PUBLISHED MAY 4, 1943. BY A. P. C.

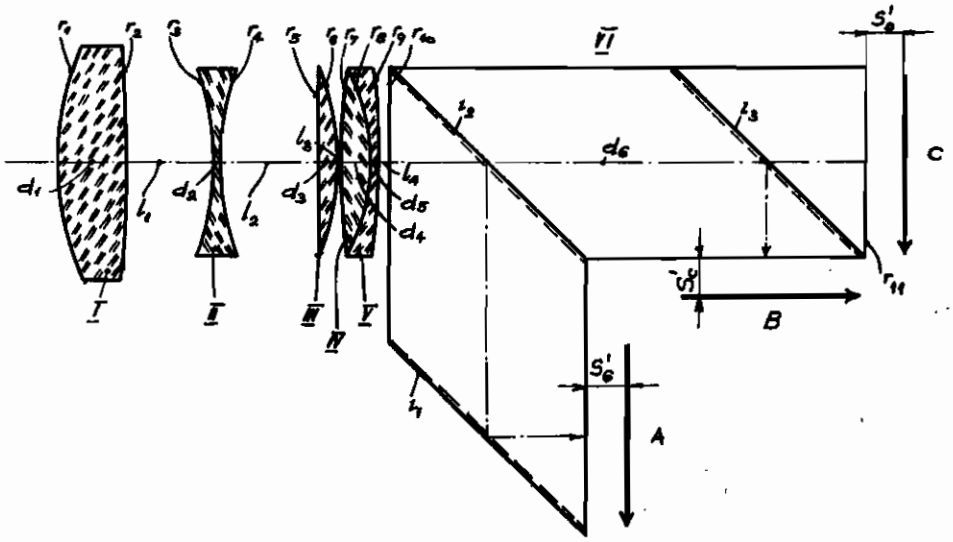
V. SMEJKAL

BRIGHT OPTICAL SYSTEM FOR COLOUR PHOTOGRAPHY

Filed Oct. 24, 1940

Serial No. 362,652

Fig. 1



INVENTOR
Vilem Smejkal

BY E. F. Wendroth

ATTORNEY

Published May 4, 1943 Serial No. 362,652

ALIEN PROPERTY CUSTODIAN

BRIGHT OPTICAL SYSTEM FOR COLOUR PHOTOGRAPHY

Vilém Smejkal, Prerau, Moravia; vested in the Alien Property Custodian

Application filed October 24, 1940

The object of the invention is a very bright optical system for colour photography, particularly for photographic cameras used in three or four colour photography. The system consists of an objective and a prismatic spectral division system in which from the entering rays by passing through reflectors partial beams of light are separated and produce in the respective focal plans partial images.

To get the objective corrected in the focal plane behind the prismatic spectral division system the following conditions are to be compiled with:

1. The chromatic deviations of the intersections must be chosen so that certain of their values be maintained behind the spectral division system in order to obtain a favourable spherochromatic correction.

2. The chromatic deviations of the focal distance must be as small as possible to obtain partial images of as much as possible equal size.

3. The objective must be subcorrected so that the value of the subcorrection corresponds to the value of the subcorrection created by the prismatic spectral division system.

4. The comma and the sine conditions of the objective connected with the spectral division system must be well corrected.

5. The value of the supercorrection of the stigmatism must be such as to be supercorrected with the contrary sign of the spectral division system.

6. The distortion must have positive values because the distortion of the prisms of the spectral division system has negative values.

In the case of hyperchromatic objectives that were used until now in colour photography, the chromatic aberration of magnification is not only maintained but certainly increased, but on account of the spectral division system employed, the aberrations are suitably removed. The well known special hyperchromatic objectives with prismatic spectral division systems had no exact corrections for three or four elementary colours and besides that their brightness was insufficient. Objectives in which before the normal objective of projection a negative optical, chromatically corrected element is set and in which the distance between the two elements corresponds at least to the focal distance of the objective of projection has been proposed, but had the disadvantage that they greatly diminish the brightness of the objective and the optical system had extraordinary dimensions. On account of their small brightness these objectives had not been used in the spectral division system for colour photography.

