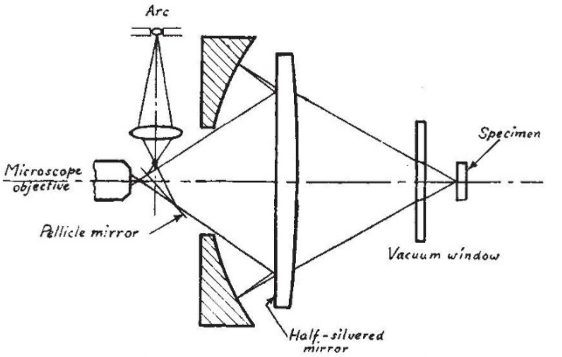
A Unit-Magnification Optical System with Long Working Distance for Microscopical Applications

OCCASIONS frequently arise in microscopy where a working distance much greater than that given by conventional objectives for a given numerical aperture is required. This occurs in the microscopy of hot metallurgical specimens inside a vacuum furnace, the examination of electrode conditions inside a vacuum tube, various biological applications, and the examination of nuclear plates which may involve working through considerable thicknesses of glass and emulsion.



A system designed to meet the conditions of the metallurgical problem outlined above is illustrated in the accompanying diagram. A concave spherical mirror is placed so that the object is nearly at its centre of curvature. Light from the object passes through a half-silvered plane mirror and falls on the concave mirror nearly at normal incidence, is reflected back to an image nearly coincident with the object, and is reflected a second time by the half-silvered mirror to form an image behind the concave mirror, which is perforated to allow the image thus formed to be examined by a conventional microscope objective.

The side of the half-silvered mirror nearer the object is worked to a weak convex curvature which enables the spherical aberration due to the vacuum window and to the half-silvered mirror plate itself to be corrected without introducing significant coma. By this means a numerical aperture of 0·5 can be obtained, corresponding roughly to an 8 m./m. microscope objective.

An experimental system has been made giving approximately this aperture with a working distance of about 34 m./m., as against the 2 m./m. of an 8 m./m. objective. Due to parasitic reflexions, a vertical illuminator cannot be used in the observing microscope in the usual way. Vertical illumination can be obtained by placing a thin half-silvered pellicle mirror at 45° in the beam converging to the final image, and reflecting light into the system as shown. An unwanted image of the light source is formed by two reflexions at the half-silvered mirror and one at the concave mirror; the system is so disposed that this image is displaced about 3 m./m. along the axis away from the image of the specimen. The hole in the centre of the out-of-focus image of the light source, due to the perforation in the concave mirror, then occupies the whole field of the observing microscope, and the image of the specimen is not obscured.

An immersion system using the same principle, with the concave and plane mirrors formed on two sides of a glass block, has been designed for nuclear plate work. This uses a 4 m./m. objective and attains a numerical aperture of 0·75, enabling the examination of nuclear tracks through a quarter of an inch or so of glass. It is small enough to be used on a conventional microscope.

A water immersion system for biological applications has also been designed.

A fuller description of these systems, together with the theory of the corrections, will be published elsewhere.

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Showers Generated in Lead by Mesons

THE main source of secondary electrons produced by mesons at sea-level is the close ionizing collision in which considerable kinetic energy is transferred to the electron concerned, and from which a small cascade develops.

Many workers have observed such showers using a thickness of dense material greater than 30 cascade units in order to be sure that electrons coming from the air are excluded, and that equilibrium is reached between the meson beam and its electron secondaries[1,2]. The results obtained in this way generally agree; but with smaller collision layers, when the transition effects at the entry into the dense medium have not yet become stabilized, the agreement between different workers is not so satisfactory[3,4,5].

Clay and Venema[4] have measured the absorption of incident electrons but not the transition effect of the layer; Stuhlinger[3] has carried out correction measurements, the principle of which is certainly good, but which are not quantitatively comparable with his original data, since the area of the layer in

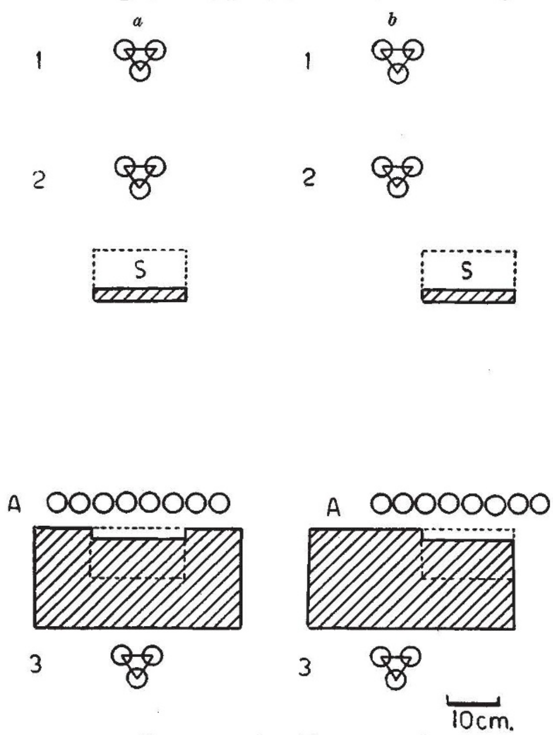

Fig. 1. Experimental arrangement