

Automation of the construction creation process of the optical instrument and creations of designer documentation

Nadezhda D. Tolstoba, Nikolay B. Voznesensky, Olga Delnova, Anna Voznesenskaya
St.-Petersburg State Institute of Fine Mechanics and Optics (Technical University)
Sablinskaya ul.,14, St.-Petersburg, Russia, 197101

ABSTRACT

The automation of the designer's documentation making process gives rise to necessity in search of new possibilities for the even greater facilitation of the instruments designing process. Now in the field of optical instruments designing is felt a deficiency in the area of the software for automation of the designer's documentation formation. The development of ZOOM-objectives optics requires complex and laborious work of optics-designer and creation of new forms of realization of the projects for improvement of creative work too.

The given report is devoted to development of the mathematical foundation and software for a construction of the mount of the optical system automatized design.

Keywords: designing, drawings, sketches, optical instrument.

1. INTRODUCTION

For the most effective work in environment of the automated designing (CAD/CAE/CAM) there are various applications for mechanical engineering, construction, architecture, electronics etc. The research of the market of the offers in the field of optical instrument making has shown absence of similar software on the given direction in the area of Russian designing. One of possible ways allowing to reduce time for release the design documentation is use of the specialized software. Most known in this area is AutoCAD of the company Autodesk, which uses at the experts CAD/CAE/CAM the deserved authority.

The known package AutoCAD of the company Autodesk is constantly developing environment of designing. This high-efficiency software with the Windows-interface allows to solve tasks concerning various branches of designing equally well.

Due to the built - in programming language the creation of the applications for the diversified industries is possible. The development of mathematical and software for effective work of the designers in the field of designing optics is a major task allowing to increase productivity of work of the optics - designer and at the expense of it to increase time, spent on the creative approach to the decision of the problem.

2. THE DEVICE DESIGN SELECTION

Design of the optical device

Designing of the device - creative process, but many skilled designers resort to some organizational solutions for automation of the work. The variety of variants during acceptance of the decision defines complexity of the automation of the device designing process.

The procedures of search of the technical decisions, as was investigated by the predecessors, consist in drawing up of the functional and structural description of the designing object. For the functional description the method of structural tree can be used [1] (Fig. 1).

