C² CONSTRUCTIVE CYBERNETICS
Research. Development. Consulting

ODF'14 ITABASHI TOKYO
9th International Conference on Optics-photonics Design & Fabrication
Optics-photonics ODF Design & Fabrication

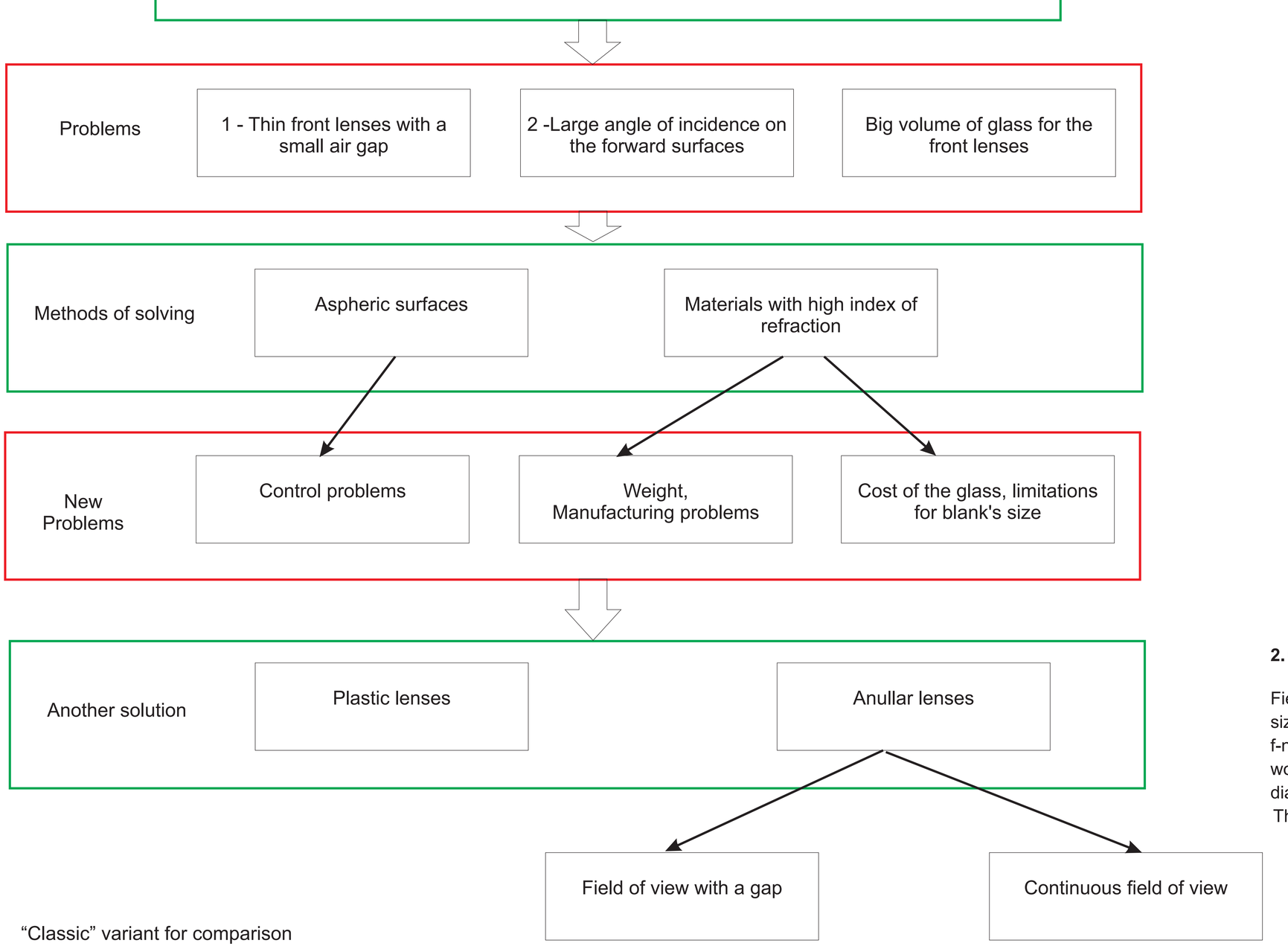
Annular lenses in wide angle optical systems

