On the Moving Striations in a Neon Tube.*

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The following paper is the continuation of the account of experiments on the moving striations in neon tubes already communicated.† In the previous experiments the discharge was excited by an induction coil, but in these direct current was used and the magnitude of the current was under control.

Three Geissler tubes (A, B, C) were used, diameters of the capillary parts were respectively 2·2 mm., 1·41 mm. and 1·27 mm., their lengths being 10·8 cm., 7 cm. and 8·5 cm. These tubes (A and B) had auxiliary platinum wire electrodes at the ends of the capillary parts of the tubes to measure the drop of potential along that part.

The rotating mirror and the telescope were set practically the same as in the previous experiments. The distance from the tubes was about 2 metres and the rotation of the mirror was 200—1000 revolutions per minute. The method of measuring the velocity and the arrangement of the pump, etc., were the same as before.

A cabinet of 500 small accumulators was used as the source of the current with an adjustable water rheostat in series with the tube to control it.

Care was taken to obtain the neon gas as pure as possible, but in the gas used there was some evidence of mercury vapour and traces of hydrogen. When these impurities were less than a certain amount, no appreciable difference in the behaviour of the moving striations seemed to result from their variations. It seems probable that the effect of the impurities is rather secondary and the main results are the same as in pure neon.

The Three Types of Moving Striations.

In the case of tubes used there are three typical forms of striations all of which move toward the cathode.

The first type is what was observed in the previous experiments with an induction coil. The striations are very distinct and distant from each other, *i.e.*, in the case of tube A, about one striation per centimetre, and for tube B two or three striations per centimetre. They move with fluctuating velocity, forming a wavy pattern when observed through the rotating mirror. Also, when the current is small their mean velocity is not constant; it is less near

* This paper was prepared by Mr. T. Kikuchi before his fatal illness.—E. R.

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the anode end, but when the current increases the mean velocity becomes nearly the same throughout the tube. Their velocity decreases as the pressure of the neon increases, but it is in general nearly independent of the current. In smaller tubes when the pressure is relatively low the velocity seems to decrease at first as the current increases and then becomes nearly constant. In general the velocity is larger in narrower tubes, It is usual for this type of striation to develop when the current is large, the pressure high and the diameter of the tube comparatively large. The order of velocity is $2—6 \times 10^4$ cm./sec.

The second type consists of slow moving striations with velocities of the order of $0{\cdot}5—1{\cdot}5 \times 10^4$ cm./sec. They are quite distinct but not so clear as the first type. There are about three striations in tube A and four or five striations in tube B per centimetre respectively. The distance between the striations is not constant, but seems to increase with increase of the current. The velocity is uniform throughout the tube so that they look like straight parallel lines when observed through the rotating mirror. Their velocity increases as the current increases, in many cases roughly proportional to the square root of the current, but it is nearly the same for the same current in tubes A and B. This type of striation is developed when the current and the pressure are moderate.

Striations of the third type are very faint and close together, moving very fast (7 or 8×10^4 cm./sec.). The velocity of this type seems to decrease as the pressure of the gas decreases. The small current, low pressure, and narrow tube are favourable for their appearance; but as they are faint it is difficult to study them in detail. The electric force in the capillary part of the tube A was about 20 volts per centimetre, and in tube B it was about 30 volts per centimetre, and as the current was increased the electric force decreased a little, but no discontinuity was detected. The electric force was nearly independent of the pressure used in this experiment.

The Relation of the Three Types of Striations.

Take the case of fig. 1, *i.e.*, tube B, neon, 5 mm. Hg pressure. When the current is less than 1 milliampère the third type of moving striations is seen nearly throughout the tube; at about 1 milliampère the second type of striations starts from the cathode side, and as the current increases, the striations fill the whole length of the tube. At about 4 milliampères the first type of moving striations sets in from the anode side, and as the current increases, the region of the first type expands until the second type can no longer be seen in the tube.

This is the usual phenomena when three kinds of striations are seen

together, but as the pressure increases (above 5 mm. Hg) the third type does not appear at all and the first type begins to appear at a smaller current than

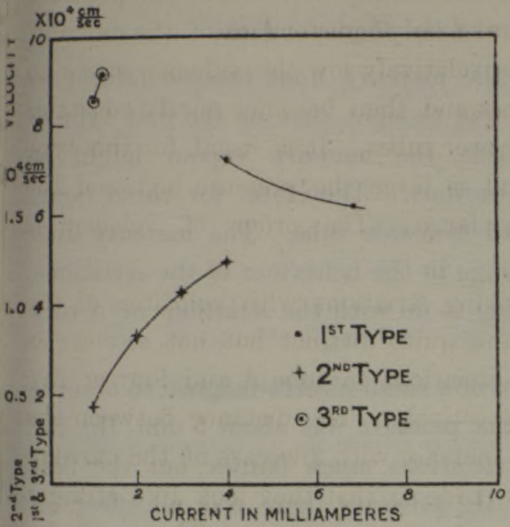

FIG. 1.

