and two stopcocks is 22 cm. The dimensions of the lever arms are 10 and 60 cm, respectively. The total length of these sylphons is 16 cm.

[1]A. B. Mlodzeevskii, Lektsionnye demonstratsii po fizike (Demonstration Lectures in Physics), vol. 1, Molecular Physics and Thermodynamics (Gostekhizdat, Moscow, 1948).

Translated by R. T. Beyer

LIGHT TRANSMISSION METHOD OF OBTAINING A PICTURE OF FRESNEL INTERFERENCE IN WHITE LIGHT

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A Fresnel interference field is produced in that part of space within whose limits the overlapping light beams are coherent. An important condition for obtaining such a field from an extended light source is the maintenance of the coherence relation. The latter makes it possible to establish the relation between the maximum permissible width of the source b_0 and the size of the interference aperture $2u_0$ which characterizes the arrangement. This dependence can be written in the form

$$b_0 \sin 2u_0 = \frac{\lambda}{2}. \qquad (1)$$

The luminous intensity of the interference pattern, localized within the limits of a certain area of the observation screen, depends of the light flux Φ_0 distributed over this surface. The value of the flux Φ_0 is proportional to the brightness and the width of the light source used. If the given arrangement is characterized by a sufficiently small interference aperture, then, in accord with Eq. (1), a broad light source can be used for the production of a three-dimensional interference field here, and consequently, an interference picture can be obtained which has a high mean illumination. The dimensions of the picture on the screen, for a fixed position of the latter, depend on the angular size of the region of overlap of the coherent light beams, Δi. To obtain an interference picture of significant size, it is important that the quantity Δi be sufficiently large. Such an arrangement for which the interference aperture is sufficiently small and the angular size of the overlap of the interfering light beams is appreciable makes it possible to obtain a bright and extended picture. These two factors characterize the situation from the viewpoint of light intensity.

On the other hand, to obtain a picture of chromatic interference fringes from a white light source, it is necessary that a set of first order interference fringes be produced in the overlapping region of the coherent beams, i.e., that the path difference of the interfering rays be sufficiently small.

In the effective experiment of R. W. Pohl for obtaining overlapping light beams, a thin mica sheet is used. In Pohl's arrangement, the interference aperture is so small that there is a possibility of satisfying condition (1) by using a light source as broad as several centimeters! The interference picture in this case is a combination of rings of higher orders of interference (for $d = 50\,\mu$ we have $250 < k < 320$, for $\lambda = 5000$ A). Therefore, a picture can be observed on the screen only by use of a monochromatic light source and, in the case of white light, by using a light filter with a sufficiently narrow pass band ($\Delta\lambda \le \lambda/k$).

The only example of a setup which makes it possible to obtain a bright and extended picture of the interference fringes from white light that we could mention is apparatus consisting of two plane-parallel glass plates clamped together so that a very thin air wedge is produced between them with a small angle $\alpha \cong 10^{-4}$ rad (R. W. Pohl). To obtain interference fringes of correct geometric shape in such an arrangement it is important that the contacting plane surfaces of the plate be sufficiently well polished. No less important is a good mechanical clamping of the plates.

The proposed high-transmission system differs in that it makes it possible to use a thick layer with a small working surface area. It is less sensitive to the degree of polishing of these surfaces and does not require good mechanical clamping of the parts of the apparatus. The arrangement is shown to have higher optical transmission, inasmuch as the mean intensity of the light flux in the overlapping region contains in reflected light a significantly larger part of the primary flux intensity than is the case for an air wedge.

The idea of the apparatus is simple enough. It is well known that the path difference between rays which interfere at an appreciable distance from a thin plane parallel layer can be expressed in the form

$$\Delta = 2\,dN_0 \cos r\left(\pm\frac{\lambda}{2}\right), \qquad (2)$$

where d and N_0 are respectively the thickness and the absolute index of refraction of the layer, while r is the angle of refraction of the rays at the first boundary of the layer and is obviously equal to the angle of incidence on the second boundary.

