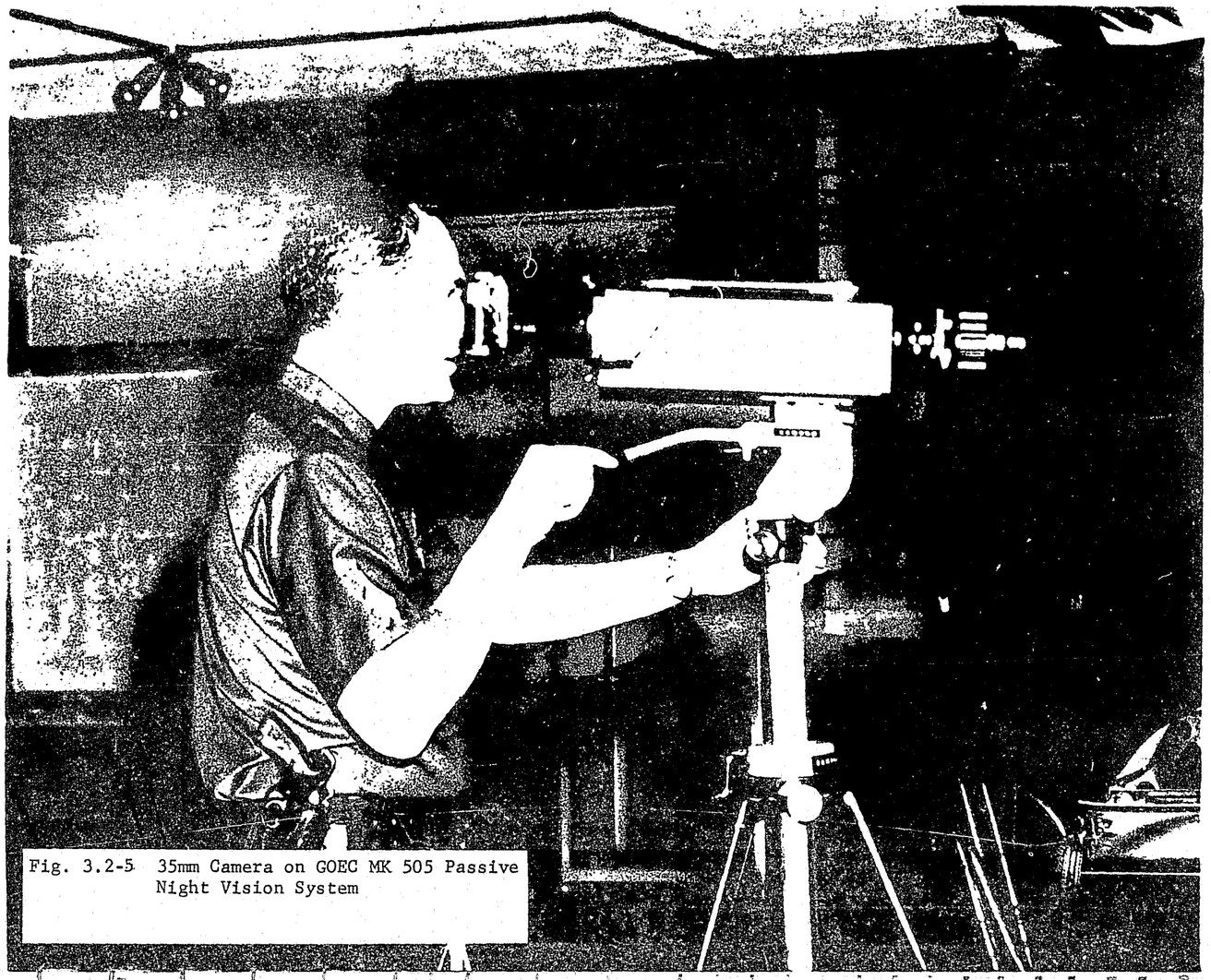

Fig. 3.2-5 35mm Camera on GOEC MK 505 Passive Night Vision System

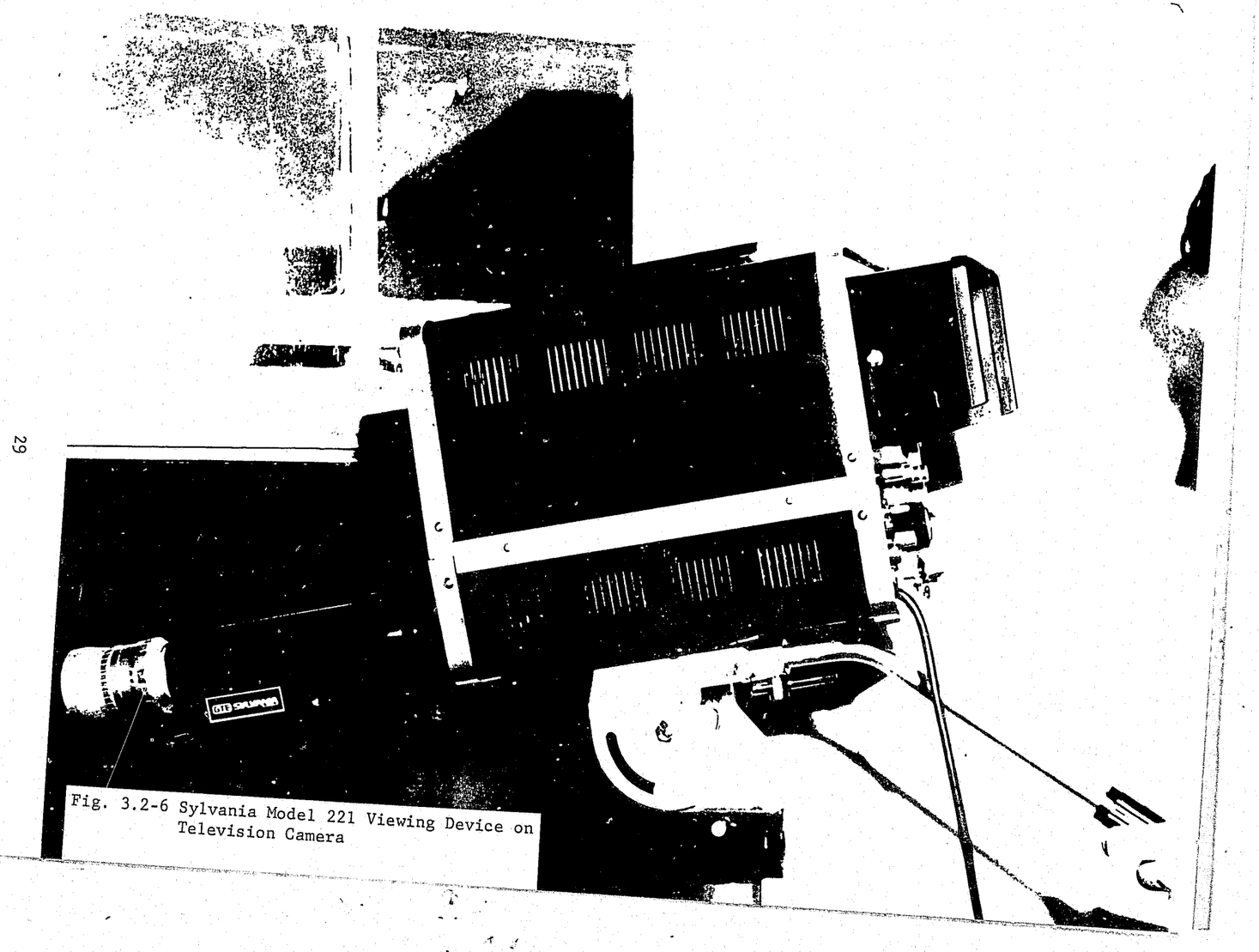

Fig. 3.2-6 Sylvania Model 221 Viewing Device on Television Camera

Fig 3.2-7 35mm Camera on Astrophysics Owl Eye Model 50AT

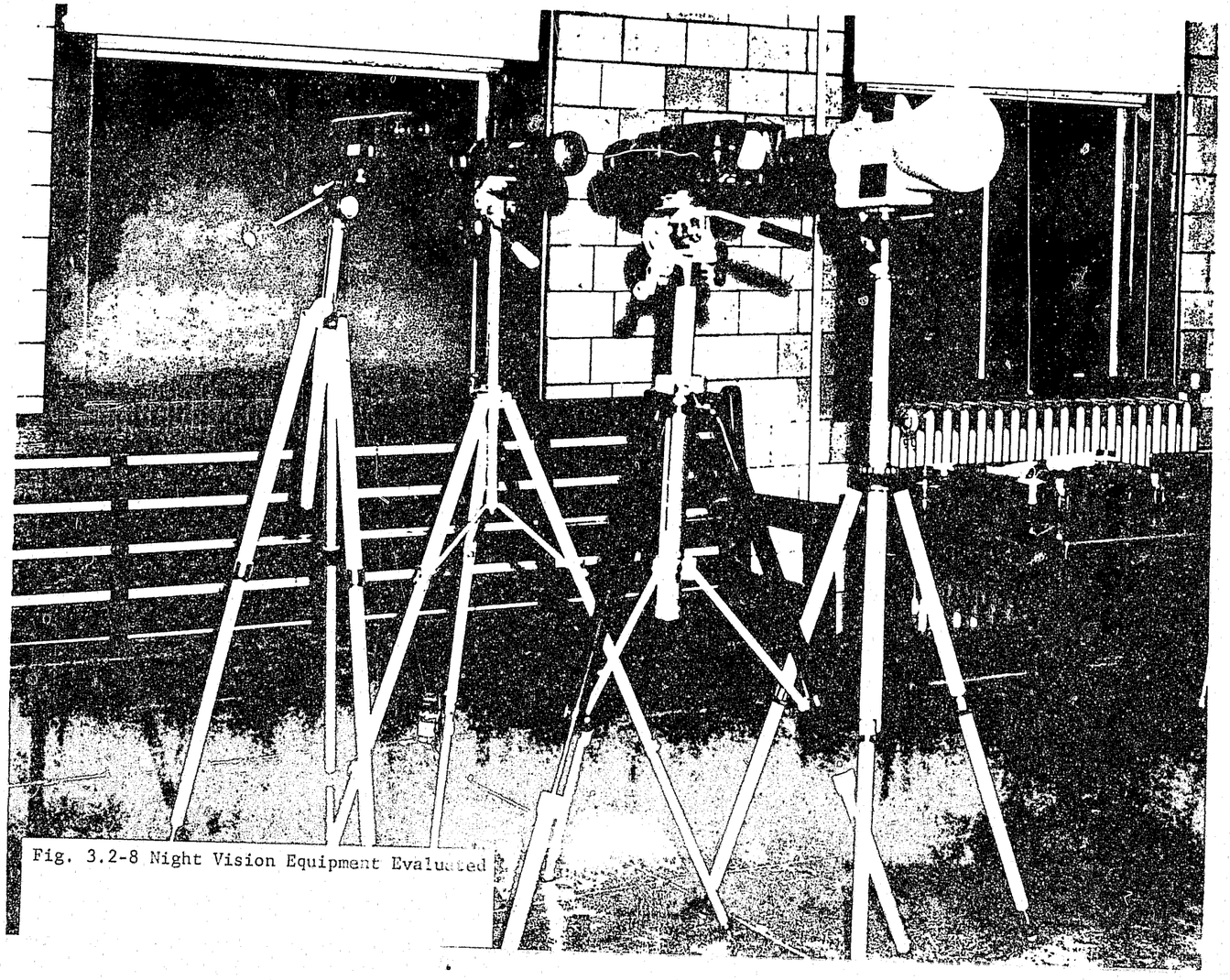

Fig. 3.2-8 Night Vision Equipment Evaluated

3.3 FIELD ANALYSIS

In addition to the extensive evaluation and analysis as performed by the Newton Police Department of all equipments, numerous field trials were conducted in actual cases involving night surveillance.

In order to establish as broad a coverage as possible, surrounding cities and municipalities were invited to participate for their own edification.

Some of the cities that witnessed and/or borrowed night vision equipment for actual field use were Somerville, Needham, Cambridge, Boston, Watertown, Waltham, Brookline and the Massachusetts State Police. With the cooperation of the Newton Police Department and several of these communities, it enhanced the thoroughness and evaluation of this program. It further enabled the Newton Police Department to obtain unbiased and factual reports from the field by cooperating with the police officials therein.

In the city of Newton the Owl Eye was successfully utilized on a burglary detail. From a source of private information, the Newton Police Department was anticipating a burglary in a commercial section of the city. Acting upon this information the burglary squad set up a surveillance in excess of one block from the ancitipated activity, although