XLII.—*The "Uniform Movement" of Flame in Mixtures of Hydrogen and Air.*

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THE measurement of the speed of the so-called " uniform movement " * of flame in gaseous mixtures has been found to be of considerable value as affording an indication of the relative rates of inflammation of different mixtures. The earlier methods of measuring this speed, which is not great in the majority of mixtures of inflammable gases with air, have usually depended upon the electrical registration of the time of fusion of fine screen-wires stretched at measured intervals across the tube in which the flame travels. This " screen-wire " method of measurement, although sufficiently accurate in experienced hands, is clearly not to be compared as regards general usefulness with the photographic method of analysing the movement of flames, using a rapidly revolving drum, which Professor H. B. Dixon has developed; for the latter method enables any slight variations in the speed of the flame from point to point along the tube to be detected, and ensures that if, as in the present instance, the speed of the uniform movement alone is required, no other phase in the propagation of flame (such as the " vibratory movement " which immediately succeeds the uniform movement) shall be included in the measurements, a matter which is sometimes by no means easy to arrange when the screen-wire method is used.

In connexion with other researches that are being carried out in these laboratories, it became necessary to obtain strictly comparable measurements of the speed of uniform movement of flame in mixtures of different inflammable gases (including hydrogen) with air, and it was decided to use the photographic method throughout. Photographic registration of the feebly actinic flames during the uniform movement in hydrogen–air mixture has presented considerable difficulty, but we have recently succeeded in obtaining satisfactory records, over a fairly wide range of mixtures, by using a tube of transparent quartz and photographing the flames through a quartz lens on Lumière bromide paper of special sensitivity. The outside of the tube was partly covered with black paper, leaving a horizontal slit 7 mm. wide throughout its length.

The quartz tube, which was 90 cm. long and of 2·4 cm. internal

* The uniform movement occurs when the inflammable mixture is contained in a horizontal tube, closed at one end and open at the other, and is ignited at the open end. It is usually maintained over about one-third of the length of the tube.

diameter, was supported horizontally and, as a precaution in the event of the detonation-wave being set up, was attached to a straight extension piece of lead piping, closed at the far end. The open end of the tube was provided with a flange, and a flanged cover, fitted with a tubulure and tap for the introduction of the explosive mixture, could be clipped thereto (see J., 1914, **105**, 2609). This cover was removed by gently sliding it upwards just before igniting the mixture, which was effected by passing a large flame comparatively slowly across the now open end of the tube. In this way, mechanical disturbance of the mixture at the moment of ignition was avoided and the mixture was ignited exactly at the open end. Unless these precautions were taken, and the same procedure adhered to rigidly, it was found that the " uniform movement " was not maintained over an appreciable distance of travel of the flame, or varied in speed from one experiment to another with a mixture of the same composition. Although precautions of the character described are required with all inflammable mixtures if accurate results are to be obtained, the uniform movement in mixtures of hydrogen and air seems to be particularly sensitive to extraneous disturbances.

Photographs were successfully obtained of the flames moving in mixtures containing between 20 and 50% of hydrogen. On either side of this range the records were too faint to measure. With each mixture three photographs were taken of successive lengths of 26 cm. of the tube, whence a composite photograph, showing the flame as it travelled from the open end over a distance of 79·5 cm. towards the closed end, was obtained. Typical photographs, reduced in size for reproduction, are shown on Plate I.

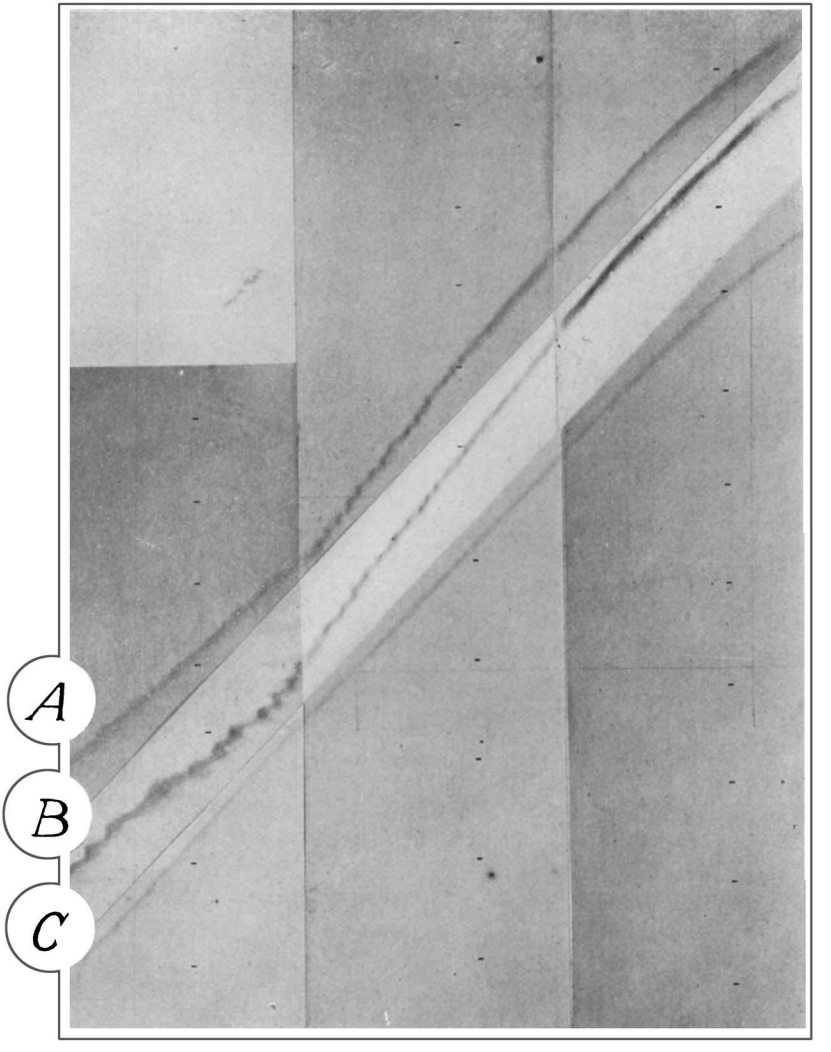
On close analysis of the movement of the flame, it was found that, in each mixture, its speed fluctuated during the first 26 cm. of travel, remained reasonably uniform over the next 26 cm.,* and then decreased slightly, antecedent to the vibratory movement, within the next 26 cm. We have therefore recorded, as the speed of " uniform movement " in the mixture concerned, that obtaining over the distance 29—55 cm. measured from the open end of the tube. Typical photographs of flames travelling in different mixtures over this section of the tube are reproduced in Plate II. The general results are recorded in Table I.

