PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Improvements relating to Objectives.

I, PAUL RUDOLPH, of Grün, near Lengenfeld, Vogtland, Germany, a German citizen, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to objectives primarily for use in photography, and has for its subject an objective by means of which a sharp image will be produced. The objective is composed of a small number of lenses and is designed to give a plastic image focally correct. According to the invention the objective is composed of three separate lenses which are separated one from another by air-gaps and arranged in the form of two lens systems. The concave surfaces of the lenses in contact with the air-gaps are directed towards the diaphragm which is disposed between the two lens systems. One lens system consists of a convex concave dispersive lens and of a concavo-convex collecting lens separated one from another by an air gap and having their concave surfaces turned towards the diaphragm. The second lens system, is composed of a biconcave lens and of a biconvex lens cemented together along a collecting surface.

In order to obtain a sharp image, a large picture-field with anastigmatic flattening of the field, efficient orthoscopy, reduction of the spherical and chromatic aberrations and consequently a focally correct plastic image, and in order to permit of the use of three different focal lengths in a single objective the convex-concave dispersive lens has a greater thickness at the centre than the biconcave lens, whilst each of the two systems, separated by the diaphragm, has a collecting effect. An objective of this very simple construction has, with the glass types at present obtainable, a small residuum error of chromatic magnification which is however not disturbing if the objective is used for amateur-purposes. If the objective is designed to be used for high grade technical purposes the error is avoided by forming the convex concave dispersive lens of a positive lens and of a negative lens cemented together. The types of glass used are chosen so that the positive lens possesses less dispersive power than the negative lens. The refractive indices may either be the same or different according to the purpose in view.

The composition of the objective thus constructed may be modified according to requirements and according to the purpose for which it is to be used. The type of glass, the radii and the thicknesses may be varied as required.

Three forms of construction are hereinafter described by way of example in the accompanying drawing. Each form serves for a different purpose.

Similar characters of reference designate similar parts in all figures.

The diaphragm is indicated by the line B—B. In Fig. 1 L_1 is the convexconcave dispersive lens and L_2 the concavo-convex collecting lens. L_3 is the biconcave lens and L_4 the biconvex lens. The curved surfaces of the lenses are indicated by r_1 r_2 and so forth, whilst d_1, d_2 . . . . are their thicknesses and b_1, b_2 indicate the widths of the air gaps between the lenses. The types of glass of the various lenses are given by the refractive index n_D for the D line of Fraunhofer spectrum, n_{G^1} being the refractive index for the G^1 line of the same spectrum.

In this form of construction the objective is designed for a focal length of 300$^{m}/_{m}$. The free aperture is 43 $^{m}/_{m}$., the ratio of aperture to the focal length being consequently 1:7. The angle of view is greater than 90°. This is the simplest form of construction as the objective is only composed of four single lens elements. The two lens systems of the objective separated by the diaphragm, have a positive focal length the front system having the longer focal length. The following particulars apply to an objective having a focal length of 100$^{m}/_{m}$.

Radii of curved surfaces.	Thicknesses and air-gaps.	
$r_1 = +16{,}03^{m}/_{m}$	d_1	$=3{,}790^{m}/_{m}$
$r_2 = +11{,}62^{m}/_{m}$	d	$=0{,}534^{m}/_{m}$
$r_3 = +15{,}36^{m}/_{m}$	d_2	$=1{,}202^{m}/_{m}$
$r_4 = +21{,}76^{m}/_{m}$	$b_1 = b_2$	$=1{,}336^{m}/_{m}$
$r_5 = -17{,}36^{m}/_{m}$	d_3	$=0{,}801^{m}/_{m}$
$r_6 = +20{,}03^{m}/_{m}$	d_4	$=2{,}871^{m}/_{m}$
$r_7 = -18{,}63^{m}/_{m}$		

Glass types:

$L_1 = L_3 : n_D = 1{,}53980$ $\quad n_G{}^1 = 1{,}55459$
$L_2 = L_4 : n_D = 1{,}62070$ $\quad n_G{}^1 = 1{,}63463$

In Figs. 2 and 3 the collecting lens of less dispersion than that shown in the foregoing example is indicated by L_1, L_2 being the dispersive lens of greater dispersion cemented to L_1. The concavo-convex collecting lens is indicated by L_3, L_4 being the biconcave dispersive lens and L_5 the biconvex collecting lens.