If the layer has a lower optical density than the surrounding medium, then, with an appropriate geometric form of the more dense medium in a diverging light beam, the angle r can take on all possible values from 0 to 90°. For r close to 90°, cos r has a correspondingly small value. In this case, Δ also remains sufficiently small for an appreciable increase in d. Consequently, there is a possibility of obtaining an interference picture from a source of white light by making use of a layer of comparatively great thickness. The increase in the thickness of the layer obviously brings about an increase in the interference aperture $2u_0$. Calculations lead to the conclusion that $2u_0 \sim d/\cos r$. By taking it into account that the increase in d must be compensated by a corresponding decrease in cos r in the arrangement under consideration, it can be concluded that $\cos r \sim 1/d$ and consequently $2u_0 \sim d^2$. Furthermore, the angular region $\Delta i'$ within which the interfering rays have a sufficiently small path difference decreases. The value of this angular region, just as the value of b_0, is seen to be proportional to $1/d^2$. Thus the permissible thickness of the plane parallel layer is limited by the requirements of optical transmission. However, even at $d = 5\,\mu$ (i.e., for a thickness which is not less than 5 times the mean thickness of the part of the air wedge used in working with a white light source), a source of width $b_0 \cong 1$ cm can be used. The angular region $\Delta i'$ is here such that the width of the interference spectra on a screen at a distance D = 3 m from the layer amounts to several centimeters on the average. Upon further decrease in d, both quantities (b_0 and $\Delta i'$) increase rapidly. Inasmuch as this arrangement corresponds to large values of the angle of incidence on the boundary of the layer, the reflection coefficients have an appreciable value. Change in the thickness of the layer leads to a change in the angles of incidence corresponding to the spectrum of given order. Moreover, the reflection coefficients are changed; consequently, the ratios of the intensities of the interfering light fluxes are also changed. The interference picture is contrasty and the spectra are in saturated colors when the intensities of the interfering fluxes do not differ appreciably. The arrangement makes it possible to satisfy this requirement in reflected light. In transmitted light, the intensities of the interfering fluxes differ appreciably. However, this difference is not as large as for other arrangements. Therefore, it is possible to obtain a picture of sufficiently good quality in transmitted light.

The apparatus for demonstration is a combination of two glass prisms; the cross section of the prisms has the form of an isosceles triangle with the base angle equal to the angle of total reflection of the given kind of glass for the short wave limit of the visible portion of the spectrum. One can use reversing prisms for this purpose. Two such prisms, which are first accurately ground, are attached on their large surfaces and slightly lapped. In this case, a compound prism is formed, with the base in the form of a rhombus and with a thin air layer along the diagonal cross section (Figs. 1 and 2).

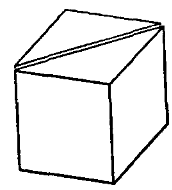
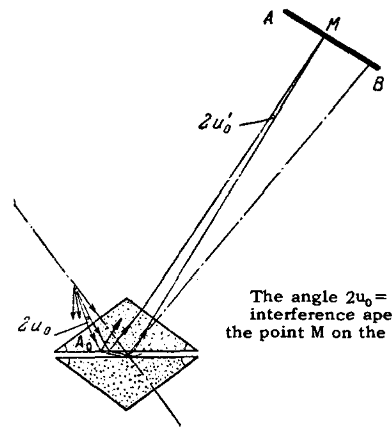


FIG. 1



The angle $2u_0 = 2u_0'$ is the interference aperture for the point M on the screen AB.

FIG. 2

A beam of light from a sufficiently intense source is collected by means of a condenser (preferably of high quality) near the middle part of the face prism surface facing the source. The apparatus is so arranged that the axis of the beam, which passes through one-half of the compound prism, is inclined to the normal to the forward surface of the layer at an angle that is close to the angle of total internal reflection i_0. Rays incident at a smaller angle $i \leq i_0$ are separated in the layer, as a result of which intersecting beams are formed both in reflected and transmitted light. The part of the split beam for which $i_0 - i \leq \Delta i'$ takes part in the formation of a three-dimensional interference field which is accessible to observation in work with a white light beam.