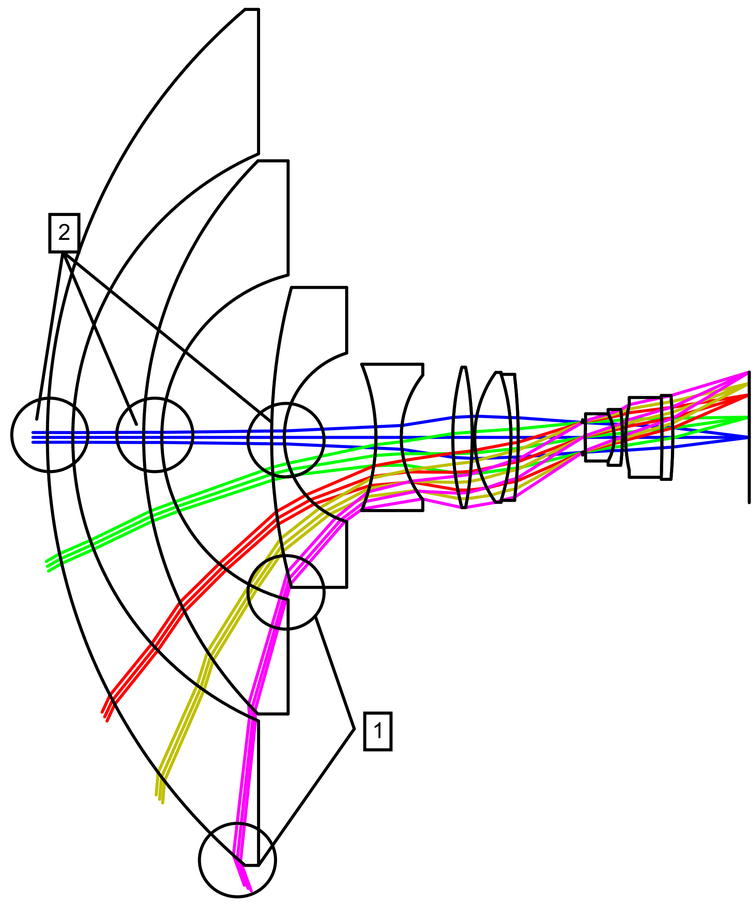
Andrey V. Pravdivtsev
Research and development group
“Constructive Cybernetics”

1. Introduction

Wide-angle optical systems (WOS) are increasingly used in various fields. Development of large dimension focal plane arrays allows to get an acceptable instantaneous field of view of a pixel. However, the development and production of such systems involve a number of problems.

The goal of this work is to discuss a way to reduce weight and cost of ultra wide angle optical systems



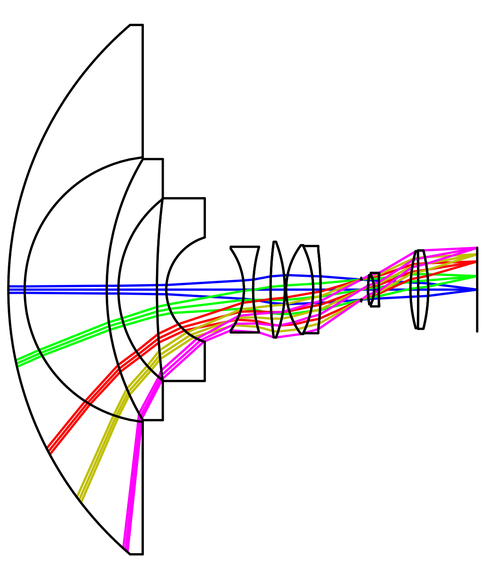


A wide-angle lens with problem areas marked:
1 - Thin front lenses with a small air gap
2 - Large angle of incidence on the forward surfaces

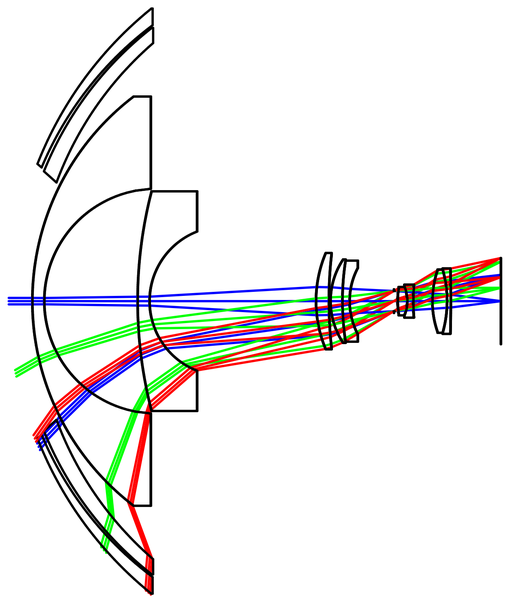
2. Optical system characteristics:

Field of view of 220°;
size of focal plane array is 36x36 mm;
f-number is 1:4;
working spectral range is 440-680 nm;
diameter of the front lens is less than 240 mm.
The quality criterion for the system is MTF at the frequency 35 cycles per mm.