in this particular incident and evening, the burglary did not take place. The Newton police officers certified that they were able to view the area without hindrance and were extremely pleased with the performance of the Owl Eye. The report detailed that the officers on surveillance were able to view the area without restriction under the cover of darkness and complete safety.

The Owl Eye was again used, supplemented with a videotape recorder, to record at night an actual transaction of the sale of stolen property to an undercover agent of the Newton Police Department. This surveillance was in a residential area and the Intelligence Division of the Newton Police Department was able to videotape the entire transaction with the aid of the Owl Eye and a 150mm lens. The surveillance team was in excess of two blocks away and again performance exceeded expectations.

In keeping with the city of Newton Police Department's constant endeavors to cooperate with local communities, the Owl Eye was loaned to the cities of Somerville and Cambridge for an actual narcotics incident. In this particular case the dangerous drug was heroin and again a videotape recorder was used in conjuntion with the Owl Eye to photograph the suspects under the cover of darkness for intelligence dissemination. The police of Somerville were able to successfully record the activity of a suspected narcotic dealer and enabled the police departments of local communities to become familiar with such activities. This information, thus recorded, provided detailed identification that the other police departments studied and were therefore able to monitor and continue surveillance in their own areas. Without the aid of a night vision system, such surveillance would have been impossible.

Without exception, whether in actual field operation, simulated environmental conditions or in demonstrations within the Newton Police Department, all law enforcement agencies of surrounding cities were given the opportunity to express their sentiments on the use of night vision equipment.

The reports were unanimously in accord, clearly defining that night vision equipment was a definite requirement for police safety and efficiency. From actual experience and demonstrations, the effectiveness was definitely proven to result in the obtaining of intelligence and evidence utilizing fewer officers on stake-out under complete safety in a substantially shorter period of time. In this regard the Newton Police Department will continue in its efforts of cooperating with surrounding communities until such time as they are able to obtain night vision equipment of their own.

Field tests were conducted to determine the ability to record on film using night viewing devices. A series of photographs with different lenses on the Owl Eye show the ability to read a license plate on a parked car at night. The lenses used were a 50mm, 135mm, 250mm and 500mm lens. The 35mm camera with Tri-X film was used. Figure 3.3-1 is shown using the 50mm lens, Figure 3.3-2 is shown using the 135mm lens, Figure 3.3-3 is shown using the 250mm lens and Figure 3.3-4 is shown using the 500mm lens.

