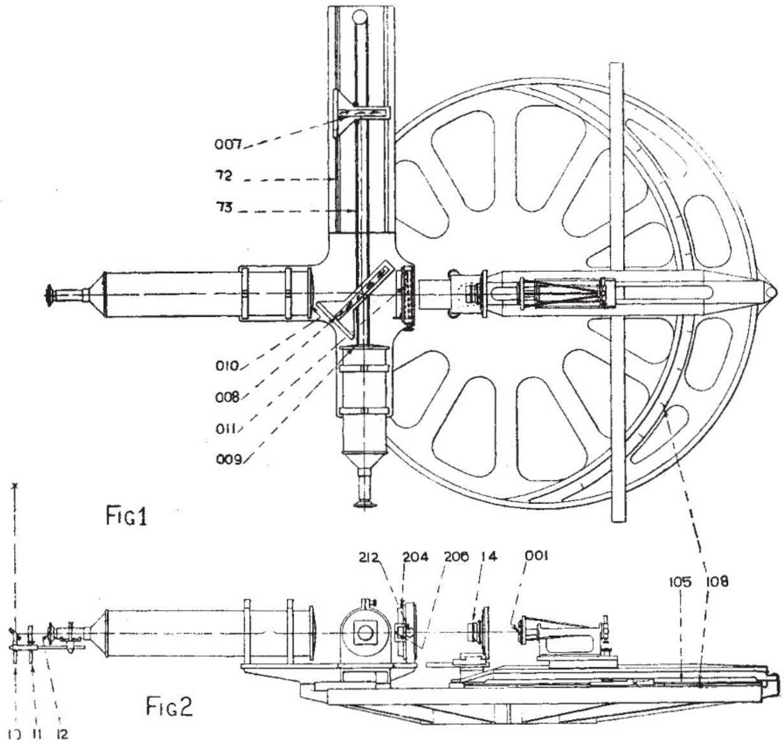
An Interferometer for Testing Camera Lenses.[1]

INTERFEROMETERS for the testing and correction of prisms and of lenses (for axial pencils) have been described in the *Philosophical Magazine* (vol. xxxv., January, 1918, p. 49). In its simplest form the instrument resembles the well-known Michelson interferometer, the essential optical difference being that the two interfering beams of light are brought to a focus at the eye of the observer. The principles of the prism interferometer have been applied to photographic lens testing in the camera lens interferometer recently constructed by Messrs. Adam Hilger, Ltd. A plan of the instrument is shown in Fig. 1, and a side elevation in Fig. 2. Light from a suitable source is reflected by a mirror 10 into the interferometer. A convex spherical mirror 001 is so disposed that its centre of curvature coincides with the focus of the lens 14 which is under test. In these circumstances, a beam the wave-front of which is a plane perpendicular to the axis of the lens will, after passage through the lens, be reflected back on its own path by the convex mirror, and if the lens be free from spherical aberration the reflected beam will, after passage through the lens, once more have a plane wave-front. If it has not, then the departure from planeness will produce interference bands which form a contour map of the corrections which will have to be applied to the lens to make its performance perfect.



FIGS. 1 and 2.—Plan and side elevation of lens interferometer.

An apparatus which will test for axial pencils only is, of course, of little use for testing camera lenses. The modifications essential for the latter purpose are (1) means of rotating the lens about a line at right angles to the axis and passing through the second principal point, and (2) mechanism whereby, simultaneously with the above rotation of the lens, the convex back-reflecting mirror is automatically moved away from the lens in such a way that its centre of curvature always falls on the plane, perpendicular to the axis of the lens, on which the lens is desired to form its image. The rotation of the lens carriage is effected by means of a bar 105 parallel to the axis of the lens and extending to the outer edge of the interferometer. The second requirement is fulfilled by a flexible connection being led from the carriage on which the mirror is adjustably mounted and over a pulley to a weight, and by there being upon the carriage a roller which by the action of the weight is retained in contact with a cross-bar mounted on the axial bar 105 and at right angles to it.

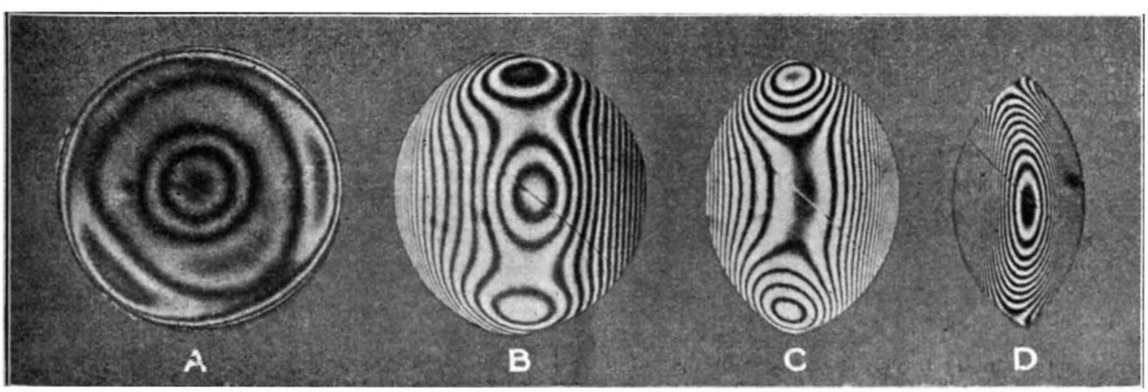


FIG. 3.—Interferograms of a photographic lens for axial and oblique beams.

