Night Vision Technologies for Defence Applications

[1]Srishti Tyagi, [2]Dr. Abhay A. Deshpande
[1]Student, [2]Assiciate Professor
[1]Electroncis and Communication Engineering,
[1]RV College of Engineering, Bengaluru, India

Abstract— Night Vision devices are widely used to increase visibility in environments that are not brightly lit. In critical situations, such as those faced by defense forces, the performance of a night vision device becomes essential. A Night Vision Device is an observational type of optical device that is used at night-time to get better visibility in less ambiently lit environment. It allows for better images to be taken by intensifying the light present in the environment at low-light conditions such as starlight and moonlight. This can be done using an Image Intensifier Tube. Another method discussed for viewing at low light conditions is Thermal Imaging that uses infrared light to show temperature variations in the environment. Both these technologies are extensively used both for surveillance and as target sight on weapons and find varied applications in military and defense forces all around the world.

Index Terms— Night vision, device, thermal imaging, image intensifier, technology

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I. INTRODUCTION

The capacity to see in the dark is referred to as night vision. The work [1] explained how normally, only owls and cats have this capacity, but as science and technology has advanced, tools have been created that enable people to see in the dark and in inclement weather like fog, rain, and dust. The human eye is one of the best examples of vision in the visible spectrum of light. The muscles in the eyes of humans can expand and contract. The work [2] elaborated on the human eye and explain that upon exposure to bright light, our eyes will contract to ensure that not a lot of light enters our eyes and damage our optical nerve. Similarly, in low light conditions, the human eye will relax, hence increasing the aperture size of the eye, which would result in more light being able to enter the eye, so that a better image can be formed. In [3], the authors attribute that due to advancements in technology, there are many methods that are employed to be able to see in the dark. They are Image Intensification, Active Illumination and Thermal Imaging.

In the middle of the 1930s, the German Army was the first to use NVDs on the battlefield. In the middle of the 1940s, the first panther tanks made use of it. Dr. Vladimir K. Zworykin, who was then employed by Radio Corporation of America, developed the first commercial NVD.[4] Night vision tools or image intensifier systems, thermal imagers, SWIR imagers, and some more sensitive visible/NIR (CCD/CMOS/ICCD/EMCCD) cameras are used by humans to gain the ability to see at night. Every company that manufacturers devices used for viewing at night need to perform tests to ensure that the device is performing under the right conditions. The devices need to meet specific standards as defined in JSS55555 and MIL DOT to meet requirements for use in military services. The devices also need to be Ingress Protected to a high standard. Many measures are taken to ensure that the devices are up to the mark for use for defence forces.

II. TYPES OF NIGHT VISION SYSTEMS

Image Intensification

The Image Intensifier Tube is a device component that will intensify images with low light levels to levels that are visible clearly to the human eye. The tube is a vacuum-based device, and requires a very small number of photons, that are then amplified exponentially by converting then into electrons and projected onto a phosphor screen. The tube is extremely sensitive to higher luminosity of light and may get damaged if exposed to a bright light. Therefore, any II Tube based device is only used in low-light condition such as night-time with moonlight or starlight as the only available light. Detectors may also be used to detect any object by means of digital image sensors. The Tube consists of mainly three components- a photocathode, a Microchannel Plate, and phosphor screen.

Figure 1: Basic Construction of Night Vision Monocular

Following steps denote the process of image intensification:

1. Dim light from a night scene enters the Objective lens at the front. The light is made of photons (particles of light) of all colours.

2. As light enters the objective lens, the photons strike the image intensifier tube (II tube) module housed in the mechanical housing. They first strike a light-sensitive surface called a photocathode, which convert photons into electrons, 3. The electrons are accelerated towards a Microchannel plate (part of II tube), which amplifies the electrons ratio of 1: 105-107 like a photomultiplier tube.
4. The electrons leaving the MCP hit a phosphor screen (part of II tube), which is a thin a phosphor light emitting layer. As the electrons hit the phosphor screen, the electrons are converted back to photons in the form of tiny flashes of light.
5. The tiny flashes of light recreate a brighter "intensified" image scene as observed by the user, through the eyepiece lens.
Since its inception, consistent work has been done in this domain to improve the working of the tube. As a result, much iteration are made that are introduced as 'Generations' of the tube. The development of NVD started with Generation 0, and now work is being done on Generation 4 of the device. Generation 0 had the disadvantage of being easy to replicate and resulted in distorted images. Due to many technological breakthroughs, the Gen 4 devices now give a much better output.