In Fig. 2 the objective is designed for a focal length of 300$^{m}/_{m}$. The free aperture is 50$^{m}/_{m}$., the ratio of aperture to focal length being consequently 1:6. The angle of view is 90°. The objective consists of five lens elements, the convex concave dispersive lens being composed of the lens L_1 and of the lens L_2 which are connected together along a plane surface. The glass types for L_1 and for L_2 have for D approximately the same refractive index, but the dispersions are different. The front lens system of the objective possesses the larger focal length. The following particulars apply to an objective having a focal length of 100 $^{m}/_{m}$.

Radii of curved surfaces.	Thicknesses and air-gaps.	
$r_1 = +18{,}02^{m}/_{m}$	d_1	$=3{,}37^{m}/_{m}$
$r_2 =$ plane	d_2	$=1{,}42^{m}/_{m}$
$r_3 = +12{,}91^{m}/_{m}$	d	$=0{,}72^{m}/_{m}$
$r_4 = +18{,}14^{m}/_{m}$	d_3	$=1{,}30^{m}/_{m}$
$r_5 = +29{,}64^{m}/_{m}$	$b_1 = b_2$	$=2{,}02^{m}/_{m}$
$r_6 = -17{,}25^{m}/_{m}$	d_4	$=0{,}94^{m}/_{m}$
$r_7 = +25{,}61^{m}/_{m}$	d_5	$=3{,}34^{m}/_{m}$
$r_8 = -18{,}53^{m}/_{m}$		

Glass types:

$L_1 \quad : n_D = 1{,}57190$ $\quad n_G{}^1 = 1{,}58460$
$L_2 \quad : n_D = 1{,}57180$ $\quad n_G{}^1 = 1{,}58643$
$L_3 = L_5 : n_D = 1{,}61650$ $\quad n_G{}^1 = 1{,}63113$
$L_4 \quad : n_D = 1{,}54440$ $\quad n_G{}^1 = 1{,}55971$

In Fig. 3 the objective has a focal length of 300$^{m}/_{m}$. The free aperture is 60 $^{m}/_{m}$. The ratio of aperture to the focal length is therefore 1:5. The angle of view is 80°. The convex concave dispersive lens is composed of the lens L_1 and of the lens L_2 which have different refractive indices as well as different dispersions. The front lens system has a smaller focal length than the rear lens system (L_4, L_5). An objective of a focal length of 100$^{m}/_{m}$. has the following dimensions:

Radii of the curved surfaces.	Thicknesses and air-gaps.	
$r_1 = +16{,}92^{m}/_{m}$	d_1	$=4{,}98^{m}/_{m}$
$r_2 = -54{,}76^{m}/_{m}$	d_2	$=1{,}00^{m}/_{m}$
$r_3 = +12{,}30^{m}/_{m}$	d	$=1{,}80^{m}/_{m}$
$r_4 = +18{,}92^{m}/_{m}$	d_3	$=1{,}98^{m}/_{m}$
$r_5 = +29{,}87^{m}/_{m}$	$b_1 = b_2$	$=2{,}49^{m}/_{m}$
$r_6 = -18{,}92^{m}/_{m}$	d_4	$=1{,}00^{m}/_{m}$
$r_7 = +29{,}87^{m}/_{m}$	d_5	$=6{,}96^{m}/_{m}$
$r_8 = -22{,}90^{m}/_{m}$		

Glass types:

$L_1 : n_D = 1{,}61140$ $\quad n_G{}^1 = 1{,}62503$
$L_2 : n_D = 1{,}55540$ $\quad n_G{}^1 = 1{,}57036$
$L_3 : n_D = 1{,}53080$ $\quad n_G{}^1 = 1{,}54244$
$L_4 : n_D = 1{,}53680$ $\quad n_G{}^1 = 1{,}55503$
$L_5 : n_D = 1{,}61290$ $\quad n_G{}^1 = 1{,}62678$

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. An improved photographic objective composed of two lens systems separated by a diaphragm and having their free concave surfaces directed towards the diaphragm, one lens system consisting of a convex concave dispersive lens and a concavo-convex collecting lens separated from each other by an air gap and turned towards the diaphragm, the other lens system consisting of a biconcave lens and a biconvex lens cemented together along a collective surface, the two lens systems each possessing its own collecting effect, substantially as described.

2. An objective according to Claim 1 wherein the biconcave dispersive lens has a smaller thickness at the centre than the convex concave dispersive lens, substantially as described.