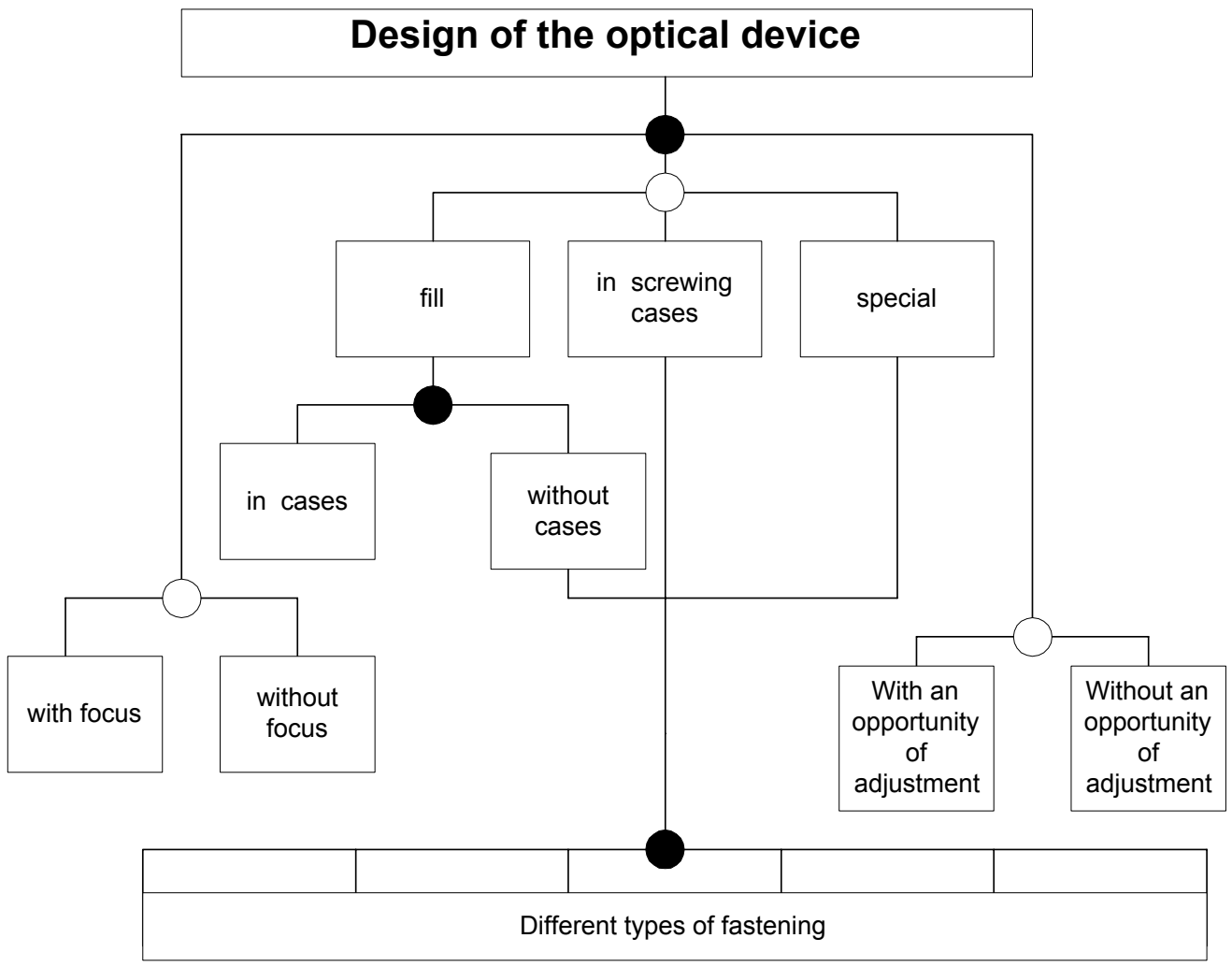


Fig. 1. Tree of the technical decisions of a design of the optical instrument (OI)

The elements, which can meet in a design simultaneously, are designated by black circles, and alternative – by light circles. But it is not enough for the complete description of designing object the usage of the Tree.

The given structure allows to help the designer to receive the information on the possible technical decisions. For observance of the given structure exists [1] so-called matrix of conformity being a means of formal reflection of structure elements relations. Lines of a matrix - functional elements, columns - attributes from their complete set. The choice of the optimum decision in conditions of presence of a plenty of parameters of a task is more convenient for making with use of a so-called matrix of the decisions on the basis of the compromise constructed in correlation with “ the principle of fair concession” (Table 1.).

The method of a matrix of the decisions simulates process of designing. If to refuse its application, the designer all the same should analyze variants, but it is very difficult to keep in mind all such volume of the information. In result the probability of a finding of the optimum decision is sharply reduced.

The algorithm of a choice of a suitable design of the optical device (Fig. 2) follows from the described technique. For adaptation of the program to computing environment and various CAD/CAE/CAM the given algorithm is realized in universal graphic environment AutoCAD on the built - in programming language AutoLISP. It allows considerably to expand traditional opportunities of system base depending on the concrete task.

Table 1. The matrix of the decisions

Parameters of quality	Weight factor	Variants of the decisions			
		1	2	...	N
A ₁	k ₁	a ₁₁ $k_1 \cdot a_{11}$	a ₁₂ $k_1 \cdot a_{12}$...	a _{1N} $k_1 \cdot a_{1N}$
A ₂	k ₂	a ₂₁ $k_2 \cdot a_{21}$	a ₂₂ $k_2 \cdot a_{22}$...	a _{2N} $k_2 \cdot a_{2N}$
...					
A _m	k _m	a _{m1} $k_m \cdot a_{m1}$	a _{m2} $k_m \cdot a_{m2}$...	a _{mN} $k_m \cdot a_{mN}$
Total rating	$\sum K_i = 1$	S ₁	S ₂	...	S _N

For example: it is required to choose the way of lens fastening, if the design works in difficult dynamic and temperature modes, its role in common optical system is low, manufacture is serial.

The drawing up of matrix for four variants of ways of the decision is submitted in (Table 2.) Parameters of quality is chosen usual for fastening optical details. On the basis of the initial data, specified in the task, we nominate the greatest weight factors of quality parameters to reliability, tolerance to temperature fluctuations, adaptability to manufacture and cost; the role of other parameters is minor. Estimated numbers for the variants, accepted to consideration, of fastening is nominated, were based on known properties, advantages and lacks of each of them on ten-mark system.

Table 2. The matrix of the decisions for a choice of a way of lens fastening.

