Optical lens design with forced performance for metallographic light microscope.

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ABSTRACT

We present results of optical lenses with special design features for the assembly forced metallographic light microscope. Presented lenses satisfy the requirements of the linear field, the correction of aberrations.

Keywords: objectives, microscopes, metallographic microscopes

INTRODUCTION

Industry produces a large number of micro-objectives to work in the reflected light. However, it should be noted that some of them they do not meet modern technical requirements. The fact that the traditional calculation of these lenses was based on the minimization of the residual aberration in the image, and only recently got serious issue of providing some special features of this type of research. Thus, mineralogy, petrography and metallography need a microscope with a reduced flare images, due to the necessity of research low-reflecting objects (ore, coal, etc.). Also today, the rapidly developing some new methods for microscopy, when the presence of scattered light in the image increases the apparent reflectivity of the investigated object and, consequently, is able to significantly affect the reliability of investigations and measurements.

ON THE SCATTERED LIGHT

The scattered light is caused by reflections from the non-working surfaces of optical components, the defects on the surface and in the environment of lenses, as well as due to reflection from optical surfaces bonded lenses. Using the microscope, reflected light in a light box is particularly strong influence on the flare images provides diffused light formed offset single reflection from optical surfaces (the so-called first order reflections). In [1] investigated the possibility of a comprehensive planned to reduce the coefficient of illumination in reflected light microscope, identified the theoretical and practical tools in this process. Thus, for example, have studied the effect of deflection of the individual surfaces, forms a single thin lens and a doublet of thin cemented by a factor of illumination; recommendations on the use of surfaces and single lens of some form.

WAYS TO REDUCE SCATTERED LIGHT

One of the methods used today to reduce the coefficient of illumination is the use of multilayer antireflection coatings on the lens surface adjacent to the air. In some cases this can reduce the scattered light is approximately two - three times, but, in principle, does not have adequate performance. This situation is aggravated by the fact that in modern planapochromat is widely used fluorite, for which there is fairly stable and effective anti-reflective coatings. Hence we may conclude that it is necessary to the extent possible to lay in a design different way of reducing the coefficient of illumination, such as choosing the circuit elements with the predetermined shape of lenses focused on minimizing the coefficient of illumination in the refraction at the surfaces. This method seems the most rational and effective. In fact, the illumination image is reduced without changing the luminous flux. Indeed, since the lighting - is a ratio of luminous flux incident on the area under consideration, to the area of the site, then increasing the land area in the image plane, through which the scattered light flux can significantly reduce lighting illumination. Thus, there is a fundamental opportunity to reduce the illumination at the expense of the design.

ON THE CONCEPT OF DESIGN OBJECTIVES OF THE REFLECTED LIGHT

It is useful to define the general concept of design objectives of the reflected light. It is still not clear whether to pursue the maximum, under the existing structure, numerical apertures. In essence, to work in the reflected light is not always needed high-aperture planapochromates, which are very difficult to be linked to requirements to minimize the coefficient of illumination. The reason is that the calculation of the lens - apochromat aperture close to the limit, in design, dominated by shallow radii (at least in front of the lens), because of the nature of the remedy sphical-achromatic aberration. The condition of minimizing the coefficient of illumination in the lens - the maximum load of all elements of the scheme (i.e., should prevail large radii of curvature). Therefore, there is a choice: either planapochromat, or a lens with a small coefficient of illumination. The same is defined and the difficulties with the calculation micro-objectives small increase (long-focus), which can not be much load all the elements of the scheme. It remains to note that this issue is resolved, but it deserves its own review of theoretical and practical study.

DESIGN ELEMENTS OF THE OPTICAL ELEMENT BASE OF MODERN LIGHT MICROSCOPE

Table 1 shows the specifications and optical scheme of the proposed objectives with the accelerated performance for completion of metallographic light microscope. Objects in metallography, mineralogy, petrography may be low-contrast or high-contrast, color multi-color or mono, phase, anisotropic, and others. Specificity studies on metallographic microscope in reflected light imposes specific requirements for optical systems of lenses - providing a flat field image of the object and the absence of scattered light. In the microscope, which uses digital image receiver, there are additional requirements for the aberration correction lens reflected light, such as the full correction of astigmatism, distortion, and others.

In the microelectronic industry in controlling the topological structures of photomasks, as well as in "small photolithography" required excess of short-focus lenses with linear magnification, 100x more reaching 300x. Lens positions 3-6 correspond to these requirements when a numerical aperture of 0.95 and securing planapochromatic aberration correction.

Interference lenses is designed to study opaque objects. These lenses have increased the front free labor segments, which allows their use for special microscopic techniques.

The main part of such lenses is an interference node, consisting of two plates of equal thickness placed in front of the front of the lens. On one of the plates deposited zonal reflective coating, a second beam-splitting layer. Rays passing through the microscope objective, forks and interfere to form a system of interference fringes of equal thickness, localized on the surface of the sample.

This method of microscopic examination allows for the measurement of the surface asperities, as well as to receive a picture microprofile sample.