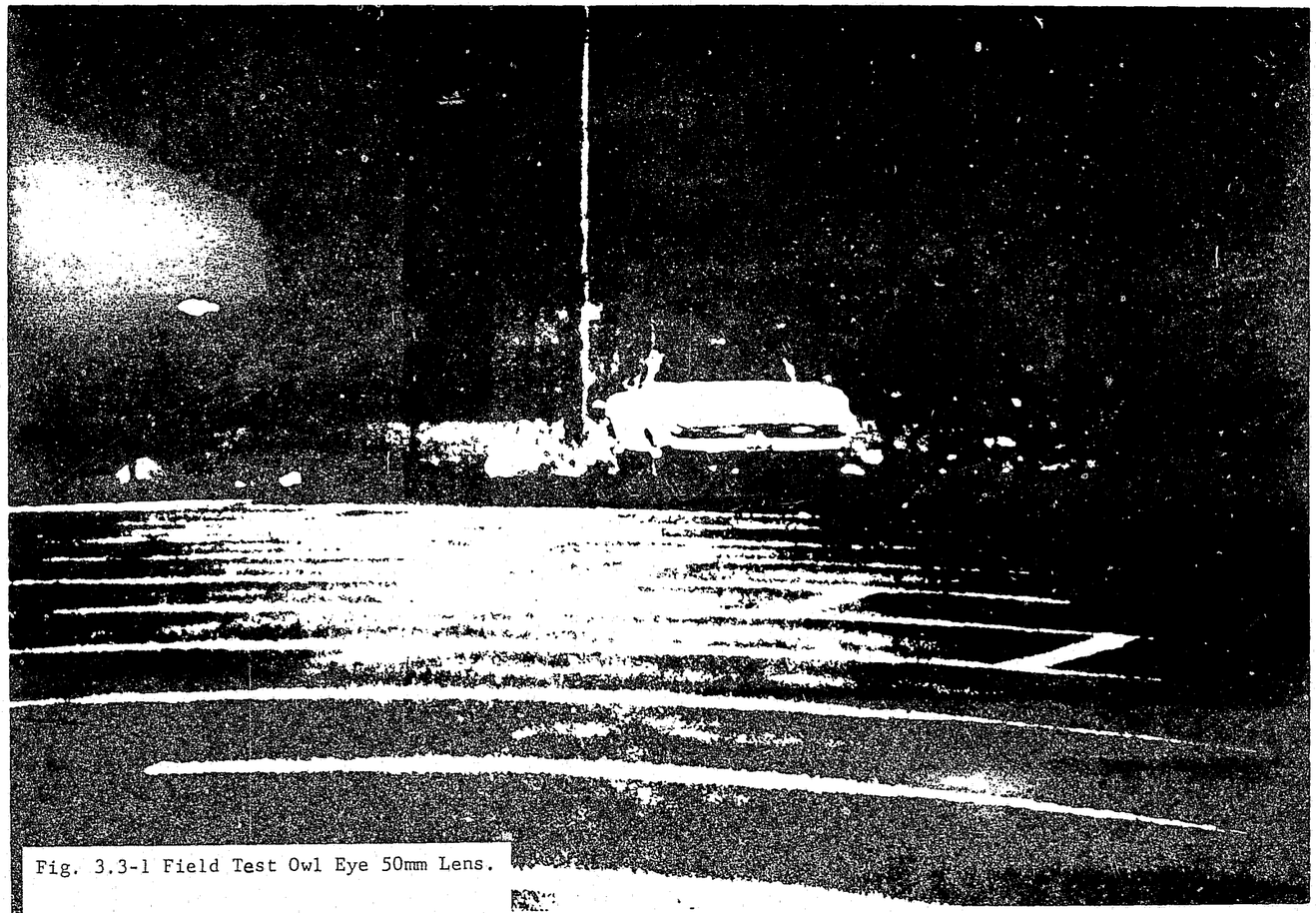

Fig. 3.3-1 Field Test Owl Eye 50mm Lens.