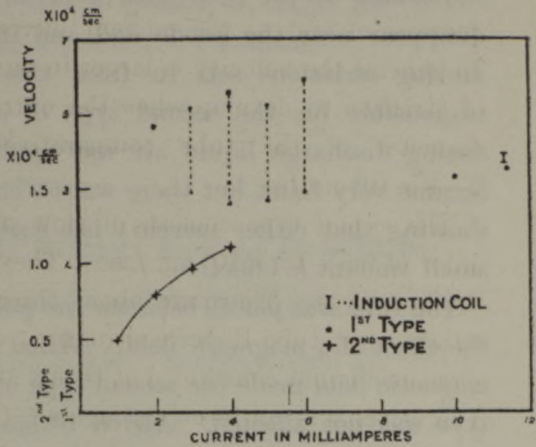

FIG. 2.

before (see fig. 2). When the pressure is still higher (above 20 mm. Hg), the second type of striations also vanish. When the pressure becomes lower, the third type seems to develop. Fig. 3 shows the appearance when the first type and the second type are observed together through the rotating mirror.

FIG. 3.

In tube A the effect of the larger bore is nearly the same as the increase of pressure in tube B. But the current at which the first type of striations sets in is nearly the same for tubes A and B, so that the current density is much larger in the narrower tube. In tube C the effect is as though the pressure is decreased in tube B, so that the third type of striations is observed still at about 100 mm. pressure. In narrower tubes, especially at low pressures, some irregularities were observed. For instance, the velocity of the second type was not very uniform throughout the tube, and showed somewhat wavy form in the rotating mirror, and their velocity increased faster than the square root of the current, and also

the mean velocity of the first type decreased at first as the current increased.

The Effect of Liquid Air and the Magnetic Field.

Looking at the tube with a prism, the mercury lines become fainter or disappear near the anode end, and it was thought that, as the first type of moving striations sets in from this side, the mercury vapour might be responsible for the second type of striations. Therefore, for three hours during discharge, liquid air was applied to a side tube. The mercury lines became very faint, but there was no change in the behaviour of the striations, showing that either mercury has nothing to do with the striations or a very small amount is effective.

The tube was placed between the poles of a small electro-magnet, to observe the effect of a magnetic field. When the pressure was about 5 mm. Hg, the magnetic field made the second type of striations much fainter, but the first type was not affected. Above 10 mm. Hg pressure there was no effect on either type of striation.

The Effect of Temperature.

The tube C was put inside a metallic cylinder and was heated to about 140° C. When this experiment was tried at pressures such that a slight change of pressure produced a large effect, it was clear that for the first and second types, when the pressure was kept constant, the raising of the

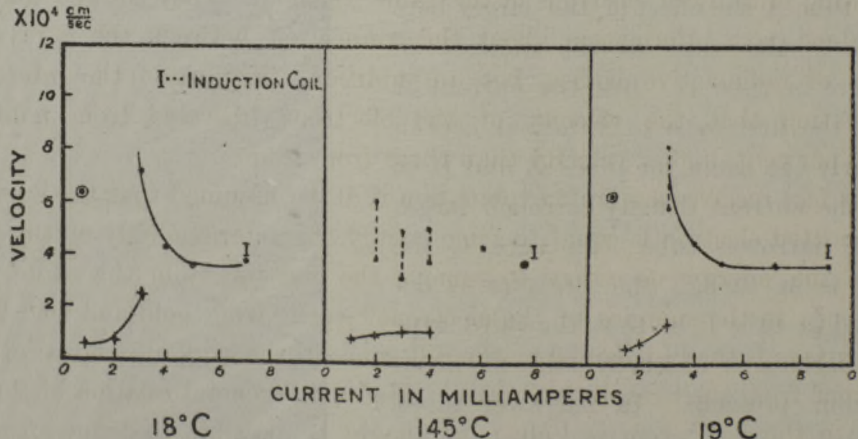

Fig. 4.

temperature produced an effect similar to a slight decrease of pressure, and when the volume was kept constant, the effect was similar to a slight increase of pressure. The third type showed an increase in their velocity when the temperature was raised.

Fig. 4 shows the case where the volume was kept constant. In this case the change of the behaviour of the moving striations when the temperature was raised was conspicuous.

The author wishes to express his hearty thanks to Prof. Sir Ernest Rutherford and Dr. Aston for their kind interest and guidance.

The Magnetic Spectrum of the β-Rays Excited by γ-Rays.

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In recent years, the photo-electric effect of light has been worked out in considerable detail, especially as regards the dependence of the velocity of the ejected electron on the frequency of the absorbed light, but very little knowledge exists about the analogous phenomenon in the region of higher frequencies. A very simple method of investigating the velocities of the β-rays was used by Rutherford, Robinson, and Rawlinson.* They found that the γ-rays from radium B and C, when passed through heavy metals, such as gold or lead, caused the emission of several groups of electrons, each group consisting initially of electrons of the same velocity. They showed that this fact alone gave information about the connection between the β-rays and γ-rays of radio-active bodies, but, in addition, they made the interesting observation that the velocity of the electrons liberated from gold had 1 to 2 per cent. higher velocity than those from lead.

This fact receives a simple explanation if it be assumed that the energy of the emitted electron is equal to some energy characteristic only of the γ-ray, minus the energy necessary to remove the electron from the atom. The difference in the energies of the electrons ejected from gold and lead by the same γ-rays is then explained by the difference in the work of removal of these electrons from their respective atoms. Since the general relation of the gold atom to the lead atom is known, it should be possible to deduce from the experimental values for this difference in the work of removal, from what part of the atom the electron originated, and then values might be obtained for the energy characteristic of the γ-ray. The work to be described was undertaken with these points in view, the experimental determination

* 'Phil. Mag.' (2), p. 277 (1914).