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MASS PRODUCTION NIGHT VISION OBJECTIVE FOR MILITARY DRIVERS NIGHT SIGHT

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Abstract: Military optical sights are made generally in thousands .Mass production of optics at low cost is possible if the optics uses indigenous optical glasses, all spherical surfaces and the optical design is worked out with loose tolerances on optical design parameters. Based on these considerations an optical design of military night vision objective is designed and the optical design data of nine element all spherical **f/**1.0 objective having focal length of 40-mm with 35degrees total field-of-view for use with 25-mm effective diameter image intensifier tube is presented. The objective is color corrected for wide wavelength band from 350-nm to 950-nm using five Indian optical glasses and one Schott glass. Radii of curvatures above 40% of the focal length are considered in the optical design of objective for higher manufacturing feasibility. The design is carried out for loose tolerances on radii of curvatures, thicknesses and air spaces for mass production of objective and easy assembling. The objective is fabricated,, assembled and tested for performance. The objective has been introduced into military night vision optical sight.

Keywords: Optical design considerations of military night vision objective, image intensifier tube, optical design, Indian optical glasses.

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INTRODUCTION

The lens objectives for night vision devices are designed with the following considerations [1].

- High speed and large aperture to provide maximum acceptance and transmittance of light. A large entrance pupil is required to achieve an acceptable signal-to-noise ratio.

- Minimum Vignetting. In low light levels, vignetting instantly results in marked ly reduced performance at the edge of the field.

- Color correction for a wide spectral region. Color correction is required from 350-nm to 950-nm wavelength range.

- Modulation transfers function with maximum values at lower frequencies. To match the modulation transfer function of opto-electronic S-25 photo cathode of image intensifier tube, the lens has to perform the highest modulation transfer function in the frequency range 0-30-lp/mm. Higher frequencies are of no significance.

- Barrel distortion. Because of the pin cushion distortion is inherent to the image intensifier tube, compensation by introducing barrel distortion in optics is favored and sometimes required.

- Long back focal length. A long back focal length is desirable to keep metal parts of the lens mount as far as possible from the high voltage across the face plate of image intensifier tube..

A 25-mm effective diameter opto- electronic image intensifier tube requires a lens objective having field-of-view 35degrees at focal length of 40-mm. The clear aperture of the objective is fixed at 40-mm. With these requirements in mind, first order optical design lay –out of objective is worked out and the design is executed. The design data of the objective along with the performance data are presented. The deep radii of curvatures are avoided in the optical design for higher manufacturing feasibility. The minimum radii of curvature in the design of objective are fixed to not less than 40% of focal length. The variation is fixed to a value of ±0.1mm in thickness, ±0.05mm in air space and ±0.1mm in radii of curvatures for Optical elements in objective in order to have the desired optical performance over these variations. The optical components of the objective are assembled and the objective gave the predicted performance. The air space values of the design data allowed the easy assembling of elements into objective. The objective has been in use with the vehicle mounted night vision device.

1. Optical Design Of Night Vision Objective

The optical objective for 25-mm effective diameter opto-electronic image intensifier tube shall have a speed of **f/**1.0 at 40-mm focal length covering 35degrees field of view. The irst order optical design lay –out of objective during initial optical design resulted a modified double –Gauss configuration for objective having nine optical elements [1-4]. The optical glasses under consideration for use in the design of objective are restricted to Indian optical glasses DBC, DF, EDF, DEDF, and Schott LAC , because optical work shop at our place has technical knowhow in polishing these glasses . The powers of optical elements and the spacing between the elements are finalized using thin lens design. The thin lens Configuration was analyzed for thick lens third order aberrations or Seidel coefficients The table 1 below contains the Seidel values of the objective. A trigonometrical ray trace for actual aberrations of objective is carried out on the design data assessed by third order aberrations.[5,6]. Minor changes are made to radii curvature, thicknesses, air spaces and stop position of objective to bring actual aberrations of the objective to the desired limits. The final optical configuration of the night vision objective for 25-mm active diameter opto- electronic image intensifier tube for drivers night sight is shown in figure 1. The design data of the objective is shown Table 2. The objective has a focal length of 40-mm at f/1.0 and covers 35degrees total field-of-view.

