Optical designs of microobjectives with use of base elements

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Introduction

Today the increasing distribution receives a principle of modular construction of optical designs of microobjectives which as from cubes develop of separate base optical components. These components should be universal under the dimensional and aberrational characteristics. The most widespread base elements are single lenses, and also double triple cemented. As base elements can be not only lenses, but also combinations of lenses, their composition. In work [1] theoretical bases of application of base optical elements with beforehand known dimensional and aberrational properties are resulted. The suggested technique is used at calculation of optical systems microobjectives. The theory of aplanatic surfaces is used also in calculation of objectives of big magnifications. However practical results of microobjectives calculation have shown that the nomenclature of base elements can be essentially expanded.

1. Practice of using base elements

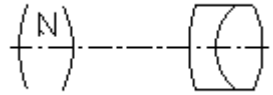
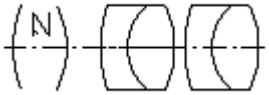
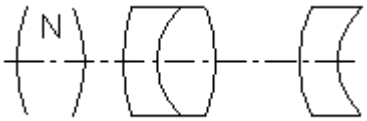
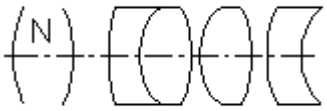
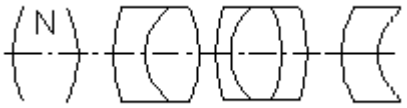
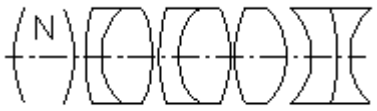
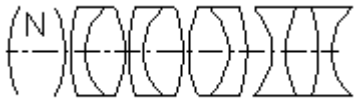
It is possible to use within the framework of one optical design all base elements with the corrected aberrations. It is known, that using in base lenses only spherical surfaces, they in some cases can be free from astigmatism, coma and spherical aberration. If we'll build optical system of such elements which will not have aberrations, all system will turn out also free from aberrations. But practice has shown that by such principle construction of objectives of small magnifications can be optimum only. At synthesis of objectives optical designs in middle and big magnifications (it is especial high aperture), the designer should solve a composition from what base elements he use for achievement of this or that optical correction of objective. It is necessary to solve what aberrations in base elements have to be correct, and what to leave (or even to increase) for their indemnification in the subsequent base elements.

Requirements to dimensional characteristics of objective determine a choice of a kind and quantity of base elements in optical system of microobjective. To those, it is possible to relate the single positive meniscuses inverted by concavity to space of subjects which are used in a frontal part of objectives. The positive two cemented and three cemented lenses used in a "middle" part of microobjectives. Single and achromatic negative meniscuses inverted by concavity to space of images, and also two cemented and three cemented biconcave negative lenses which can be used as reversive telephoto lenses in "compensating" parts of an objective.

2. Unification of optical designs of microobjectives

As base compositions of two and more optical elements can be considered also. In a frontal part of a microobjective it is possible to use N positive single components, in the subsequent part a combination of base elements. The choice of used base elements determines size of their relative apertures, that is influences light diameters of lenses. It means, that at achievement in objectives of identical numerical apertures, but using of various optical designs diameters of lenses can be different. Optical forces of lenses also can be different. These circumstances, define initial requirements to assignment of tolerances for manufacturing details, to development "mechanical" design of objective, a choice of a quality control of details. It is necessary to note, that characteristics of separate base optical elements, and also some kinds of their combinations within the framework of uniform optical design of objective for microscope can be formalized. Certainly, the easier optical design of objective, easier to lead unification of components, but unification is possible and in difficult optical designs. In the table some examples of optical systems compositions are submitted on the basis of combination within the framework of one optical design and more base optical elements.

In the table recommendations also submitted at the choice of a combination of base elements for achievement in objective of the necessary aberrational correction. Also types of objectives for which the offered combination is optimum are named. There are references what aberrations remain not corrected.

The optical circuit of microobjective	The description and correctional opportunities
	Two -components system, first of which N the single lenses, the second double cemented lenses from negative and positive lenses. It is used for objectives achromats and microfluars. Curvature of the image and lateral chromatic aberration are not corrected.
	Two-component system, first of which N the single lenses, the second is two double cemented lenses from negative and positive lenses. It is used for objectives achromats and microfluars. Curvature of the image and lateral chromatic aberration are not corrected. Classical Abbe's system.
	Three – components system, first of which N the single lenses, the second double cemented lenses from negative and positive lenses, the third - the single negative meniscus inverted by concavity to space of images. It is used for objectives with a flat field of the image. Curvature of the image and lateral chromatic aberration are corrected.
	Four -components system, first of which N the single lenses, the second is double cemented lenses from negative and positive lenses, the third - single positive lens, fourth, negative meniscus inverted by concavity to space of images. It is used for plan achromats and plan microfluars with a flat field of the image. Curvature of the image and lateral chromatic aberration are corrected.
	Four -components system, first of which N the single lenses, the second is double cemented lenses from negative and positive lenses, the third is three cemented lenses, the fourth, negative meniscus inverted by concavity to space of images. It is used for plan achromats, plan microfluars and plan apochromats with a flat field of the image. Curvature of the image, secondary spectrum and lateral chromatic aberration are corrected.
	Five -components system, first of which N the single lenses, the second and the third are double cemented lenses from negative and positive lenses, the fourth single positive lens, the fifth biconcave negative, double cemented lens. It is used for plan achromats and plan microfluars
	Five -components system, first of which N the single lenses, the second, third and fourth are double cemented lenses from negative and positive lenses, the fifth is biconcave negative three cemented lenses. It is used for plan achromats, plan microfluars and planapochromats.

References:

[1] M.M. Rusinov L.Mashinostroenie Technical optics, 1979M.

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