Interference micro-objectives allow not only to conduct monitoring and research non-transparent objects, but also to measure microscopic surfaces to receive a picture microprofile sample, including those with 3D projection on the digital receiver and using special software. Lenses are enlarged front free labor segments, the main part of such lenses is the interference node, consisting of two plates of equal thickness interference, located in front of the front of the lens. At one of the plates inflicted zoning reflective coating on the second - beam splitting layer. The rays that pass through the microscope objective, forks and interfere form a system of interference fringes of equal thickness, localized on the surface of the sample. Optical calculation of such lenses has its own specifics. Lens positions 7-9 fully meet the requirements for using the size and aberration characteristics.

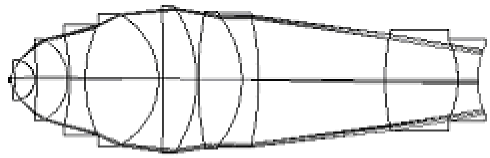
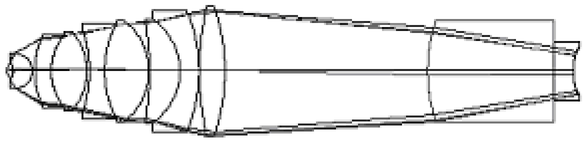
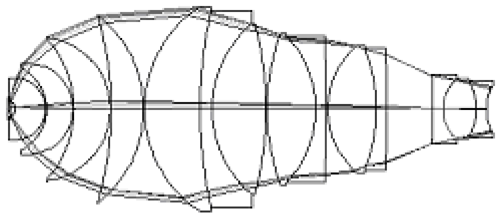
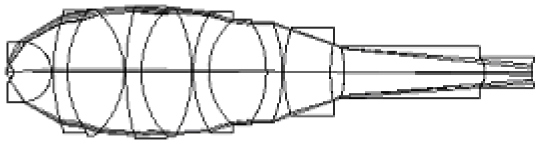
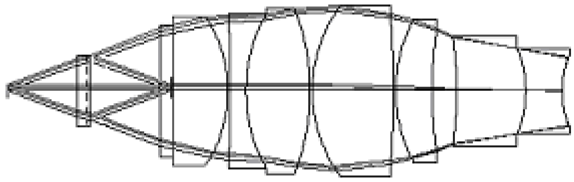
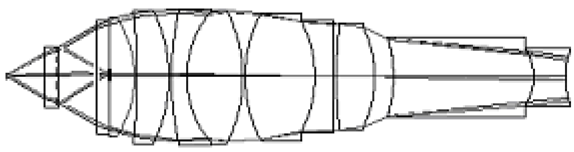
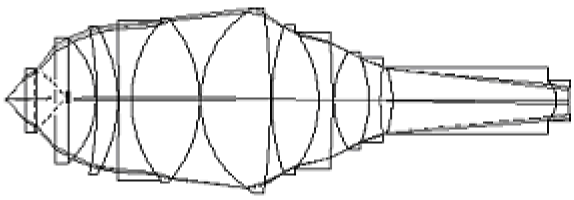
Lenses provided in positions 10-14 implement the most advanced to date technology of optical calculation and design, consider limiting the power of modern optical and assembly industries. Most of these lenses still have no analogues in the world. The result of the optical design managed to obtain optical lens design, which simultaneously implements three achievements. This long working distance, planapohromatic aberrational correction, very large linear increase. Figure 2 illustrates the characteristics of the current image quality of the lens 500h0.65 LD.

CONCLUSION

The developers of optical systems must constantly improve the basic elements of microscopes. The advent of new lens reflected light for optical metallographic microscopes will allow researchers and users of microscopes to make their work more productive and quality.

REFERENCES

[1] Ivanova T.A., Kirillovskiy V.K. Design and control of optical microscopes. Leningrad, Mashinostroenie, 1984.

Technical characteristics		
increase x aperture, type of correction	Free working distance, mm	Principal optical scheme
height 45mm, infinity tube length, F’tl=180mm, 2y’≈25mm planapochromat		
1) 50x0.95	0.50*	
2) 100x0.95	0.45*	
height 45mm, infinity tube length, F’tl=160mm, 2y’≈25mm planapochromat		
3) 100x1.40 oil	0.28	
4) 160x0.95	0.40*	
5) 200x0.95	0.40*	
6) 250x0.95	0.40*	
7) 300x0.95	0.40*	
height 45mm, infinity tube length, F’tl=160mm, 2y’≈20mm planapochromat		
8) 20x0.35 interference	5.74	
9) 50x0.50 interference	2.99	
10) 100x0.70 interference	1.60	
height 95mm, infinity tube length, F’tl=200mm, 2y’≈20mm planapochromat		