3. An objective according to Claim 1 wherein the biconcave dispersive lens has

a smaller thickness at the centre than the convex concave dispersive lens, which latter is composed of a positive and a negative lens element cemented together, substantially as described.

4. An objective according to Claim 3 wherein the positive lens element is made of glass of smaller dispersive power than the negative lens element, substantially as described.

5. An objective according to Claim 4 wherein the positive and the negative lens element are of substantially equal refracting power, substantially as described.

6. An objective according to Claim 4 wherein the refracting powers of the positive and negative lens elements are different, substantially as described.

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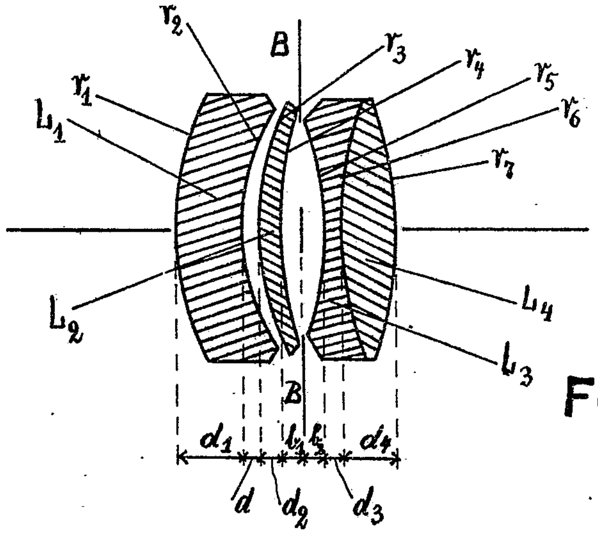

Fig. 1.

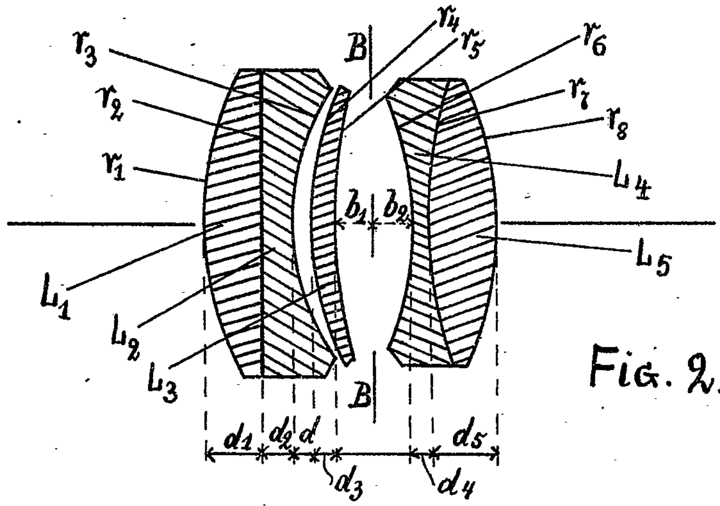

Fig. 2.

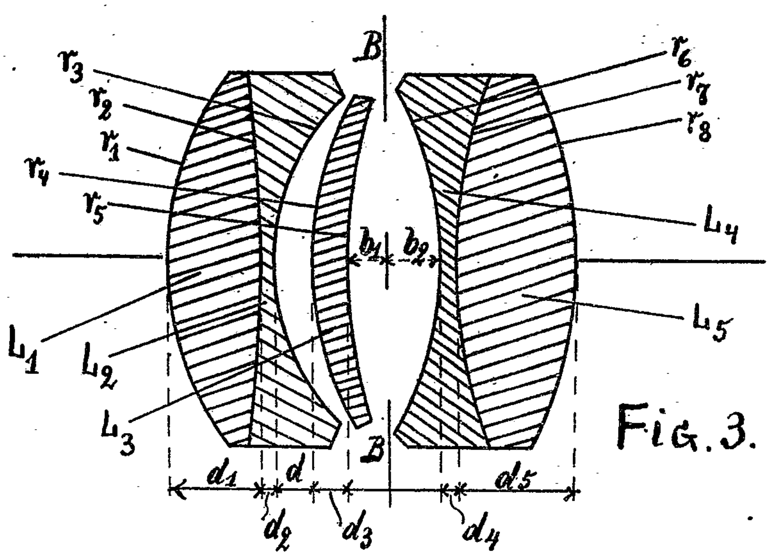

Fig. 3.