On a Kinematograph of Instantaneous Electric State of High Tension Current.

By

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Introduction.

In course of studying the sparking phenomena, the authors have come across facts, from which it could be concluded that the form of a high tension alternating current may be totally different from that of the primary current of the transformer.

Indeed, in the high tension circuit electric oscillation of high frequency can be easily excited by some trivial causes.

In order to investigate the electric state of a high tension current it is not convenient to use the ordinary oscillograph, for charge accumulation will occur through the existence of thin wires and sharp edged corners in the parts of the oscillograph. This gives rise to corona discharges and oscillations which disturb exact measurement.

Beside these practical inconveniencies, the oscillograph can not be used in the case of high frequency, since the suspension filament of the mirror, which is the principal part of the oscillograph, has the proper oscillation, and the frequency to be measured is confined to limits far below those of the proper oscillation of the filament.

On the other hand, the cathode ray oscillograph invented by Rogowski is very sensitive and can be used to measure such an instanteneous state of electric oscillation as that of 10^{-9} second. But it is said that it is very hard to use.

Therefore it is necessary to find some apparatus, which is sensitive enough to measure an instantaneous state of electric oscillation. But it is evident that the electric conditions of the current must not be affected by inserting the apparatus. From this consideration, the authors have

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A Short abstract was published in the Proceedings of the Imperial Academy 1929 by the authors: An Experimental Study of Instanteneous Electric Oscillations by Vacuum Tube.

tried to insert a vacuum tube and to photograph the glows of the tube with rotating film.

Apparatus.

The apparatus which was used is shown in Fig. 1. The film is wound outside of a drum. The rotating speed of the drum is reduced by belt and pulley for obtaining sufficient intensity of the glow to be photographed. The camera is fitted with a lens (F. 2, focal length 5½″, made by Taylor Hobson,) and a shutter. The shutter is a plate which has a slit and is arranged to fall down, when the circuit is cut with an electromagnet, to which the plate is attracted. The length of the slit is adjusted in such a way that the film rotates once during the time in which the slit passes down.

The spectrum tubes which the authors tried are of hydrogen, helium, oxygen, argon, neon, and air. The luminousty of a neon tube does not sensitize the film, the others except helium are very faint to be photographed. For this reason a helium tube of 14 cm. length has been used in the following experiment.

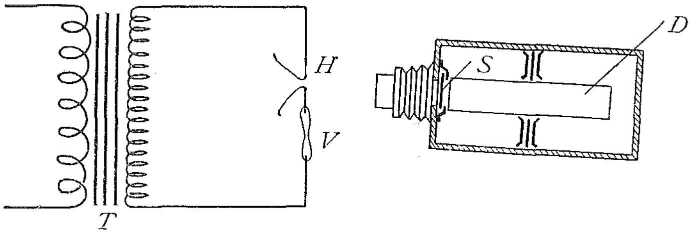
Experiment.

In order to show that it is practical to study the instantaneous electric state of high tension current by making use of a spectrum tube and rotating film, the authors have attempted to take photographs of the glows of the tube, first, in the case where the current is considered to be smooth, and next, in the case where the current is considered to be agitated by oscillations.

For the former, the vacuum tube alone was inserted in the secondary of a transformer (max. volts 70,000, cycles 60) or in the secondary of an induction coil having a spark length of 30 cm. Photographs were taken of the glows of the tube as shown in Fig. 4, a and b.

For the latter case, the vacuum tube was inserted in series with a horn gap in the secondary of the transformer or the induction coil. The diagram is given as follows:

Arch. f. Electrotechnik, 14. 1925, 18. 1927.
Naturwissenschaft, 164. 1928.



D: Drum.
H: Horn gap.
S: Shutter.
T: Transformer.
V: Vacuum tube.

Fig. 3.

If a horn gap is inserted in the secondary of the transformer and the voltage of primary current is adjusted, sparks or arcs ("Büschelbogen" according to the classification by Toepler"[1]) or combinations of the two can be secured. The arcs at the gap are photographed in some tenths of one second as shown in Fig. 2.

