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ALL SPHERICAL MILITARY WIDE ANGLE AERIAL RECONNAISSANCE CAMERA OPTICS

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Abstract: Military conducts aerial reconnaissance at altitudes from 7 Kms to 21 Kms from MIG aircraft platforms. A military reconnaissance aerial camera optics is designed and the optical design data of eight element all spherical **f/7**.0 relative aperture photographic objective having focal length of 750.74-mm with 37 deg full field is presented. The aerial reconnaissance camera (ARC) optics is all refractive and all the elements are meniscus, No cemented elements are used in the optical design. The ARC camera optics consists of four individual lens units which are arranged into two optical assemblies and each optical assembly contains two lens units. The two optical assemblies are mounted left and right sides of the bay of MIG aircraft The four lens units as two optical assemblies together cover a 133 degrees x 22.66 degrees full field –of – view . The optics of the each lens unit is the same. The lens unit is designed for a back focal length of 558.15mm so that aerial photographic film roll and its associated mechanical assembly is accommodated with in the back focus.

Keywords: Military Aerial Reconnaissance Camera Optics, Wide Angle Aerial Photography, Optical Design,

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INTRODUCTION

The camera lens units for aerial reconnaissance camera optics are designed with the following considerations[1].

- Long focal length, long back focal length and large aperture .The large aperture provides maximum acceptance and transmittance of light. A large entrance pupil is required to achieve an acceptable signal-to-noise ratio.

- Minimum Vignetting. vignetting instantly results in markedly reduced performance at the edge of the field.

- Color correction for a visible spectral region. Color correction is required from 400-nm to 700-nm wavelength range.

- Resolution. The lens shall resolve 200 lines /mm from center to 5.5 degrees field –of-view(FOV),100lines /mm at 10 degrees FOV ,50 lines/mm at 30 degrees FOV and 25 lines/mm at 37 degrees full FOV.

- Long back focal length. A long back focal length is desirable to keep photo

- Graphic films far from metal parts of the lens mount...

A all meniscus configuration is visualized for large aperture, long focal requirements and long back focal length. The required field of view is 133 degrees by 22.67 degrees to photograph the large area of ground from MIG aircraft .To make the optical design simple, the field of view requirement is distributed to four similar lens units. The four similar lens units form two separate optical assemblies The first optical assembly is mounted on left side of the aircraft bay and the second optical assembly is mounted on the right side of the aircraft bay so that all the four lenses effectively give a 133 degrees FOV along the direction perpendicular the flying direction of aircraft and 22.67 degrees FOV in the flying direction .The lens units1 and 2 on the left side of the bay make 15.5 and 51.5 degrees with a perpendicular to the flying direction of aircraft and lens units 3and 4 are mounted at same angles on the right side of the aircraft bay. The figure 1 below shows the non overlaping field of view covered by four lens unit aerial reconnaissance camera optics.The figures (a),(b) and (c) of figure1 are drown for self explanatory