The device most in use in the market today are Generation 2+ and Generation 3. [5] These generations are comapred as follows:

Table 1: Comparison Between Gen 2+ and Gen3 IIT

Parameter	Gen 2+	Gen 3
Photocathode sensitivity	500-800µA/lm	1800-2200 µA/lm
Photocathode response	Inferior than Gen 3	Better than Gen 2+
Resolution	55-68 lp/mm	60-72 lp/mm
Signal to Noise ratio (SNR)	19-26	22-30
Photocathode type	S-25 (Multi-alkali)	Gallium Arsenide (GaAs)
Luminous Gain	28000-55000 fl/fc	40000-70000 fl/fc
Reliability(Lifetime operational Performance)	Less operational hours than Gen 3	More operational hours than Gen 2+

Active Illumination

A near-infrared (NIR) or short-wave infrared (SWIR) active source of illumination is combined with imaging intensification technology to provide Active Illumination. Active infrared night-vision combines infrared illumination of spectral range 700–1,000 nm (just below the visible spectrum of the human eye) with CCD cameras sensitive to this light. The resulting scene, which is apparently dark to a human observer, appears as a monochrome image on a normal display device.[6]The images produced by active infrared night-vision systems often have a higher resolution than those produced by other night-vision technologies because they can integrate illuminators that create intense amounts of infrared light. Today, active infrared night vision is frequently used in government, commercial, and residential security applications because it offers efficient imaging at night in low light.[7] However, since active infrared light can be detected by night-vision goggles, there can be a risk of giving away position in tactical military operations.

Thermal Imaging

Thermal detectors are of classified into 3 categories[8]:

1. Thermocouple/Thermopile- Thermocouple is an electrical device that consists of two dissimilar electrical conductors that form electrical junctions at varying temperatures. A magnetic field is seen when various metals are connected at the ends and there is a temperature gradient between the joints. Thermoelectric current is the cause of this magnetic field. A thermopile is composed of several thermocouples connected usually in series or, less commonly, in parallel.

2. Bolometers- Bolometer is a device that is used for measuring the power of incident electromagnetic radiation that is induced as a result of heating of a material that has electrical resistance that is dependent on temperature. It consists of an absorptive element, such as a thin layer of metal, connected to a thermal reservoir (a body of constant temperature) through a thermal link. The result is that any radiation impinging on the absorptive element raises its temperature above that of the reservoir – the greater the absorbed power, the higher the temperature.

3. Pyroelectric sensors- Certain crystals in nature are naturally electrically polarized. As a result, they contain large electric fields. This property of the crystals is known as Pyroelectricity. Passive infrared sensors are often designed around pyroelectric materials, as the heat of a human or animal from several feet away is enough to generate a voltage

Microbolometer- For application in Thermal Imaging Devices, a specific kind of Bolometer is used as detector. This is known as Microbolometer. This works as a thermal based sensor that will experience change in resistance based on variations in temperature. Infrared radiation with wavelengths between 7.5-14 µm strikes the detector material, heating it, and thus changing its electrical resistance. This resistance change is measured and processed into temperatures which can be used to create an image. Unlike other types of infrareds detecting equipment, microbolometer does not require any cooling. It is developed as a grid of amorphous silicon or vanadium oxide heat sensors placed on top of a corresponding grid of silicon. Infrared radiation from a specific range of wavelengths strikes the vanadium oxide or amorphous silicon and changes its electrical resistance. This resistance change is measured and processed into temperatures which can be represented graphically.