In order to ascertain whether the influence of inserting the vacuum tube upon the sparking phenomena, can be neglected, photographs of both sparks and glows of the tube have been taken. They are shown in Figs. 5, a and b. The lower series of lines corresponds to the sparks in the upper series of Fig. 5, b. Between the photographs a and b, differences can hardly be seen. The potential difference at the gap in these two cases has also been measured and it has been found that the difference can be neglected against the terminal voltage at the gap.

When there appears an arc, the glow of the tube generally gives on the film a continuous band and sometimes a continuous band with lines in each half one cycle as shown in Fig. 6, a and b.

In order to show the band and lines clearly, the glows of the tube alone are photographed, which is given in Fig. 7.

From this, it may be concluded that the electric state of 5×10^{-5} second can be photographed.

We have tried to use the induction coil as high tension producer. The current state of the secondary circuit is given in Fig. 4, b. Inserting a horn gap in series with the tube, the authors have photographed the glows of the tube when sparks and arcs appear at the gap, as shown in Fig. 8, a and b.

1) Zeitschrift für Technische Physik, 3, 1929.

These experiments with the induction coil were carried on making use of a mercury interrupter. The irregularity shown in the figures can be considered to be due to the assymmetries in the jets and wings of the interrupter.

Last, the authors have tried to apply the special alternating current of 500 cycles to the same transformer which is constructed for 60 cycles: of course, the primary voltage was adjusted by resistance so as to avoid damage to the machine. The glows of the tube are given in Fig. 9.

The 500 cycles generater, constructed by Kurosaki is of induction type having capacity of ¼ K.V.A. and R.P.M. 3330.

The existence of the thin line in each single cycle of Fig. 9, can be explained as the following; small iron needles in the rotor might cause a small disturbance in the primary current, and it would be enlarged by the transformer.

Summary.

The ease with which both the continuous and instantaneous electric states of high tension current can be kinematographically photographed by our method making use of a spectrum tube of helium and rotating film is to be noted.

Although the authors are not sure to conclude that the photograph can indicate exactly the electric state of current, we can, at least, assert that it is a convenient and practical method to study the instantaneous electric state of high tension current.

We can easily increase the resolving power of the photograph taken under this method by increasing the rotating speed of the drum on which the film is wound.

If it is uncertain that the spectrum tube, inserted in series to the circuit, should affect the electric condition, the tube can be inserted also parallel to the circuit, or only to put near to the circuit. The tube is so sensitive that one need not necessarily to put it in the circuit. The photograph taken in this case is faint, but it is sufficient to be measured from the negative film. The authors will improve this apparatus later to increase the rotating speed and luminousity of the tube.

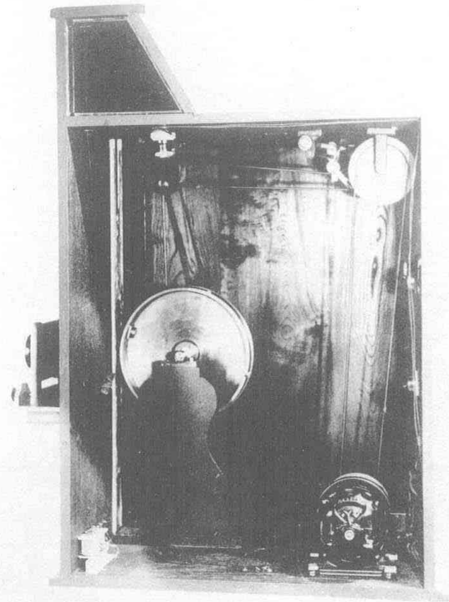


Fig. 1.