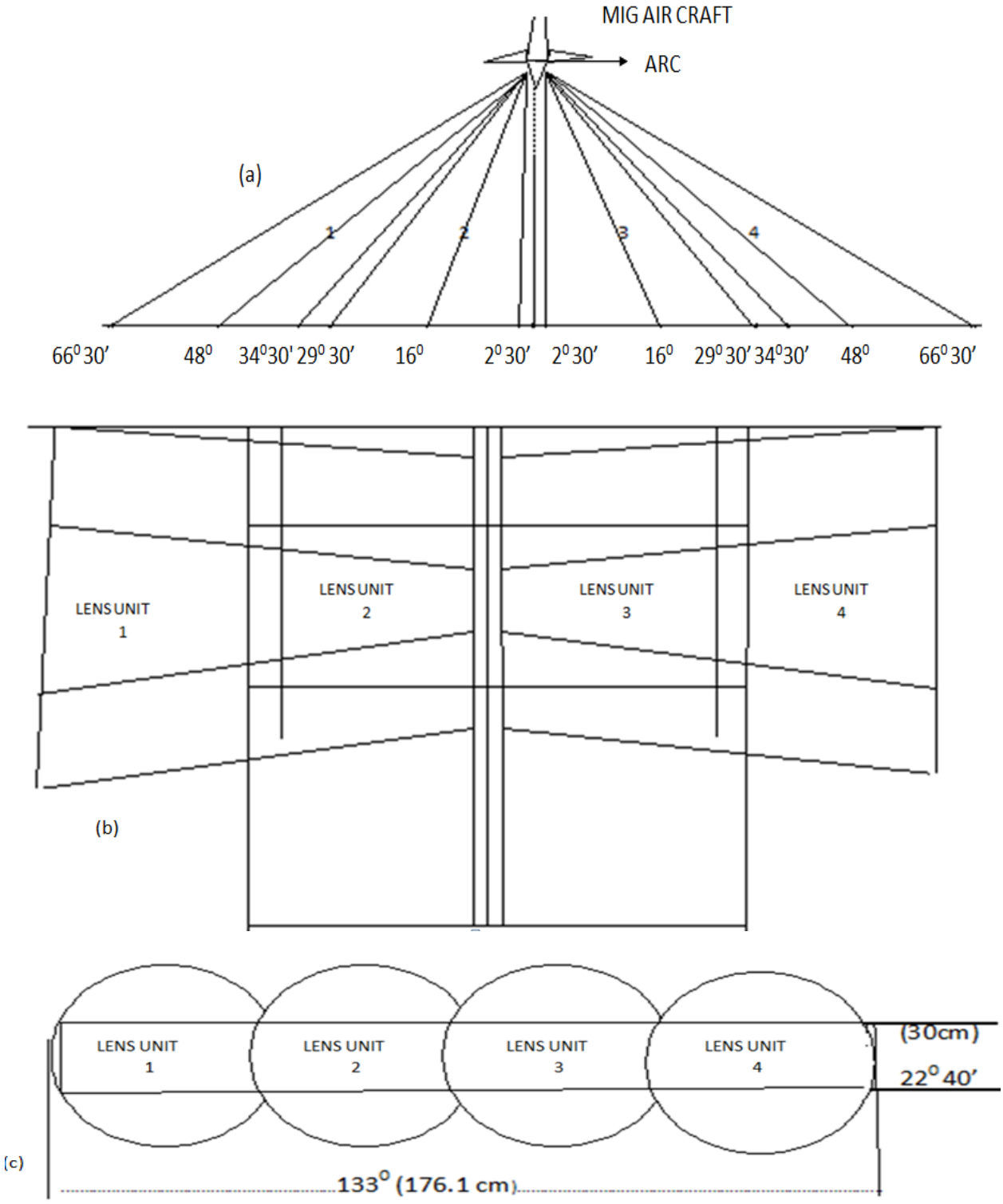
MIG AIR CRAFT
ARC
(a)
1
2
3
4
66° 30′
48°
34°30′
29° 30′
16°
2° 30′
2° 30′
16°
29° 30′
34°30′
48°
66° 30′
LENS UNIT 1
LENS UNIT 2
LENS UNIT 3
LENS UNIT 4
(b)
LENS UNIT 1
LENS UNIT 2
LENS UNIT 3
LENS UNIT 4
(30cm)
22° 40′
(c)
133° (176.1 cm)

Figure 1

OPTICAL DESIGN OF AERIAL CAMERA LENS UNIT.

All the four lens units use the same optical design. The first order optical design lay –out or thin lens design of aerial lens unit during initial phases of optical design is worked out for a minimum back focal length of 550mm [1-6]. The powers of the optical elements and the air spaces between optical elements of lens unit are finalized during thin lens design. This thin lens Configuration is analyzed for thick lens third order aberrations or Seidel coefficients by assigning appropriate thicknesses to the optical elements in the lens unit. Appropriate bending operation is carried out on all the lens elements in the lens unit for desired Seidel values. Thus satisfactory design solution for optical configuration of aerial lens unit is obtained. A trigonometrical ray trace for actual aberrations of aerial lens unit is carried out on the design data assessed by third order aberrations.[7,8]. Minor changes are made to the values of radii curvature, thicknesses, air spaces and stop position of to control the actual aberrations within the desired limits. The final design data of lens configuration of the lens unit is qualified through spot diagrams, radial energy distribution curves and modulation transfer function The figure 2 and table 1 below show the optical configuration of lens units and the final optical design data of the lens units of the military wide angle aerial reconnaissance camera optics.