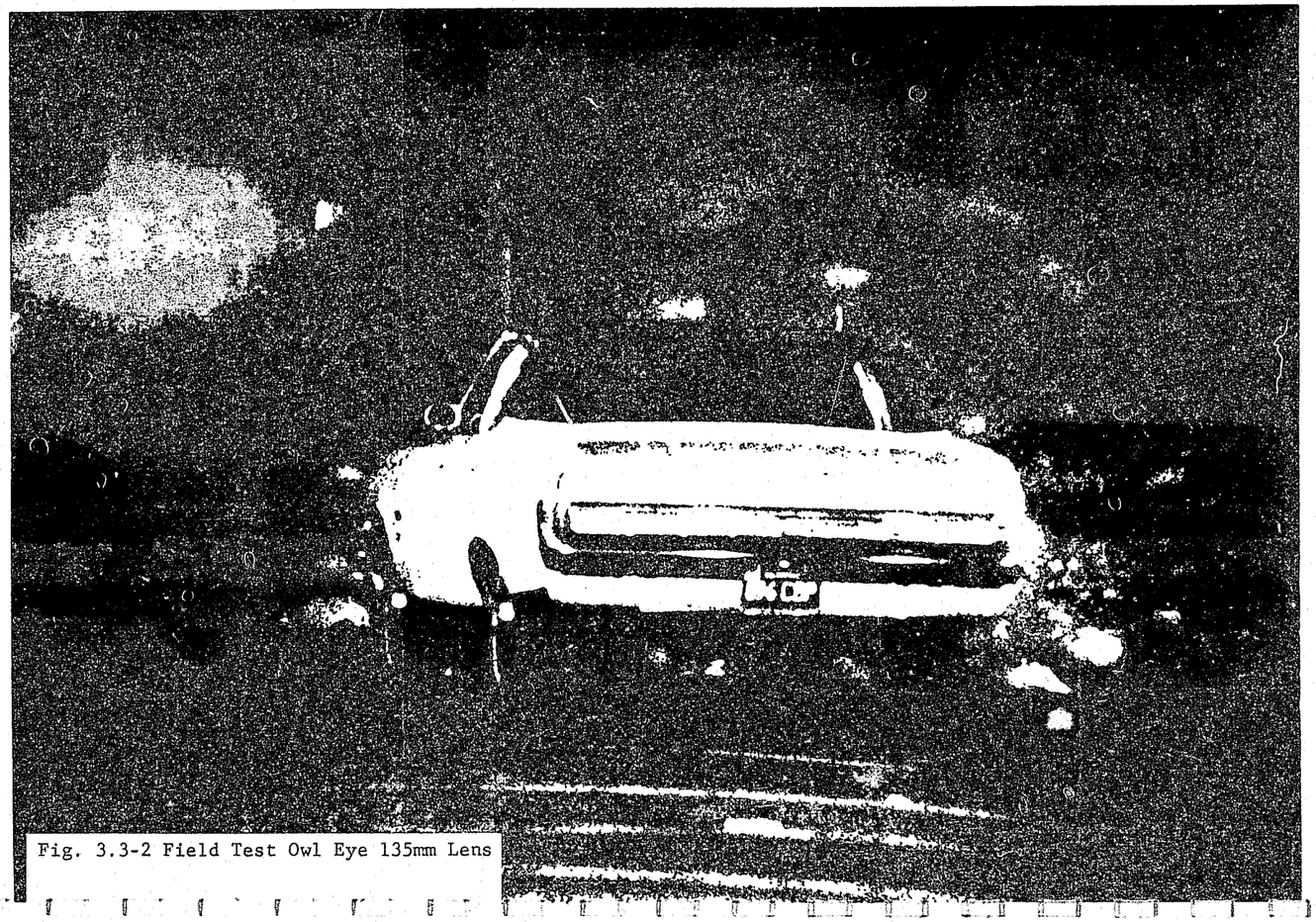

Fig. 3.3-2 Field Test Owl Eye 135mm Lens

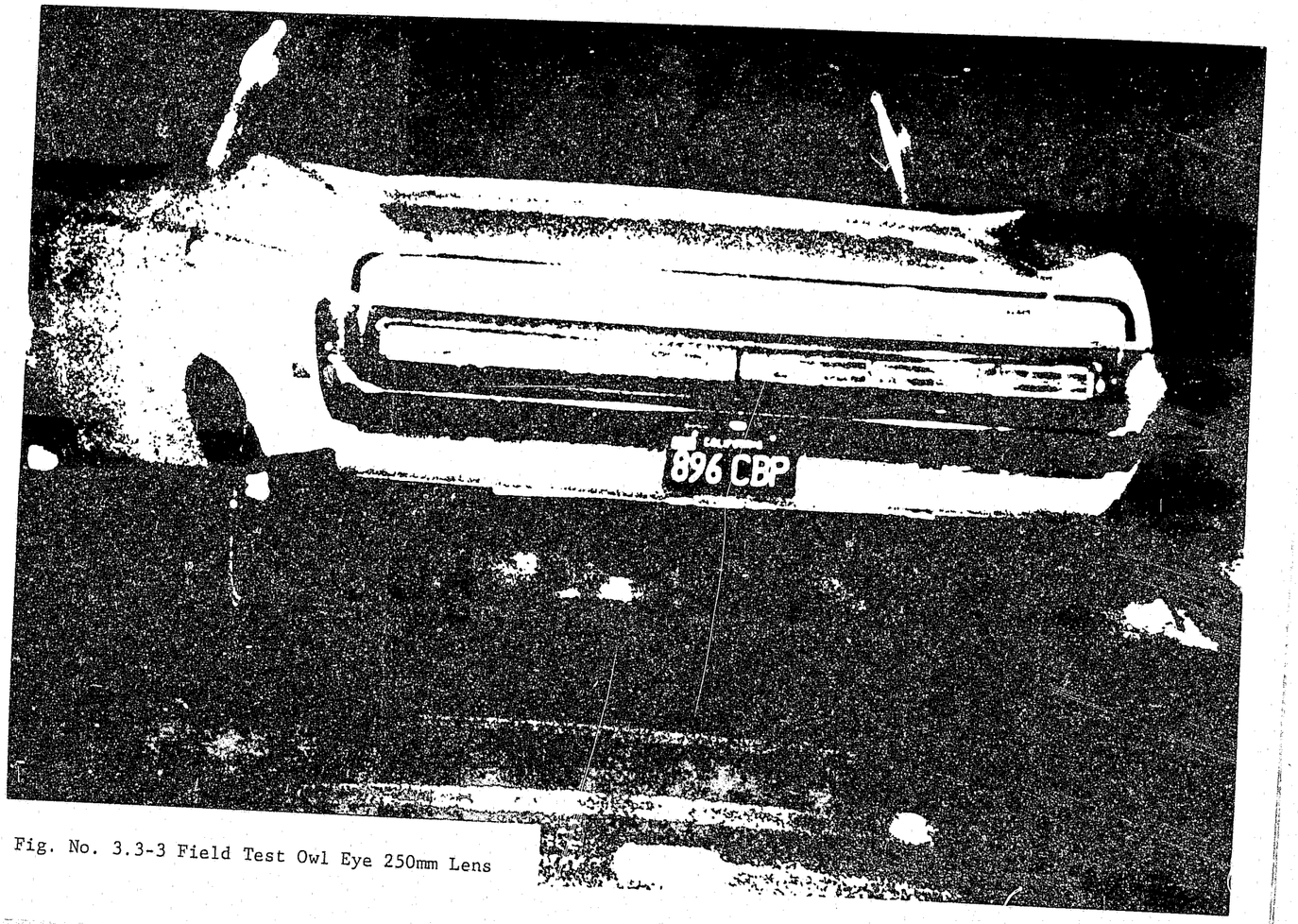

Fig. No. 3.3-3 Field Test Owl Eye 250mm Lens

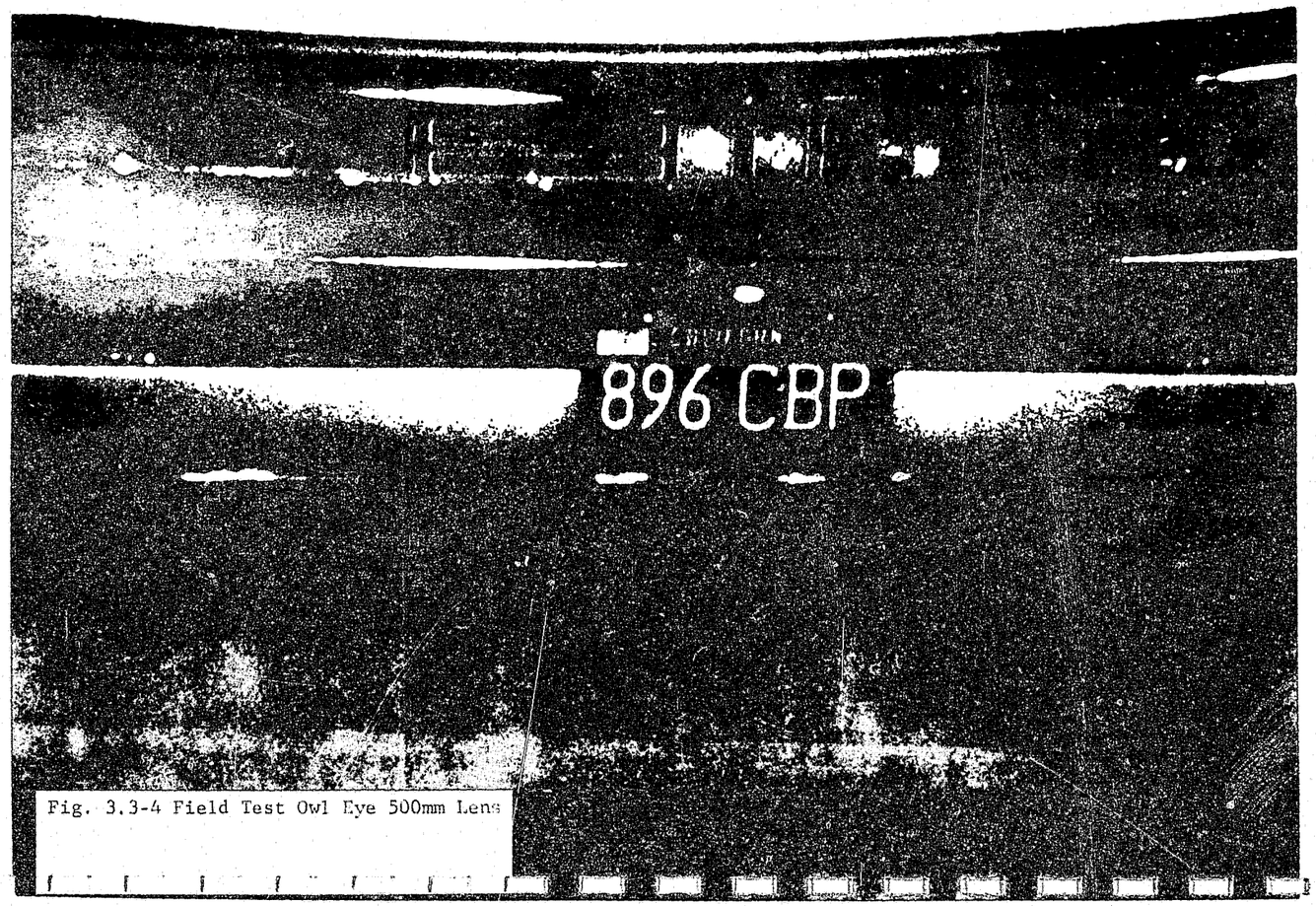

Fig. 3.3-4 Field Test Owl Eye 500mm Lens

4. CONCLUSIONS

The conclusions presented in this section are the result of the engineering and operational analysis conducted during the course of this stidy of the suitability of low-light-level direct-view devices for municipal police work. The conclusions from this project are:

- The low-light-level scopes require very little formal instruction or training prior to field deployment. Their simplicity of operation and their rapid interchangability of lenses proved very effective in field use.

- The current generation of night scopes falls into two distinct classes; large tripod-mounted and small hand-held devices. The large devices require a stable mount such as a tripod; they are more amenable to stake-outs at long range (using long focal length lenses) or where evidence is to be recorded via photography or video-tape recording. The hand-held devices, being significantly lighter and less bulky, would be more amenable to field use where there is not adequate time or space to set up the large scopes as outlined in various missions described in the report.