[1] Abstract of a paper read before the Optical Society on April 14 by F. Twyman.

Adjustments are provided for bringing the second principal point of the lens under test on to the axis about which it is rotated by the bar, and also for bringing the centre of curvature of the mirror exactly on the axis of the roller above-mentioned and on the optical axis of the lens. The distance from the centre of the roller in the axial position to the axis of rotation of the lens is measured by a vernier. When all adjustments have been made, this vernier gives the focal length of the lens to an accuracy of about 0·001 in.

The apparatus measures the degree to which the wave-front, impressed by the lens on light from a distant point source, differs from a spherical wave-front. The indications are given in aberrations of wave-front to a scale of wave-lengths, the aberration shown being in every case twice that present in the once transmitted beam which normally forms the image of a distant point. The form in which the indications are presented is that of a series of interference fringes which are lines of equal aberration of wave-front. These interferometer pictures can be translated into terms of geometric optics by an observer who has had a little practice with the instrument. The various types of aberration and their chromatic variations produce characteristic interference patterns, and thus they can be readily differentiated and measured in terms of wave-length. By means of the pair of deflectors 011 a measurement of the distortion can also be obtained.

With a suitable source of light and a suitable camera the interference patterns can be photographed, and a complete photographic record can be obtained of the performance of any camera lens. Fig. 3 is a photographic reproduction of the interferograms of a well-known lens of high repute for the green mercury radiation ($546\mu\mu$) for the axial beam and for obliquities of 5°, 10° and 15°. It will be seen that even the best photographic lenses—of which this is a fair example—are very far indeed from perfection.

Mutations and Evolution.

IN the series of articles by Dr. Ruggles Gates appearing under the above title in a *New Phytologist* Reprint (No. 12), published by Messrs. Wheldon and Wesley, Ltd., we have the most recent attempt to present a reasoned and comprehensive statement of the problem of evolution. As the author tells us, his aim has been to show that though germinal (by which apparently we may understand chromosomal) changes are of importance in the evolutionary process, they cannot be considered as all-sufficing; that only from the Neo-Lamarckian point of view is it possible to explain a large class of organic phenomena. From this point he sets out to show how the Darwinian doctrine and Mendelian conceptions in combination may furnish us with a solution. To this end, however, it scarcely seems necessary to maintain, as the author is at pains to reiterate, that in the application of Mendelian principles we are merely putting into use a refinement of the theory of natural selection. Nor does any point appear to be gained by this insistence on accord, since, by the author's own showing, the underlying difference between Darwinism and Mendelism—the difference, namely, between the idea of continuity and discontinuity—is profound enough to have divided biologists into two opposite camps. One feels that what is common ground might more easily be made apparent if an attempt were made to define more strictly, or else to abandon, terms which are used to cover an ever-increasing complex of ideas. It will be obvious, for example, that a fresh analysis of evolutionary processes should be couched in terms which clearly differentiate the causes (=true factors) to which variation is presumably due from the mechanism by which variations, once having appeared, are perpetuated, and from conditions which permit or limit the occurrence of variation. That the author evidently has in mind the necessity for precision in this connection appears from the fact that he is careful to point out that isolation due to geographical barriers must be regarded as a *condition*, and not as a *factor*, yet he fails to draw this distinction when dealing with natural selection.

The important point which Dr. Gates seeks to establish is that a new character may arise in *two* different ways: (1) as the result of what we have still to term *spontaneous* nuclear (=karyogenetic) mutations; (2) from a so-called organismal change, *i.e.* a change due either to environmental effects on the cytoplasm or to the morphological principle known as orthogenesis. In the first case the mutation is perpetuated through the *whole* cell-lineage, and the associated character is inherited as a unit. In the second *a localised region or a particular stage in the life-cycle* only is usually affected. Perpetuation of an organismal modification connotes the inheritance of acquired characters.

Mutations.—The more striking observations of Morgan and other American workers on Drosophila and of de Vries, the author, and others on Œnothera, which indicate a direct relation between chromosomal behaviour and somatic appearance, are set forth. Definite zygote characters are shown to be constantly associated with definite irregularities in the meiotic division, as, *e.g.*, the *lata* habit in Œnothera with the presence of an extra chromosome. The author brings forward evidence of independent sporadic appearances of this form, and a parallel mutation has been obtained in cultures of other Œnothera species. In every case the number of chromosomes was found to be 15 instead of the typical complement 14. The occasional occurrence of an 8–6 instead of a 7–7 separation of the chromosomes in another mutant form supplied the clue to the mode of origin of these 15-chromosome forms. In another instance a particular strain of Drosophila, indistinguishable in general from the normal but showing an aberrant type of inheritance, led Bridges to infer the duplication of a sex-chromosome—a prediction which later investigation proved to be correct. These forms with an extra chromosome are found seldom, if ever, to breed true. Their importance, according to the author, lies in the support which they give to the conception of the origin of a zygotic character from a nuclear mutation rather than in their significance in evolution. It is held to be otherwise, however, when the whole chromosomal equipment is duplicated (tetraploidy) and associated with a characteristic giant habit as in Primula and Œnothera.

The separate class of Mendelian mutations is regarded as due also to a nuclear change (in this case possibly chemical) which is presumed, however, to affect only a particular locus or element in the chromosome. It is clear, however, from Bridges's observation cited above, and from Heribert-Nilsson's work on Salix (which the author does not discuss), that, on one hand, duplication of chromosomes *need not* be accompanied by any gross change in the organism, and, on