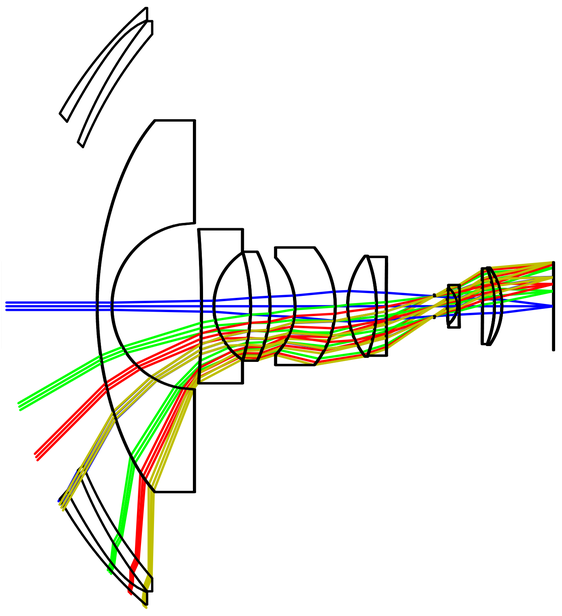
“Classic” variant for comparison



Total weight: 3.1 kg

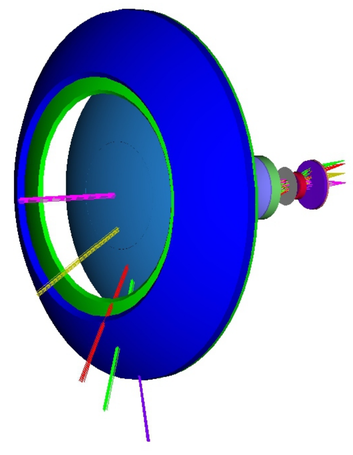


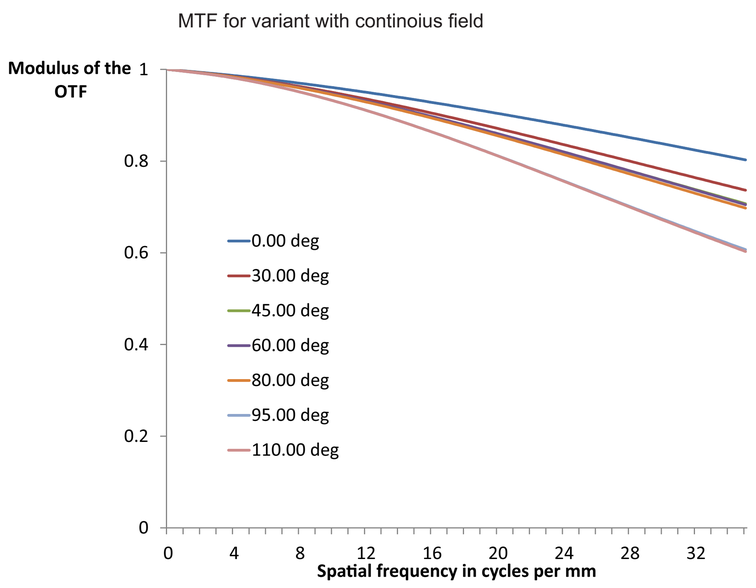
Total weight: 2.5 kg (with glass lenses)



Total weight: 1.1 kg

3D model for lens with continuous field of view





3. Things to pay attention to during the optimization:

1) Point spread function for overlapping fields - the shape of the PSF on the boundary should be similar for inner and outer parts.

2) The value of gap in noncontinuous variant.

3) To avoid the gap the edge of inner and outer fields should overlap. It can be done by using aspheric surfaces. When using only spherical surfaces the angle of incidence on annular lenses in intersection zone should equal to 90 degrees.

4) The similar distortion curve for outer and inner parts.

4. Results:

1) In the report we discuss the possibility of decreasing weight and cost in wide angle optical systems (field of view about 180 degrees).

2) The decrease of weight can be achieved by replacing solid lenses by annular lenses. It allows us to design optical system with the same image quality (but this variant will have a “blind” zone).

3) Additional improvement is based on usage of aspheric plastic annular lenses. It allows us to design a light weight optical system with continuous field of view and the same image quality. In some cases they allow to create faster optical systems.

4) Aspheric surfaces give additional possibility to control distortion over the field.