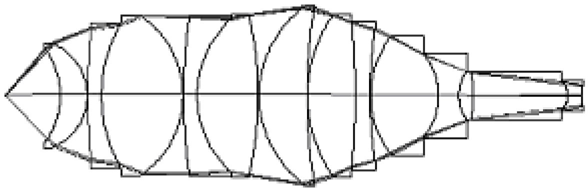
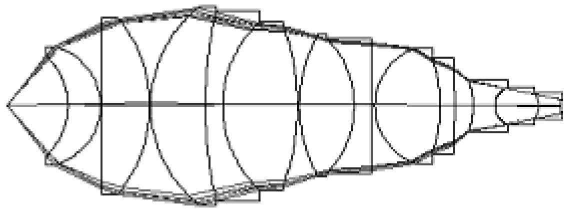
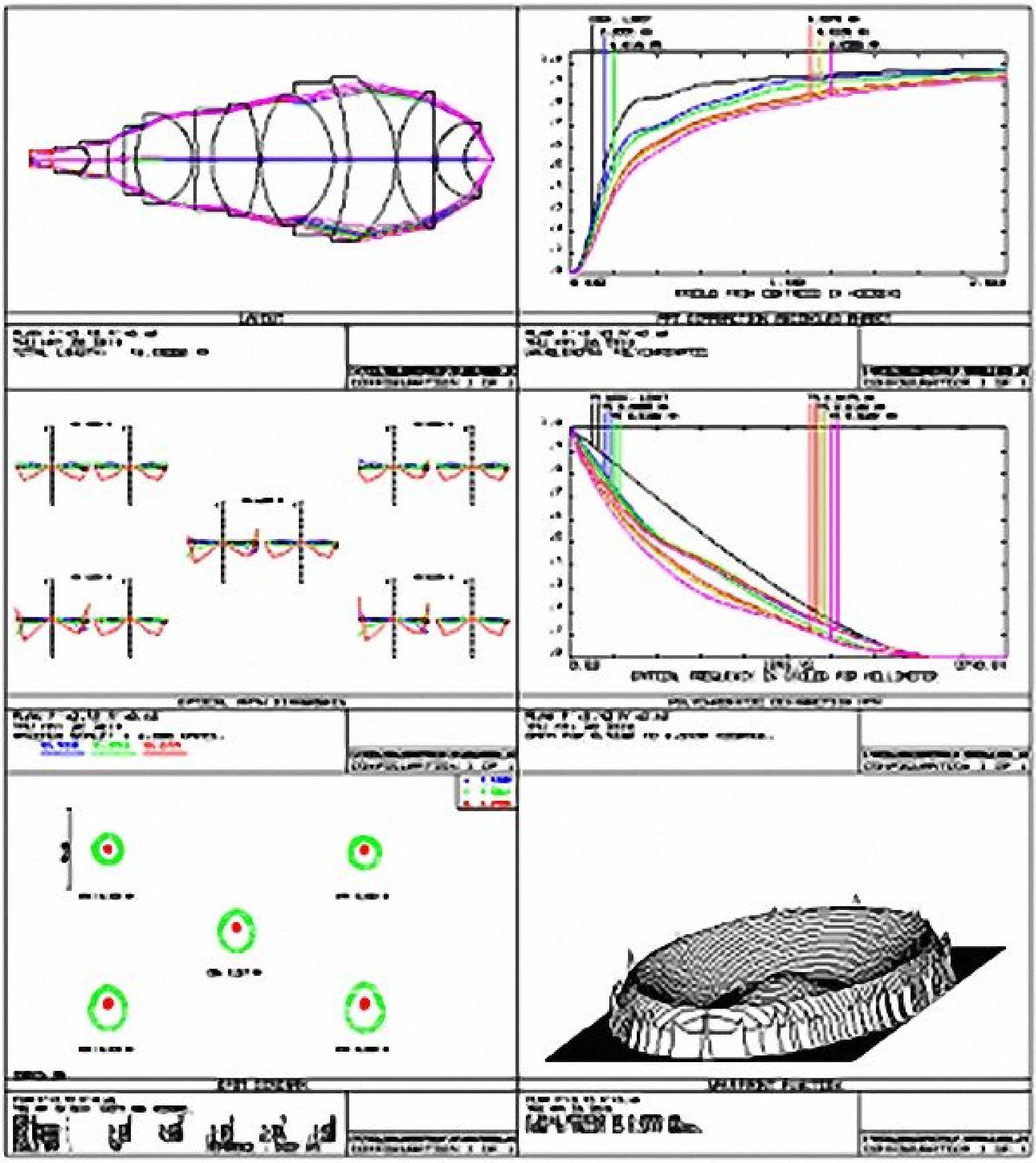
11) 100x0.55 LD	**15.00***	
12) 150x0.60 LD	**8.00***	
13) 200x0.60 LD	**7.00***	
14) 250x0.65 LD	**5.50***	
15) 500x0.65 LD	**3.00***	
* taking into account the deflection of the front lens microscope objective		

Table 1



Picture 1

Captions and tables

Table 1 Objectives for metallographic light microscope

Fig.1 Characteristics of image quality microscope objective
F '= 0.4mm (V =- 500x) Na = 0.65 LLD (wd = 1.25mm)