Parameters of quality	Weight factor	Variants of ways of fastening			
		Rolling up	Clamped ring	By a wire ring	Tightening and springing by rings
The location accuracy	0,05	8 0,4	4 0,2	4 0,2	6 0,3
Reliability of fastening	0,30	2 0,6	10 3,0	6 1,8	10 3,0
Absence of tension	0,05	8 1,6	2 0,1	4 0,2	6 0,3
Tolerance to temperature fluctuations	0,20	10 0,5	2 0,4	4 0,8	6 1,2
Constructibility (dimensions)	0,05	4 0,8	5 0,25	6 0,3	2 0,1
Adaptability to manufacture	0,20	4 0,8	8 1,6	6 1,2	5 1,0
Cost	0,15	6 0,9	6 0,9	7 1,05	2 0,3
Total rating	1,00	S=5,2	S=6,45	S=5,55	S=6,2

In the given example the greatest value S corresponds to variant of lens fastening by the clamped ring. If there will be by other initial conditions, the restrictions and weight factors, appropriate to them, together with results will change.

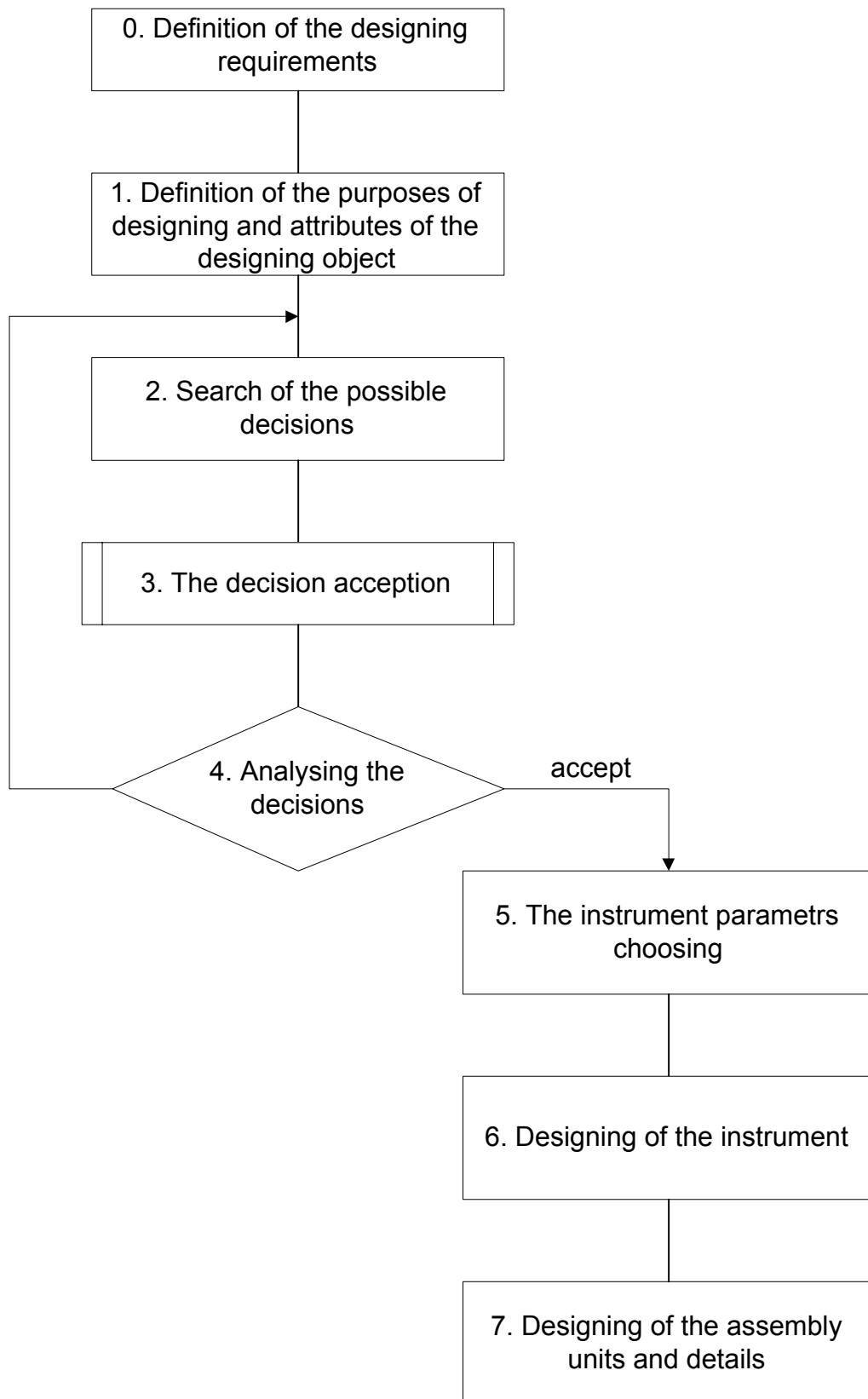


Fig. 2. Algorithm of search of an optimum OI.