The disadvantages and wants of objectives until now in use in colour photography have been removed by the special arrangement of the objective which forms the object of the present invention complying with all conditions required from an objective for such purpose i. e. chromatic, spheric, astigmatic correction as well as correction of comma and distortion. This invention is characterized by the ratio of the diameter of the frontal convex surface of the first element of the objective on the side of the object to be photographed and the focal distance of the objective being smaller than 1:2,5. The objective consists suitably of a biconvex lens as first element and a plano-convex lens as third element, the distance of the frontal curved surface of the first element being greater by a third of the focal distance of the objective from the surface of the third element facing the object to be photographed. An advantage of the new objective is its high hyperchromatism together with its easy production and execution, for the second element—a dispersion lens—is of a symmetrical form and the two diameters of the further elements may be equal and one surface is plane. In comparison with all optical systems known up to now, the new optical system offers the advantage of a more precise correction for three or four colours of the partial image i. e. for the red, yellow and blue (eventually grey) colours used in the three or multicolour photography as well as a complete correction of the comma and the distortion. The objective is moreover characterised by its considerable brightness required in colour photography.

In order that the present invention may be clearly understood and readily carried into effect, the same will now be described more fully, by way of example, with reference to the accompanying drawing.

The objective itself consists of five elements having eight surfaces that are in contact with the air. The first element I is a condensing element consisting of a biconvex lens. This lens is made so that the ratio of the diameter r of the frontal convex surface facing the object to be photographed and the focal distance of the objective is no less than

$$1{:}2{,}5 \left(\frac{r_1}{r} < 1{:}2{,}5\right)$$

The second element II is a dispersion element consisting of one biconcave lens. The best results are obtained if the radius of curvature of the beconcave lens II is from 0,5 to 0,7 of the focal distance f of the objective. The third element III is again a condensing element consisting of a plano-convex lens. The last two elements IV and V are joined and form a double condensing element.

The first and the third element (I, III) are placed in such a manner that the distance between the frontal curved surface of the first ele-

ment I and the straight plane of the plano-convex lens III be greater than the third of the focal distance of the objective i. e.

$$d_2+d_1+l_1+l_2>\frac{f}{3}$$

The distance between the frontal curved surface of the condensing element and the frontal curved surface of the biconvex lens II is chosen so as to be greater than a fifth of the focal distance of the objective, i. e.

$$d_1+l_1>\frac{f}{5}$$

The prismatic spectral division system VI placed behind the described objective is provided with the optical reflecting surfaces i_1, i_2, i_3 where the entering beams enter without obstacle into the focal plane, whilst the marginal beams are reflected through the optical surfaces in the direction of the respective focal planes, where all partial beams are of an absolutely equal length. A, B, C represent partial images of equal size of which the image B is reversed with regard to the images A and C.

The values of the optical system for an objective of a great brightness and a focal distance $f=100$ are f. i. the following ones:

$r_1 = 56.37$	$d_1 = 13.4$
$r_2 = 287.8$	$l_1 = 17.1$
$r_3 = 60.82$	$d_2 = 2.2$
$r_4 = 60.82$	$l_2 = 18.5$
$r_5 = 00$	$d_3 = 4.5$
$r_6 = 54.89$	$l_3 = 0.1$
$r_7 = 180.98$	$d_4 = 5.9$
$r_8 = 38.57$	$d_5 = 1.5$
$r_9 = 180.98$	$l_4 = 1.78$
$r_{10} = 00$	$d_6 = 94.31$
$r_{11} = 00$	

Kinds of glasses

I	II	III	IV	V	VI
$D=1,56857$	1,6[illegible]	1,58890	1,588890	1,61300	1,51802
$v=42.6$	36.0	60.5	60.5	37.1	64.4

The exact calculation of the objective gives:

For the line c	$s_C=8.675$	$f_C=100.044$
For the line D	$s_D=8.557$	$f_D=100.00$
For the line G	$s_G=8.189$	$f_G=100.015$

The optical system of the afore mentioned values have then a high apochromacy for the differences of focal distances d do not go beyond 0.3%. A diminution of the chromatic deviation of the intersections may be produced by a spectral division system made of glass and the Abbe-number (v) of which differs from the indicated value.

If v_1 is the Abbe-number of the first element of the optical system and v_2 the Abbe-number of the second element of the optical system and φ_1 the refractivity of the first element and φ_2 the refractivity of the second element of the system, then is the refractivity of the first two elements

$$\frac{\phi_1+\phi_2}{v_1+v_2}$$

This designed and described optical system for colour photography is of course only an example for the execution of this invention and particulars of the system may be altered without going beyond the outlines of the present invention.

VILÉM SMEJKAL.