On a screen placed perpendicular to the axis of the reflected beam of light, the illumination field has the form of a circle that is divided into two parts: a bright part, which is produced as the result of total reflection, and a shaded part, corresponding to partial reflection from the boundaries of the layer. Upon slight com-

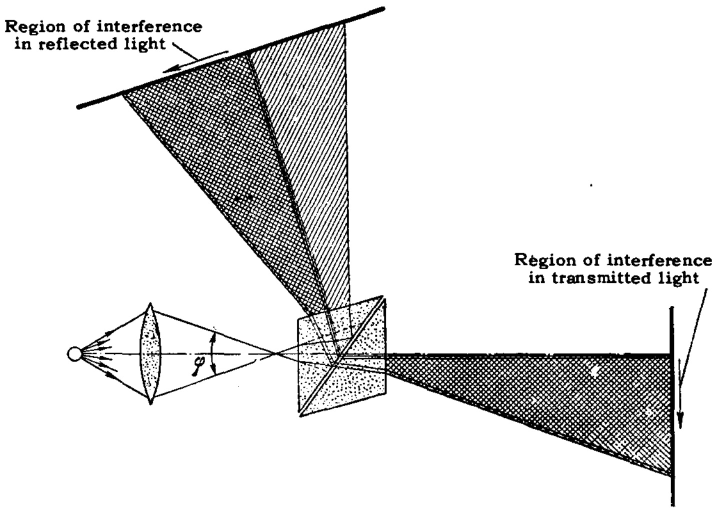


FIG. 3

pression of the two halves of the prism against each other, first-order interference spectra appear, whose width, brightness, and saturation with spectral colors depend on the degree of compression. The separation boundary is dark, since the path difference of the rays which interfere in the boundary region, ($i \cong i_0$, $r \cong 90°$). in accord with Eq. (2), is close to $\lambda/2$. The result of the interference, for a definite thickness of the layer, depends on the value of the angle r. Therefore the interference fringes are reminiscent of curves of equal inclination. The dark boundary of separation, just as the fringes, has the form of an arc of large radius. For a fixed position of the screen, the dimensions of the illuminated field and the corresponding longitudinal dimensions of the interference fringes are determined by the value of the angle φ (Fig. 3).

Description of the demonstration. Entirely satisfactory results were obtained by using two standard reversing prisms made for demonstration purposes (light crown, length of edge 4 cm). A 300 watt (110 v) movie projector lamp served as the source. An achromatic condenser was set up such that $\varphi \cong 35°$. To increase this angle, it is advisable to use two condensers in series. In this case it is advantageous to limit somewhat the width of the light beam. The apparatus was so prepared that the interference region occupied approximately one half of the illuminated field on the screen. If no interference spectra are seen, this means that the air gap is too large. By exerting several successive small compressions and expansions of the prisms comprising the apparatus, it is not difficult to select the most appropriate thickness of the layer. The demonstrator carries out this operation by holding the apparatus in his hands behind a frosted glass and observing the illuminated field on the screen. A bright spectral picture in reflected light corresponds to a sufficiently bright picture in transmitted light, too. The interference spectra are observed in practice for any separation of the screen from the apparatus and it is obvious that in this case the use of an objective for focusing the picture is not required. Spectra of good quality can be obtained with prisms of very small dimensions. For example, we used for this purpose two prisms with hypotenuse surfaces that did not exceed 1.5 cm.

On a screen at 3 m distance from the apparatus, the illuminated field has a diameter of about 2 m (for $\varphi \cong 35°$). It is necessary that the interference spectra of the first four or five orders fill a significant part of the field of view. One can obtain spectra of width 20—30 cm each.

With the use of a nearby screen, for example, at a distance of 0.3 to 0.5 m from the apparatus, the dimensions of the picture are proportionately reduced, and its illumination correspondingly increased in inverse proportion to the square of the distance. In this case the picture is easily visible even without a darkened auditorium.

This arrangement makes it possible to carry out a demonstration of interference spectra even from a very weak light source. Successful results are obtained with a small 6 v lamp, and even with one of 3.5 (2.5) v! No condenser is used in this experiment. The lamp is covered by a tin hood to screen the auditorium from direct rays and to decrease the harmful light scattering. The apparatus is mounted close to the light and the screen is located at a distance on the order of 20 cm in the corresponding direction. The characteristic features of the demonstration are similar to those given above. Upon adequate darkening, the experiment performed on such an apparatus can also be shown to a large auditorium.

Translated by R. T. Beyer