3. EVALUATION OF BEAMS DIMENSIONS OF OPTICAL SYSTEMS

After a choice of the OI suitable design, it is necessary to provide the check on passage of beams and presence of parasitic reflections directly in environment of the automated designing, that will allow to estimate efficiency of a formed design from the point of view of dimensions of beams and elimination of the parasitic patches of light.

For modelling work of optical system, calculation of its paraxial characteristics, the known mathematical technique of matrix optics was taken.

Using the mentioned mathematical technique, it is possible to look the ray trace or beam of rays in concrete optical system, and on the basis of it make conclusions about chosen designs and materials of mechanical and optical details. This choice also can be automated to not complicate the operator.

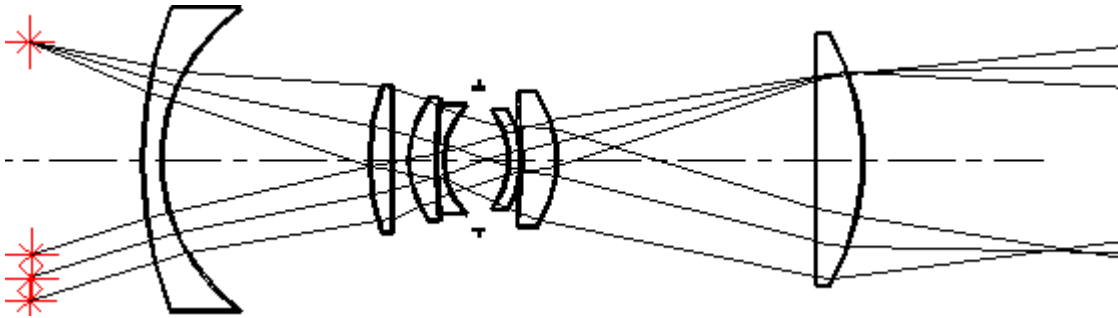


Fig. 3. Display of real passing beams through the optical system

Result of performance of the given stage is the sketch of the OI construction with the real beam passing (Fig. 3, 4) and, if necessary, textual file with numerical values of some designed parameters. They can be used as intermediate in work of the designer, and can be added to the engineering specifications as auxiliary data.

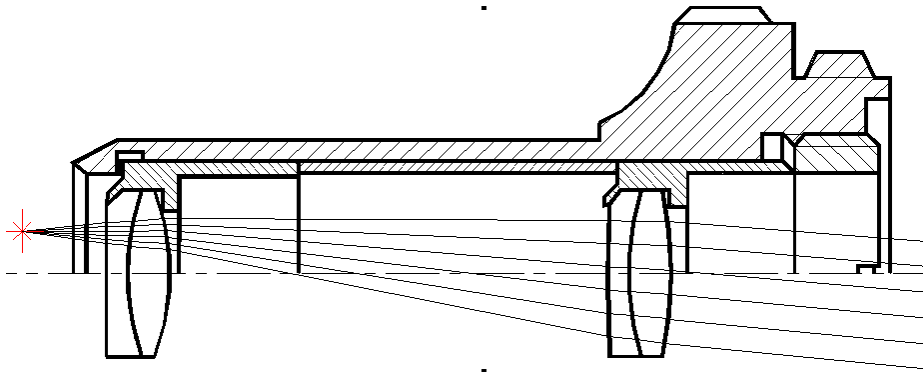


Fig. 4. Display of real beam passing through the OI

The given stage is a link between account of optical systems, OI designing and performance of the design documentation. Besides the designer for the first time has an opportunity to check occurrence of parasitic reflections and to struggle with them, using functions, necessary for it.

4. DEFINITION OF THE NORMATIVE INFORMATION WITH THE HELP OF THE SPECIALLY CREATED BASE OF THE TABLES

The preparing of the design documentation for OI is closely connected to the usage of the normative documents. In most cases the process of using of state standards is difficult. Unfortunately, all technical literature on optical instrument making does not comprise a complete set of the tables necessary for the optics - designer for constant use. Therefore daily work needs a plenty of the literature, that complicates and, naturally, slows down the designing process.

