CCXXIII.—*The Study of Moving Flames.*

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DURING researches on the propagation of flame in gaseous mixtures methods of photography have been developed in the laboratories of the Safety in Mines Research Board which depend upon the abrupt change in the optical properties (refractive index) of a gas mixture at the surface of a flame passing through it. A method depending upon the same principle has recently been described by A. G. White (this vol., p. 1159). It is therefore considered desirable to place on record brief descriptions of the two methods which we have been using during the past few years. Such methods should prove of value to other workers.

It was first suggested by Foucault (" Annales de l'observatoire imp. de Paris," Tome V) that changes in the optical properties of glass caused by flaws could be followed by the refraction of a beam of light passing through the glass. This suggestion was applied to the similar problem of refraction in air, by Töpler in his Schlierenmethode (*Ann. der Phys.*, 1867, **131**, 33) and by Dvŏrák in his "shadow method" (*Ann. der Phys.*, 1880, **9**, 502). Both these investigators recorded the effects they obtained photographically.

The methods developed in these laboratories for determining the speeds of flames and examining their mode of propagation are based on those of Töpler and Dvŏrák. Two cameras are in use. The first, which we have designated the "flame-speed camera," utilises Dvorák's method. It is of limited application, being of chief use for the photography of slowly moving and feebly actinic flames. The second, which we term the "wave-speed camera," is based on Töpler's method and has been used with success for the photography of both slowly and rapidly moving flames, whether feebly or strongly actinic, as well as of movements of invisible compression waves which are sent out by rapidly burning mixtures. The "wave-speed camera" has been described in detail in Safety in Mines Research Board Papers Nos. 18 and 29, 1926.

Both cameras make use of a revolving drum around which the photographic film or paper is stretched, and special means of synchronising the time of exposure with the moment of passage of flame across the field of view have been designed. Both cameras have been arranged so that a direct photograph of the flame can be obtained of exactly the same size as the refraction photograph, when the flame is sufficiently actinic. The two photographs of one explosion are often of great assistance to each other in interpreting the results obtained.

The flame-speed camera. With the flame-speed camera the method used differs but little from that described by White. A diverging beam of light from a powerful mirror-arc lamp is passed through a small orifice (to provide a point source of illumination) and through the explosion-vessel containing the mixture to be inflamed, whence it passes to the camera drum. In order to obtain a photograph of a sufficient length of explosion vessel without using too wide a film, a simple plano-convex condenser, 20 cm. in diameter, is placed between the explosion vessel and the photographic paper, so that a reduction to approximately one-quarter natural size is obtained.

The wave-speed camera. The wave-speed camera is more complicated, but it has the advantage that it can be used for the photography of all kinds of flames and shock-waves, and may be used in an undarkened room. Where the flame is sufficiently actinic it is recorded on the film simultaneously with the refraction photograph. A converging beam of light is used—namely, the beam from a mirror-arc lamp reflected by means of a concave mirror. This reflected beam is focussed on the lens of the camera, a diaphragm on which serves to separate refracted from non-refracted light.

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