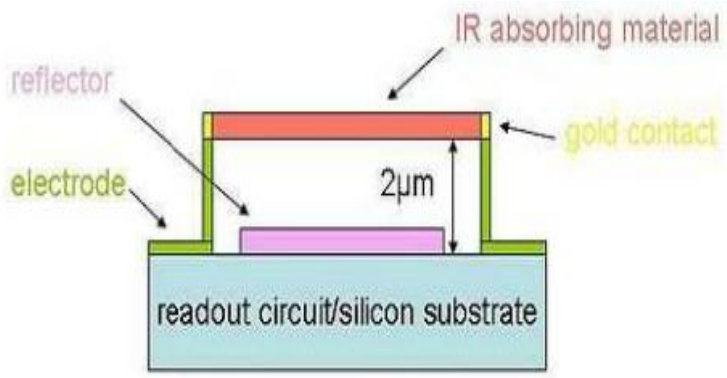

Figure 2: Construction of Microbolometer

III. TYPE OF DEVICES USED BY DEFENCE FORCES

Monocular- A monocular, as the name suggests, has only one eyepiece and one objective lens. It is available as both II (Image Intensifier) based and TI (Thermal Imaging) based device. It may be used as a handheld device for surveillance and reconnaissance or as a helmet mountable/weapon mountable sight for target allocation. Mechanical designs in the monocular make chassis makes it much easier to use it under varied applications.

As a TI device, it will consist of various modes such as White-Hot, Black-Hot, Sepia, Rainbow, Red-hot, etc., that can give better view under various environmental conditions.

As an II device, it is accompanied by a laser for improved visibility.

Figure 3: Monocular

Goggles- Goggles will have two eyepiece lens and one objective lens. It may also be used as helmet or weapon mountable device or as handheld device. Goggles do not have zooming capabilities.

Figure 4: Goggles

Binocular- A binocular is the same mechanism as a google, with one objective lens and two eye piece lenses, with the addition of an extra lens system attached to the objective lens, in order to gain the advantage of magnification. The magnifications most commonly used are 2x, 3x, 5x, 7x, and 11x.

Figure 5: Binocular

Weapon Sight- A weapon sight is mounted on weapons and used for target shooting. The most commonly used sights are TI, II, holographic and red dot.

Figure 6: Weapon Sight

Disadvantages of Night Vision Devices

IV. DISADVANTAGES OF NIGHT VISION DEVICES

Although a lot of extensive work has been done in this area to ensure that newer advancements in technology are effectively used in implementation on devices, especially for military use, there are quite a few disadvantages that are yet to be covered. Some of them are limited field of view, inability to see through transparent obstacles like glass, haze, distinction between objects and target, etc. These are ever improving as new devices are developed, but the cost is significantly increased. It is believed that with time, the cost will gradually reduce as production and technological advancements will increase in the near future.

V. CONCLUSION

In this paper, various technologies that are used for devices for night vision has been described. New technologies are emerging every day, and it is only a matter of time before we have even better technologies. The devices that are used for defence applications, as described by the paper, are extremely important to be up to the standardised requirements of the armed forces, so that soldiers can work efficiently during critical and high intensity situations. As the technology advances to become better and more accessible, more doors will be open for it to be available to a larger group of people.

REFERENCES

[1] Nkolika O. Nwazor, Stella I. Orakwue, A review of night vision technology. Australian Journal of Science and Technology. 2208-6404.
[2] Rupesh P.Raghatate, Swapnil S.Rajurkar, Manisha P.Waghmare, Pooja V. Ambatkar, Night Vision Techniques and Their Applications. International Journal of Modern Engineering Research. 2249-6645
[3] Saad A A, Vishak Vijayan, Claijo Kurian V. Night Vision Technology and It's Applications, International Journal of Advanced Research in Computer and Communication Engineering. 2319-5940
[4] Diesendorf G. Facts about Night Vision Technology; 2016. Available from: https://www.communities.theiet.org/ blogs/830/3802.
[5] Hussain Z. Digital Image Processing: Practical Applications of Parallel Processing Techniques. London: Ellis Horwood Limited; 1991
[6] A. Rogalski*1 and K. Chrzanowski, Infrared Devices and techniques, Opto-Electronics Review 10(2), 111–136 (2002)
[7]www.nightvision.com
[8] V. John, S. Mita, Z. Liu, and B. Qi, "Pedestrian detection in thermal images using adaptive fuzzy C-means clustering and convolutional neural networks," in Proceedings of the 14th IAPR International Conference on Machine Vision Applications, MVA 2015, 2015, doi: 10.1109/MVA.2015.7153177.
[9] FLIR Systems. What is the Difference between Thermal Imaging and Night Vision? Wilsonville, Oregon: FLIR Systems; 2011.