- The large tripod-mounted scopes for operation in a medium-size city such as Newton can add to overall police effectiveness depending upon the criminal incident rate under the cover of darkness. The cost effectiveness can only be determined by direct comparison to the number of manhours normally required for a stake-out as compared to the number of hours required while using night-vision devices. It is difficult to determine the effectiveness of night-vision devices as a deterrent to crime unless publicized that such devices are available; however, such publicity in cases of organized crime and narcotics are usually not desirable. Under these circumstances it was not possible during this study to effectively determine the cost effectiveness in these areas appropriately.

- The OWL EYE has a better group viewing feature, more versatile power supply options and greater overall magnification than all other devices evaluated. The ability to photograph while simultaneously viewing provides a far superior unit for overall police application.

The hand-held scopes in practice offered a great deal of advantages to police efforts on mobile patrol in residential areas.

- The number of potential opportunities for a police officer to use a hand-held scope on mobile patrol is high.

- The weight and bulk of these devices would prove to be an encumbrance to an officer on foot patrol. They are basically designed for operation in a police mobile vehicle.

- The adverse vision effects caused by devices with only a monocular viewer could actually impair an officer's effectiveness.

- The scopes do help the officer to conceal his presence and definitely provides an element of safety to his operation. In a large number of situations, unobtrusiveness is not needed and cannot easily be maintained regardless of light situations; however, these are examples rather than the rule.

- The hand-held scopes as Newton police officers reported, enabled them to observe a suspicious person who was not visible with the naked eye; however, these scopes were range limited as compared to the tripod-mounted long-range units. It proved very difficult to actually identify a suspect with the hand-held scopes beyond a range of 100 yards.

- The devices seemed to be well constructed, fairly rugged and very durable. The Newton police officers proved very competent in their professional handling of these devices and thus is indicative of the police capability to utilize effectively these sophisticated systems in the field.

- The hand-held scopes appeared to be very effective from a slow-moving police vehicle.

- The tripod-mounted systems were more favorable from a stationary observation point for long-range surveillance.

Of all scopes under study, the OWL EYE proved more versatile for tripod-mounted situations. Of the hand-held scopes, the Sylvania 221 proved to be the most versatile for field use. The OWLETTE which was introduced during the I.A.C.P. Convention in Anaheim, California, although not evaluated during the study in Newton, Mass., appears to have great promise for an improved hand-held mobile system from demonstrations conducted at the Convention. The Machlett scope although perhaps the most ruggedly built, is not suitable for well-lit areas and is not provided with a selection of lenses.

Night-vision equipment for police use can play a very important role as an aid in combatting crime by providing to the police officer the ability to see at night where otherwise his operation would be severely hampered. Considering the cost of the various scopes with an adequate complement of lenses and auxilliary equipment, the cost-effectiveness as offered in a medium-size city such as Newton could only be determined as a direct ratio of the incident crime rate under the cover of darkness.

TABLE A-1

PRICE SHEET

ITEM	LIST PRICE
OWL EYE, 50AT	
12 Volt Adapter 110 Volt Charger Carrying Case Customer choice of lens: 50mm, 125mm, 135mm, 150mm, 500mm	$6,500.00
Accessories:	
50 mm f/1.4 lens	375.00
125mm f/1.2 lens	600.00
135mm f/1.7 lens	375.00
150mm f/1.3 lens	600.00
500mm f/5.6 lens	600.00
Screen Magnifier	100.00
Tripod	75.00
Camera Adapter	95.00
"C" Mount Adapter	50.00
135mm Bayonet Adapter	25.00
Screen Nite Filter	75.00
OWLETTE - 60AT	$2,400.00

TABLE A-2
STANDARD PRICE LIST

MODEL 220 - SYLVANIA

Night Viewing Device with Automatic Brightness Control	$2,875.00

MODEL 221

Night Viewing Device with Automatic Brightness Control and Focal Plane Iris	2,995.00

OPTIONAL ACCESSORIES

TV Camera Adapter	250.00
Photographic Camera Adapter	250.00
Biocular Viewer	600.00
Pistol Grip	20.00
Light Weight Tripod	35.00
Heavy Duty Tripod	295.00

LENSES

Focal Length	f/#	Price
28mm	f/0.8	$ 157.00
50mm	f/1.4	119.95
50mm	f/1.8	69.95
85mm	f/1.8	149.00
100mm	f/2.0	149.00
135mm	f/1.8	235.00
300mm	f/3.2	520.00
300mm	f/4.5	485.00
500mm	f/4.7	637.00
500mm	f/5.6	510.00
Zoom Lens		
20-100mm	f/2.5	230.00
25-100mm	f/1.8	515.00
22.5-90mm	f/1.5	400.00
15 to 145mm	f/2.5	750.00