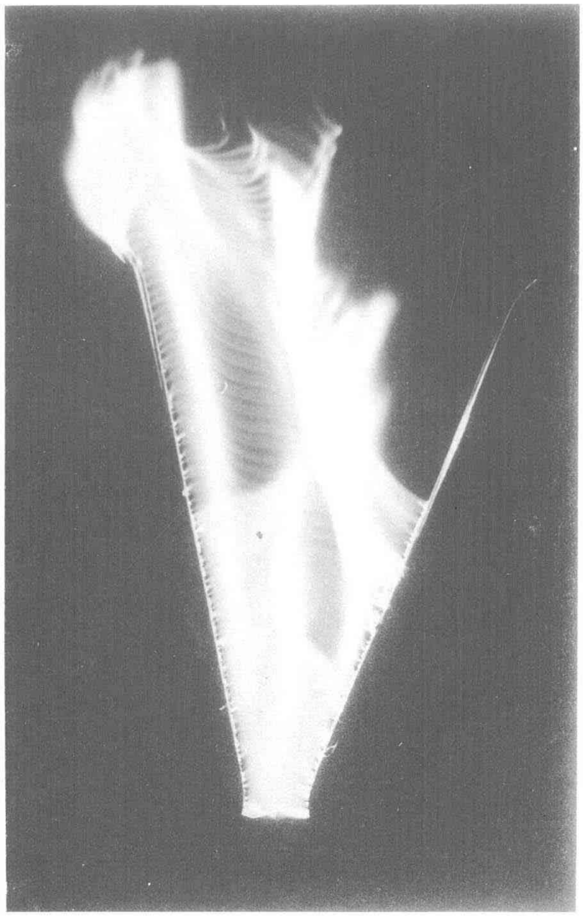


Fig. 2.

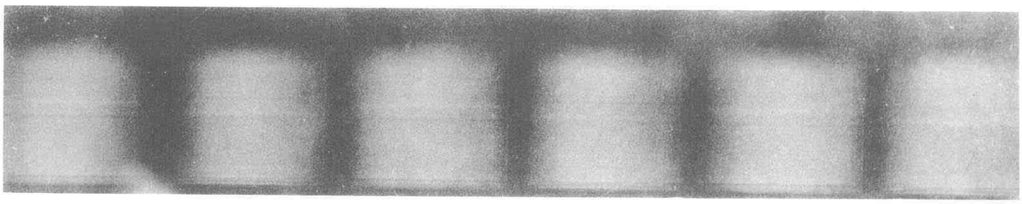


Fig. 4, a.

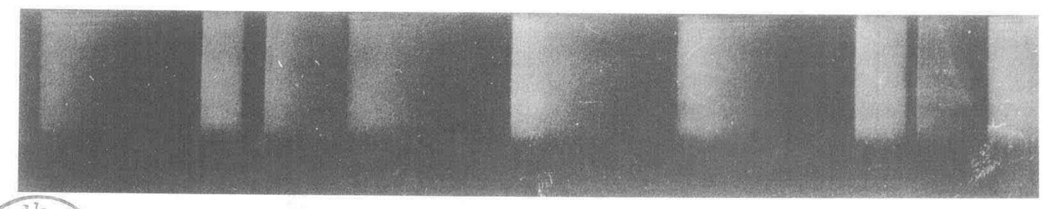


Fig. 4, b.

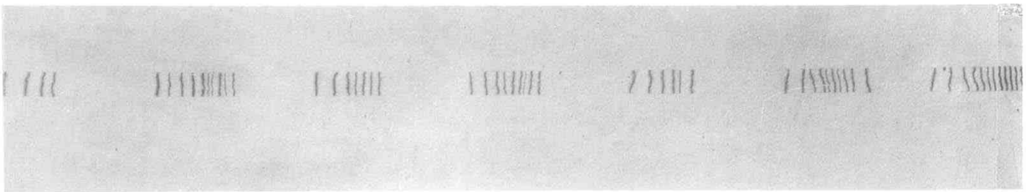


Fig. 5, a.

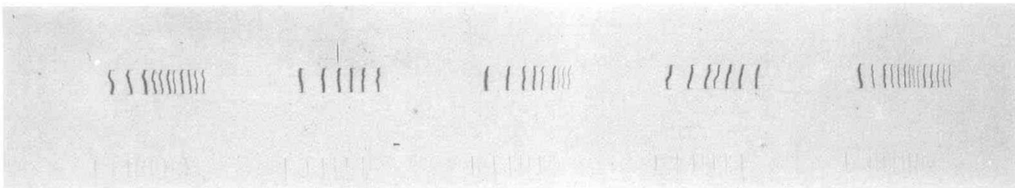


Fig. 5, b.