The performance of the drawings of optical and mechanical details requires from the optic designer of use of huge amount of the help information. The sketch of the drawing of a lens represented on a Fig. 5., can serve as confirmation to that.

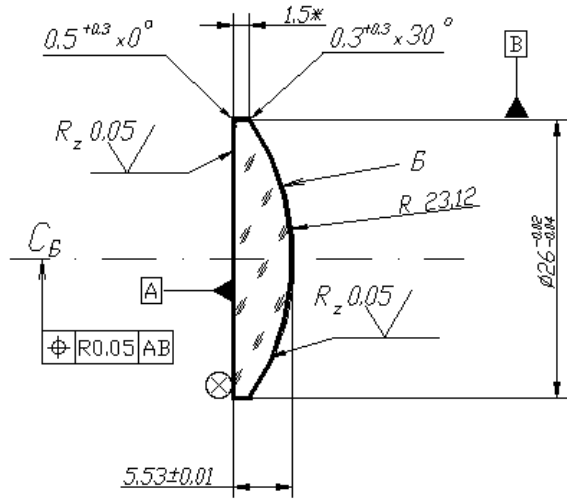


Fig. 5. The sketch of the lens drawing

The creation of base of the tables on the basis of the standards and data from the technical literature is the integral part of automation of the designing process of the OI as its first and basic part.

Within the framework of testing the submitted work the software package working with base of the tables was created. The base was created in a textual kind, that allows to bring in necessary corrective amendments with the help of any text editor (Table 3). The work with the database is carried out by means of special functions created in language AutoLISP.

Table 3. An example of the information storage The table of limiting deviations of the basic apertures

Interval		Field of the tolerances of the basic aperture							
size, MM		H5	H6	H7	H8	H9	H10	H11	H12
The top deviation ES, micron									
from	to	(bottom deviation EI=0)							
1	3	+4	+6	+10	+14	+25	+40	+60	+100
3	6	+5	+8	+12	+18	+30	+48	+75	+120
6	10	+6	+9	+15	+22	+36	+58	+90	+150
10	18	+8	+11	+18	+27	+43	+70	+110	+180
18	30	+9	+13	+21	+33	+52	+84	+130	+210
30	50	+11	+16	+25	+39	+62	+100	+160	+250
50	80	+13	+19	+30	+46	+74	+120	+190	+300
80	120	+15	+22	+35	+54	+87	+140	+220	+350
120	180	+18	+25	+40	+63	+100	+160	+250	+400
180	250	+20	+29	+46	+72	+115	+185	+290	+460

5. PREPARING THE DOCUMENTATION FOR DETAILS MANUFACTURING

After creation of the authorized assembly drawing it is necessary to begin release of the design documentation for manufacturing both optical details, and mechanical, required for the complete description of the device and its manufacturing.

At skilful use of the help information from base of the tables, the release of a package of the documents on OI manufacturing of a concrete design is not creative, but typical operation, its realization requires designer's attentiveness and patience. Therefore at this stage the automation of details drawings release is essential necessary.

The program realization of separate parts of the project is carried out in environment AutoCAD in language AutoLISP. The stages of formation of optical scheme drawing, lens drawings, evaluation of beam dimensions, drawings of typical mechanical details are realized.