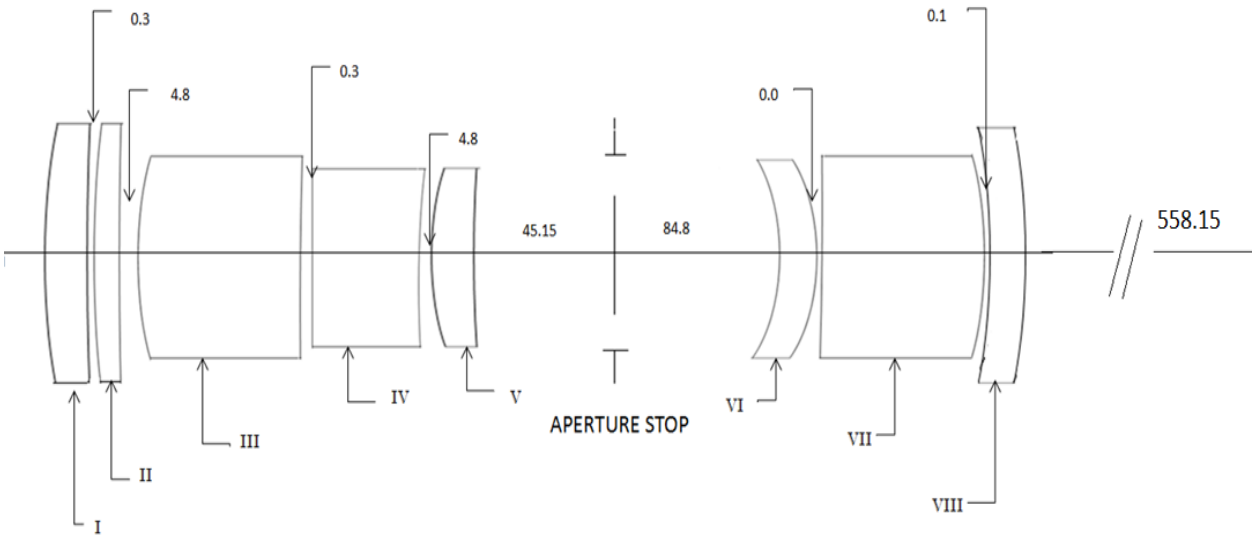

Fig.2.Optical configuration of lens units 1,2,3,4 of aerial reconnaissance camera optics

Table 1. Optical design data of lens units1,2,3,4 of aerial reconnaissance camera optics

LENS	GLASS	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	CT	CA
I	BaSF 6 668419	348.1 VEX	1036.0 CAV															13.8	162
II	DEDF 755276			1100.0 VEX	925.5 CAV													8.0	162
III	BF 700412					218.6 VEX	822.3 CAV											50.0	124
IV	DEDF 755276							826.4 VEX	139.9 CAV									33.5	104
V	LF6 567428									170.8 VEX	177.4 CAV							9.6	104
VI	LF6 567428											166.8 CAV	233.3 VEX					16.0	144
VII	LAC 678552													922.0 CAV	153.9 VEX			66.9	144
VIII	MBC 569561															154.4 CAV	271.7 VEX	19.1	180

ALL THE DIMENSIONS ARE IN MM

CONCLUSIONS

The four lens unit aerial reconnaissance camera optics forms 30 cm x 176.1cm image on the photographic film placed in the back focus of the optics. The optics gave ground resolvable distance (GRD) of 0.59m, 1.177m, 1.77m at 7kms, 14kms, 21kmsw altitudes and 66.5 degree semi field –of- view. At intermediate semi field angles, the GRD values are much lower in magnitudes. This publication brings out a wide angle aerial camera optics configuration using four all spherical lens units, each covering a full field –of –view of 37 degrees. The four lens units together cover non-overlapping field of view of 133 degrees x 22.67 degrees. All spherical surfaces are considered for aerial reconnaissance camera optics for ease of manufacturing and optical testing. This camera optics configuration is entirely new. to the best of my knowledge .

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