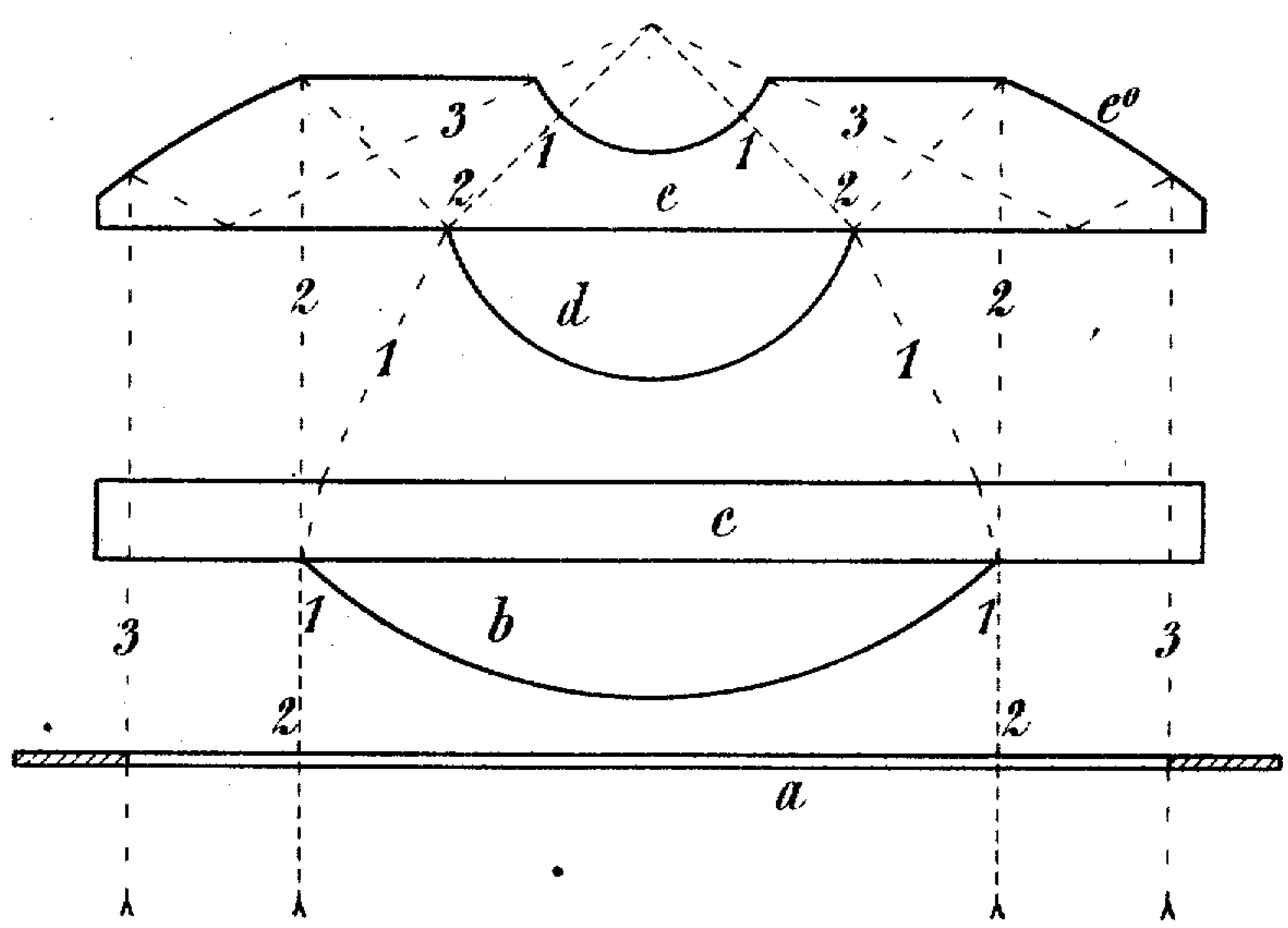
H. SIEDENTOPF.
ILLUMINATING SYSTEM.
APPLICATION FILED APR. 22, 1909.

929,795. Patented Aug. 3, 1909



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UNITED STATES PATENT OFFICE.

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ILLUMINATING SYSTEM.

No. 929,795. Specification of Letters Patent. Patented Aug. 3, 1909.

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To all whom it may concern:

Be it known that I, HENRY SIEDENTOPF, a citizen of the German Empire, and residing at Carl-Zeiss strasse, Jena, in the Grand Duchy of Saxe-Weimar, Germany, have invented a new and useful Illuminating System, of which the following is a specification.

The invention relates to illuminating systems intended for receiving the rays of light on one side as a parallel or weakly convergent or divergent pencil and to transmit them to the other side as a powerfully convergent pencil. This problem has hitherto been solved in a dioptrical way, but in not quite a satisfactory manner, because a multi-composite system is requisite to obtain a tolerable correction.