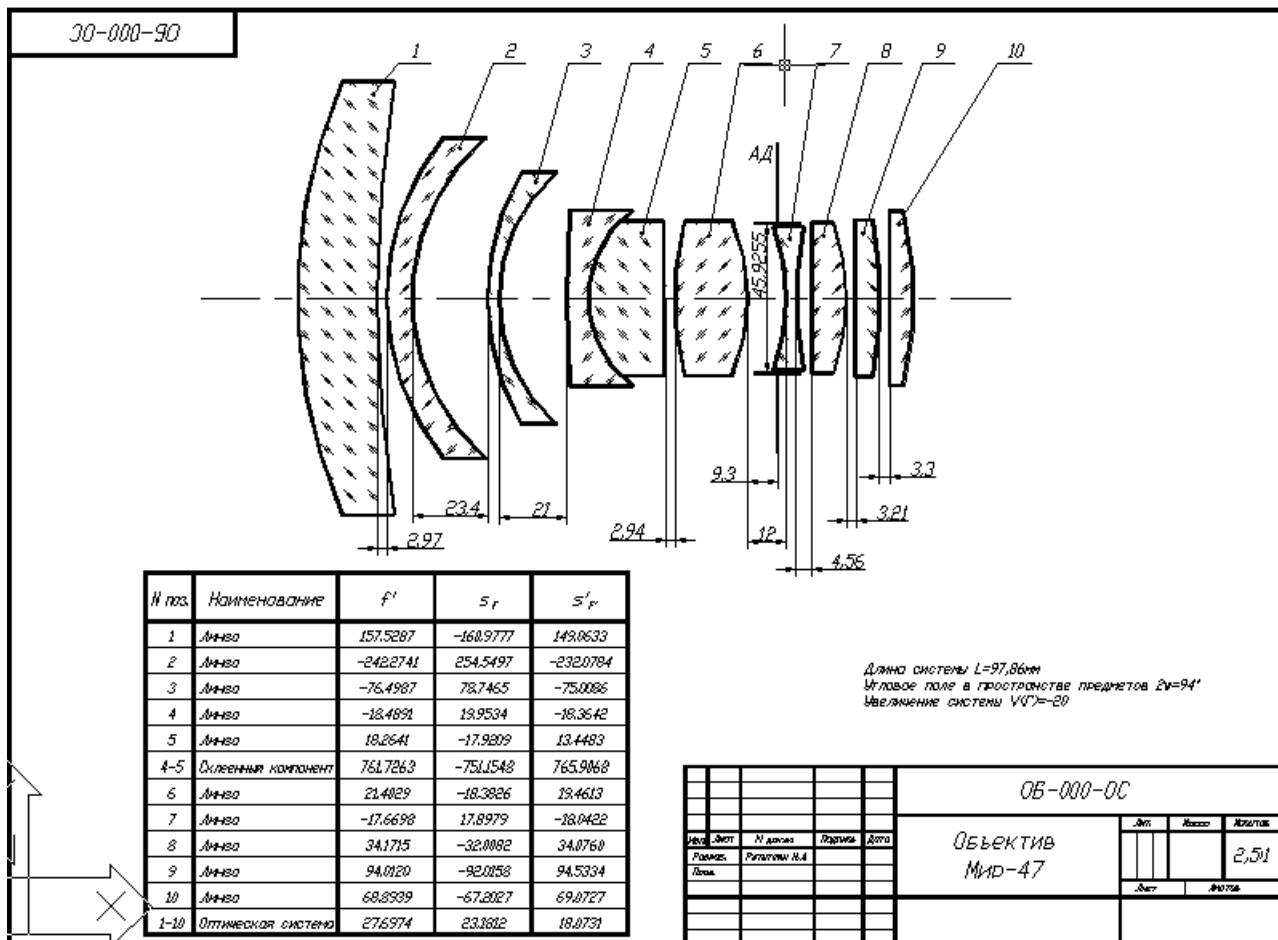


Fig. 6. An example of the optical scheme created with the help of the given program.

The developed mathematical model allows to realize the following stages of designing of the optical device:

- Development of a design of the device, which final result is creation of the assembly drawing:
 - 1) Evaluation of dimensions of optical system with the purpose of beams passage check, influence of light patches and parasitic reflections from elements
 - 2) Support of process of designing by the normative materials and rules.

- Formation of the design documentation on the drawing:
 - 1) Assembly drawing and specification
 - 2) Optical scheme drawing (Fig.6)
- Performance of the parametrical drawings of the OI details:
 - 1) Lens drawings
 - 2) Prisms drawings
 - 3) Drawings of flat optical details
 - 4) Drawings of the mechanic part of a design
 - 5) Formation of the table of optical requirements
(For a lens, prism, plate, cemented component etc.)

6. CONCLUSION

Thus, the given mathematical model enables the choice and rational construction of the OI design and making of the design documentation necessary during manufacturing.

The base of the tables with the data has opportunities for expansion, and also can be used in any areas instrument making and mechanical engineering, regardless of the fact that it was created for the automated designing of optics.

The given development is supposed to be used further together with others for creation of a uniform package being a means of adjustment of environment AutoCAD for needs of optical designing and allowing quickly and qualitative to carry out the design documentation on the OI.

REFERENCES

1. Bykov V.P. Methodical maintenance CAD/CAE/CAM in mechanical engineering. – L.: Mashinostroenie, 1989.
2. Kluchnikova L.V., Kluchnikov V.V. Designing of optical-mechanical instruments. – SPb: Polytechnika, 1994.