Apart from the anomalous results obtained with the 23·9 and 24·95% mixtures, which we are unable completely to explain,†

* Faint undulations that made their appearance during this period did not affect the mean speed of the flame.

† The vibratory movement apparently started earlier with these mixtures than with the others.

PLATE I.



The propagation of flame in mixtures of hydrogen and air.
A. 26·95%. B. 30·95%. C. 41·70%.

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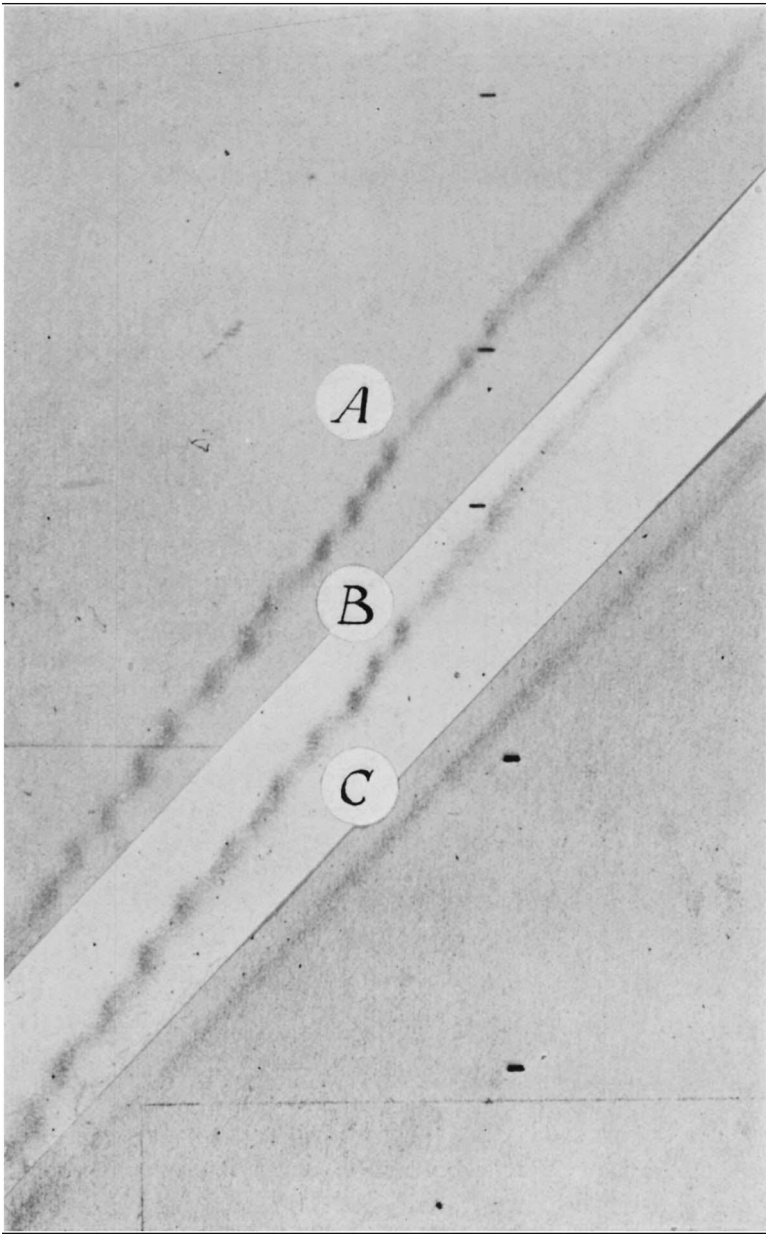
PLATE II.



The uniform movement of flame in mixtures of hydrogen and air.
A. 26·95%. B. 30·95%. C. 41·70%.

TABLE I.

The Uniform Movement of Flame in Mixtures of Hydrogen and Air.
(Tube 2·4 cm. in diameter.)

Comp. of mixture (hydrogen %).	Speed of uniform movement (cm. per sec.).	Comp. of mixture (hydrogen %).	Speed of uniform movement (cm. per sec.).
20·30	320, 323	36·70	474, 464
23·90	437, 414	37·50	520
24·95	462	40·45	478, 472
26·95	371, 362	41·70	501, 493
30·95	424, 418	45·45	433, 434
33·30	462, 461, 436	49·65	395, 393
34·90	501, 491		

these figures are comparable with those recorded by Haward and Otagawa (J., 1916, **109**, 83), when using a glass tube of 2·5 cm. internal diameter and measuring the mean speeds of the flames over the distance 10—50 cm., from the open end, by the screen-wire method.

A future communication will deal with the speed of the uniform movement in hydrogen mixtures in which the nitrogen of the air has been replaced by either argon or helium. A striking feature of the results is the high actinic value of the flames.

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