The present improvement consists in only a core of the pencil obtaining the powerful convergence by refraction, whereas the remaining annular part obtains it by reflection. Thus the illuminating system can be composed of two different, but comparatively simple parts, a central refracting one and a peripheral reflecting one.

In the reflecting system part simple reflection, in fact any odd number of successive reflections, should be particularly avoided for the following reasons. Firstly, the adjustment of the system parts relatively to each other would have to be altered in order to maintain the union of the rays, each time a pencil of rays of a slightly different aperture is employed, because in that case the point of convergence of the rays reflected an odd number of times moves in an opposite direction as the point of convergence of the refracted rays. Secondly, in the annular cone of rays behind the reflecting system part, the order of the rays between the concave and the convex cone surface would be reversed to that in the ring of rays in front of this system part. Two disadvantages would consequently arise. On the one hand, behind the system, the intensity of illumination from the axis to the convex surface of the entire cone would no longer show a continuous course, but would increase in the transition from the core cone of the refracted rays to the annular cone of the reflected rays with a discontinuity. On the other hand an iris diaphragm, which with regard to the powerful convergence of the pencil leaving the system can practically only be laced in front of the system, would indeed, when contracted, begin by stopping down the annular cone, but in a reversed direction, namely, from inside to outside.

The advantage of an even number of reflections would be realized practically in hardly any other manner than by double reflection. The reflecting surfaces are suitably arranged as in Stephenson's microscope condenser for dark ground illumination by giving a glass body producing the first reflection a convex, silvered, annular back surface, but shaping its front surface so as to effect the second reflection with the peripheral part of this surface.

Should the refracting system part be provided with a separate front lens, this latter can be mounted without stopping out any parts of the ring of the rays to be reflected, if it be constructed of two parts and one of these penetrates on all sides outwardly through the ring of rays.

In the drawing a constructional form of the new catadioptric illuminating system is shown in an axial section.

Through the fully opened iris diaphragm *a* there enters a cylinder of rays parallel to the axis, of which 1, 1, as surface rays, belong to the core cylinder of the rays to be refracted, 2, 2 and 3, 3, however, as rays of the concave and the convex surfaces, to the annular cylinder of the rays to be reflected. The core cylinder of rays is refracted by the front lens, which consists of a plano-convex part *b* and a plano-parallel part *c* cemented together, into a weakly converging core cone and the latter by the front surface of the lens *d* into the powerfully converging illuminating core cone. The annular cylinder of rays passes unrefracted through the part of the disk *c*, projecting beyond the lens *b*, and into the disk *e* cemented with the lens *d*. In this disk it is reflected by the silvered part e^0 of the back surface, formed as a zone of a paraboloid, and thereupon undergoes a second, total reflection on the front surface of the disk *e*. As shown the core cone is supplemented by the annular cone into an uninterrupted total cone. This illuminating cone from the disk *e* passes without refraction through a spherical surface concentric to its apex, the cavity of which surface amplifies at the same time the space for the object to be illuminated. Should a more highly refractive medium than air be intercalated between the disk *e* and the object, the plane back surface of the disk *e* does not require to be made discontinuous by a concave exit surface. As regards the refracting system part, it should furthermore be pointed out, that even without increasing the number of glass bodies its spherical correction can be improved and a chromatic correction obtained. For this purpose, besides a suitable selection of the kinds of glass, the construction of one of the two cemented surfaces, perhaps also of the core part of the exit surface of *c*, with finite radius, further a reduction in the radius of curvature of the core part of the exit surface of *c*, and even a deformation of one or the other spherical surface may prove serviceable.

By means of the iris diaphragm *a* it is possible to continuously cut down the annular cone from outside inward and further in the same direction the core cone until each is extinguished.

I claim:

1. An illuminating system constructed to cause a pencil which enters on the one side with parallel rays to emerge on the other side with powerfully convergent rays and comprising a central refracting part and a peripheral reflecting part, the latter comprising an even number of reflecting surfaces.

2. An illuminating system constructed to cause a pencil which enters on the one side with parallel rays to emerge on the other side with powerfully convergent rays and comprising a central refracting part and a peripheral reflecting part, the latter being a glass body which comprises two annular reflecting surfaces, one a back surface and the other a front surface, and the back surface being convex and silvered.

3. An illuminating system constructed to cause a pencil which enters on the one side with parallel rays to emerge on the other side with powerfully convergent rays and comprising a central refracting part and a peripheral reflecting part, the refracting part including a separate front double lens, one of the components of which extends through the annular space of the peripheral rays to be reflected, the reflecting part being a glass body which comprises two annular reflecting surfaces, one a back surface and the other a front surface, and the back surface being convex and silvered.

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