Table 1: Objective Seidel sums

SURFACE NO	SAB	OSC	AST	DIST	AC	TC	PTZ
01	0.250878	0.005118	0.137740	0.010858	0.243427	0.004966	0.005638
02	0.001917	0.000215	0.031673	-0.029815	-0.077898	-0.008719	-0.003434
03	0.005644	0.000383	0.304227	0.026809	0.200526	0.013597	0.004603
04	0.032912	-0.005025	1.011808	-0.057601	0.126685	-0.019341	-0.001565
05	0.187514	0.003081	0.066774	0.018103	0.348301	0.005723	0.013001
06	0.124426	-0.005502	0.320925	-0.006774	-0.137713	0.006090	-0.000088
07	-0.767216	-0.017690	-0.538029	-0.043419	-0.512926	-0.011827	-0.019641
08	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
09	-3.663991	0.055669	-1.115648	0.035935	-0.768896	0.011682	-0.021992
10	0.001677	-0.000085	0.005617	0.000162	-0.236990	-0.011941	0.000005
11	1.723515	-0.008037	0.049430	-0.005720	0.400265	-0.001866	0.014626
12	0.004043	0.000621	0.125766	0.073699	0.087367	0.013417	0.005075
13	0.676773	-0.014487	0.409062	-0.009416	0.229269	-0.004908	0.002864
14	-0.017146	-0.004023	-1.244939	0.041955	0.054911	0.012883	0.009751
15	-0.053497	-0.000466	-0.005355	-0.000083	-0.320374	-0.002791	-0.000083
16	1.702210	-0.007645	0.045288	-0.000408	0.412086	-0.001851	0.000831
SUMS	0.209660	0.002296	-0.665662	0.054283	0.048040	0.005114	0.009589

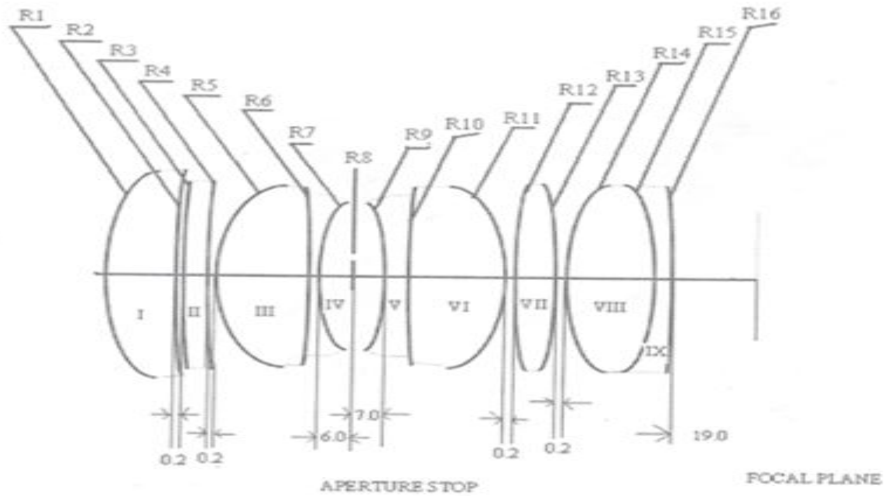

Figure 1: The optical configuration of objective for 25-mm effective diameter opto - electronic image intensifier tube.

Table 2 Design data of the night vision objective

Lens	Radius of curvature (mm)	Separation or air space (mm)	Outside Diameter (mm)	Clear Aperture (mm)	Glass	Refractive Index	Abbe NO
1 2	67.00000 110.00000	7.00000 0.2(air)	22	20.0	DBC 610573	1.607060	57.3
3 4	85.00000 250.00000	5.00000 0.2(air)	21.3	19.3	EDF 648338	1.642710	33.8
5 6 7	31.50000 300.00000 19.50000	11.6000 1.90000 6.0(air)	19.9	17.9	LAC 697562 DF 626353	1.693550 1.620730	56.2 35.3
Aperture stop	8	7.0(air)					
9 10 11	-18.60000 95.00000 -28.00000	1.9 13.5 0.2(air)	16.8	14.8	EDF 699301 LAC 697562	1.692210 1.693550	30.1 56.2
12 13	80.69999 -143.0000	6.0 0.2(air)	18.6	16.6	LAC 697562	1.693550	56.2
14 15 16	42.00000 -70.00000 -500.0000	11.0 5.5 18.99(image distance)	15.25	13.25	LAC 697562 DEDF 717294	1.693550 1.710320	56.2 29.4

3. The Performance Of The Objective

At full aperture, the on axis vignetting of the objective is 0% and the off-axis vignetting is 61.1% at 35 degree full field. The radial energy distribution shows 22 microns on axis and 191 microns at full field. The spot diagrams are assessed at 19-mm from the last vertex of the objective. The on axis geometrical frequency response shows 0.93,0.75,0.5 at 5,10,15 line pairs/mm respectively where as the full field geometrical frequency response is 0.28, 0.06, 0.04 at 5,10,15 line pairs/mm respectively The driver of the military truck uses half the field of view of the night vision aid. For identification of objects on road and drives the vehicle and the other half off axis field of view for recognition or detection. The night vision objective met the field of view versus performance requirements of military truck drive

4. CONCLUSIONS

The optical design of nine element all spherical night vision objective is presented which meets requirements of military truck driver and ease of mass production Loose tolerances on all optical design parameters of objective and maximum utility of Indian optical glasses are considered in the optical design of objective. All the radius of curvature of lenses are kept above 45% of the objective focal length for ease of mass production. The optical design is first of its kind using one imported optical glass in the nine element objective. The objective is mass produced and it has been in use with Army night vision sight.

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