TABLE A-3
RETAIL PRICE LIST FOR
TM
STAR-TRON PASSIVE NIGHT VISION SYSTEMS

MK-202 A MODEL	LIST PRICE
Complete with 85mm f/1.8 lens, 25mm eyepiece (provides magnification of 3.4X), fitted foam-lined case, battery and lens cleaning kit.	$2,475.00
Options (if ordered, must be specified at time the scope is ordered):	
1. Automatic brightness control (ABC).	150.00
2. Light Shade TM brand field iris.	130.00
TOTAL - Complete if Options 1 and 2 are specified	$2,755.00
Accessories for above:	
a. Biocular viewer (permits both eye viewing of output screen at distances from 2 to 24 inches, similar to a 3" diameter television screen. Recommended for long duration viewing and for use from moving vehicles and helicopters).	600.00
b. 85mm f/1.8 lens - if ordered separately (standard with basic unit).	135.00
c. 135mm f/1.8 lens (provides magnification of 5.4X with 25mm eyepiece or 2.3X with biocular viewer).	235.00
d. 135mm f/2.5 lens (provides magnification of 5.4X with 25mm eyepiece or 2.3X with biocular viewer).	155.00
e. 210mm f/2.8 high resolution telephoto lens complete with focusing wheel and sunshade.	675.00
Carrying case for 210mm lens	75.00
f. 300mm f/2.8 high resolution telephoto lens complete with sunshade.	750.00
Carrying case for 300mm lens	55.00
g. 500mm f/5.6 catadioptric lens complete with sunshade and case.	530.00

TM
RETAIL PRICE LIST FOR STAR-TRON PASSIVE NIGHT VISION SYSTEMS MK-202 A MODEL

Accessories - Cont'd.	LIST PRICE
h. Photography attachment including high performance relay lens - without camera body. The camera body to be used with relay lens must be specified with order; an appropriate mount adapter will then be supplied. If body is not specified at time of order, the relay lens will be supplied with Cannon breach lock type lens mount.	$1,200.00
(Photography attachment may be interchangeably used on both MK-202A and MK-505A STAR-TRON™ Night Vision Systems with appropriate adapters. Price includes one adapter only, to interface with STAR-TRON model as specified with order. Spare adapters for either model may be purchased separately for $50,00 List Price.)	
1. Camera body for use with Item (h) above - Cannon FT-QL, single lens reflex with low light level booster meter.	234.00
2. Camera body for use with Item (h) above - Cannon F1, single lens reflex with super sensitive low light level booster meter, featuring illuminated controls, can be used with long eye relief finder and motor drive adaptation.	594.00
i. Pistol grip with quick release.	24.00
j. Adjustable mount for pistol grip (permits proper balance when device is used with biocular viewer).	15.00
k. Light weight tripod	30.00
l. Heavy duty tripod with geared elevation and geared tilt head.	159.00
m. Battery Mallory TR-132.	1.20

NOTE: RIFLE MOUNTS, POWER CONVERTERS, POWER ADAPTERS AND WATER-PROOF RUGGEDIZED CONFIGURATIONS WILL BE QUOTED ON REQUEST.

RETAIL PRICE LIST FOR
TM
STAR-TRON PASSIVE NIGHT VISION SYSTEMS

MK-505 A MODEL	LIST PRICE
Featuring dual quick release swing type accessory mounts. Permits interhcnageable positioning of any combination of two accessories (biocular viewer, photography attachment, high magnification viewer, etc.) from a ready position into a use position. Complete with fitted foam-lined case, biocular viewer in quick release swing type accessory mount, 135mm f/1.8 lens, battery, automatic brightness control (ABC), lens cleaning kit, and Light Shade™ brand field iris.	$4,290.00
Accessories for above:	
a. High magnification narrow angle eyepiece (provides a magnification of 3.5X with 135mm lens) in quick release swing type accessory mount.	150.00
b. High magnification wide angle viewer (covers complete field of view and provides a magnification of 3.8X with 135mm lens) in quick release swing type accessory mount.	620.00
c. 135mm f/1.8 lens - if ordered separately (standard with basic unit).	235.00
d. 135mm f/2.5 lens.	155.00
e. 210mm f/2.8 high resolution telephoto lens complete with focusing wheel and sunshade.	675.00
Carrying case for 210mm lens	75.00
f. 300mm f/2.8 high resolution telephoto lens complete with sunshade.	750.00
Carrying case for 300mm lens	55.00
g. 500mm f/5.6 catadioptric lens complete with sunshade and case.	530.00

RETAIL PRICE LIST FOR STAR-TRON™ PASSIVE NIGHT VISION SYSTEMS-MK 505 A MODEL

Accessories - Cont'd.	LIST PRICE
h. Photography attachment including high performance relay lens in quick release swing type accessory mount - without camera body. The camera body to be used with relay lens must be specified with order; an appropriate mount adapter will then be supplied. If body is not specified at time of order, the relay lens will be supplied with Cannon breach lock type lens mount.	$1,200.00
(Photography attachment may be interchangeably used on both MK-202A and MK-505A STAR-TRON™ Night Vision Systems with appropriate adapters. Price includes one adapter only, to interface with STAR-TRON model as specified with order. Spare adapters for either model may be purchased separately for $50,00 List Price.	
1. Camera body for use with Item (h) above - Cannon FT-QL single lens reflex with low light level booster meter.	234.00
2. Camera body for use with Item (h) above - Cannon F1, single lens reflex with super sensitive low light level booster meter, featuring illuminated controls, can be used with long eye relief finder and motor drive adaptation.	594.00
i. Heavy duty tripod with geared elevation and geared tilt head.	159.00
j. Quick release mounting base for heavy duty tripod with special adapter for night vision device. (Permits quick and convenient attachment or removal from tripod).	14.95
k. Battery Mallory TR-235R.	4.75

NOTE: POWER CONVERTERS AND POWER ADAPTERS FOR 24, 12 AND 6 VOLTS DC WILL BE QUOTED ON REQUEST.

END