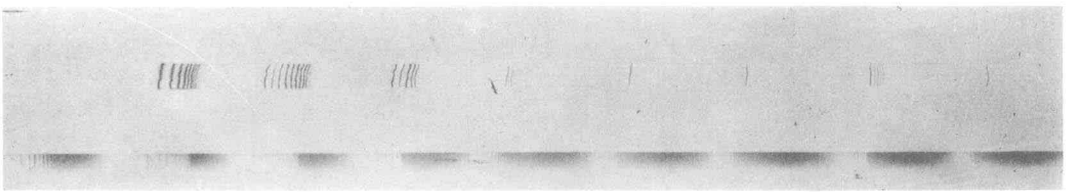


Fig. 6, a.

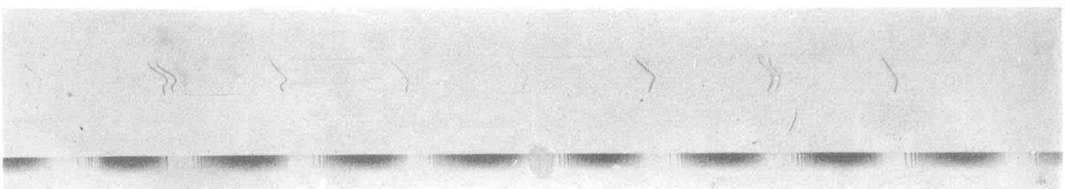


Fig. 6, b.

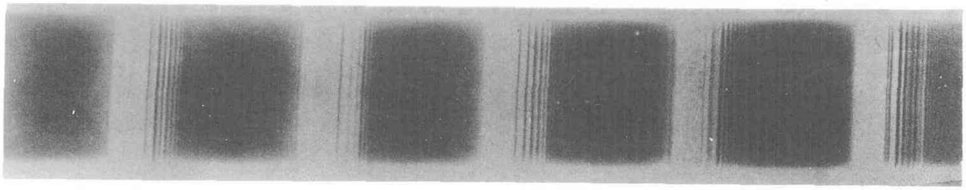


Fig. 7.

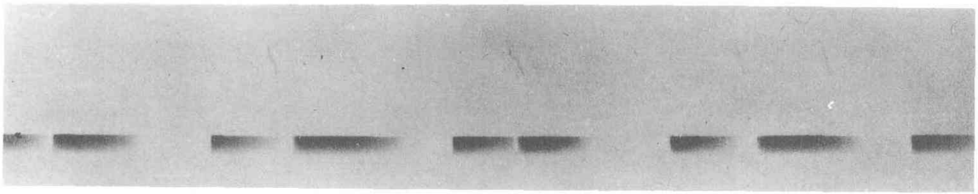


Fig. 8, a.

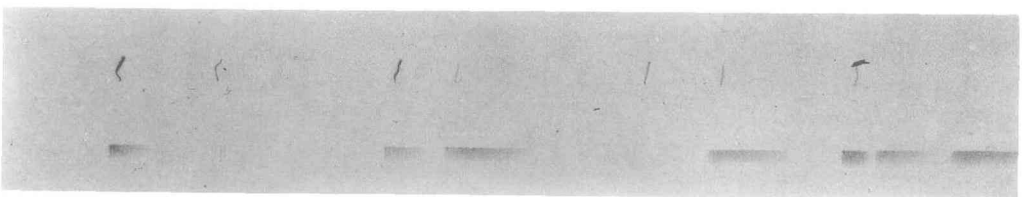


Fig. 8, b.

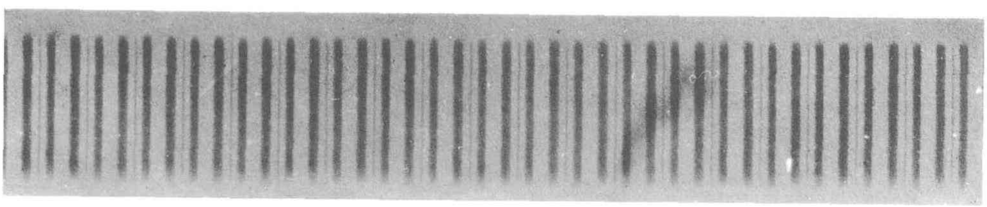


Fig. 9.