Further Investigation on the Figures Produced on Photographic Plates by Electric Discharges.

By

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In the former investigation[1] on the figures produced on photographic plates by electric discharges, beautiful cathode and anode figures were obtained; and a distinct difference between the regular cathode figures und the irregular anode figures was noted. In the anode figures (Fig. 3 and 13 of the former paper) we notice that every branch consists of two parts; namely a more intense portion near the electrode, and a weaker portion more removed. When a celluloid film is used instead of a common photographic plate, these two portions are more clearly distinguishable as is seen in Fig. 18 of the former paper, and Fig. 1 of this paper, the ends of the intense portions of the branches terminating with a continuous outline.

In the former paper the writer tried to explain the formation of the figures, and the transition from brush discharge to spark discharge by the following assumptions: (1) in a cathode branch, the ionisation in its end portion is caused by the collision of negative ions with gas molecules in the air, aud these negative ions are supplied by the ionisation due to the collision of positive ions with gas molecules in the neighbourhood of the cathode, or with the cathode itself; (2) in an anode branch also, the ionisation in its end portion is caused by the collision of negative ions with gas molecules, and the ionisation due to the collision of positive ions occurs in the portion nearer to the anode.

When two electrodes placed on a photogtaphic plate, one of which

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1 These Memoirs, 2, 105 (1917).

is connected to the tin foil under the plate, were respectively brought in contact momentaneously to both terminals of an influence machine, a discharge figure was produced at the electrode not connected to the tin foil. When this was anode, an anode figure was produced at this electrode.

As already noted in the former paper, though the ends of some anode branches reached the cathode connected to the tin foil, yet no direct spark passed between these two electrodes. This was explained by the two assumptions mentioned above, and also by the consideration that in order to let a direct spark pass between the two electrodes the ionisation due to the collisions of positive ions with the gas molecules or with the cathode itself should occur near the cathode.

When a celluloid film was used instead of a common photographic plate, several photographs were obtained showing that, though the ends of some anode branches of weaker intensity reached the cathode, no direct spark occurred (Fig. 2). In about 60 photographs it was never observed that no direct spark occurred, though the intense portion of the anode figure reached the cathode.

Judging from this we may infer that a direct spark will pass between the electrodes when the end of the intense portion of an anode figure reaches the cathode, but the mere arrival of the weaker portion of an anode figure to the cathode will not cause a direct spark between the electrodes. This may be explained by the supposition that the weaker portion of an anode figure is impressed by the luminosity caused by the ionisation due to the collision of negative ions with the gas molecules, and the ionisation due to the collision of positive ions with gas molecules takes place at the intense portion of the anode figure; because to cause a direct spark to pass between the electrodes the ionisation due to the collision of positive ions should take place near the cathode, as was assumed before.

When a direct spark passed between the electrodes interesting phenomena occurred both at the cathode and anode figures. An enveloping margin of the figure appeared at the cathode leaving a nearly unaffected dark portion between the enveloping margin and the cathode figure as is seen in Fig. 3 of this paper and Fig. 22 of the former paper. Many anode branches which were enveloped by white margins, as if a photographic reversal took place, appeared at the anode as is seen in Fig. 4.

As these phenomena seemed to the writer not to be explainable by mere photographic reversal, a further research was undertaken.

Two electrodes were placed upon a photographic plate laid on a sheet of tin foil, one of these two electrodes being connected to the tin foil. A wire was so attached to one electrode at some distance (2 or 3 cm) above the photographic plate that a direct spark might more easily pass between this wire and the other electrode than on the photographic plate. When these two electrodes were respectively brought in contact momentaneously to both terminals of the influence machine, a discharge figure appeared at the electrode which was not connected to the tin foil; and, at the same time, a direct spark passed between the wire and the other electrode. The phenomena before mentioned appeared only in the portion of the photographic plate illuminated by the light of the direct spark; and in the shadow of the electrode cast by the spark, only the ordinary cathode and anode figures were impressed as is seen in Fig. 5 and Fig. 6. This indicates that the light of the direct spark plays an important part in the occurrence of such phenomena.

Even when the intensity of the light emitted by the direct spark was much reduced by making the spark pass at a height of 10 cm or more above the photographic plate, these phenomena were easily observed. And in every case examined the light emitted by the spark was too weak to give rise to an ordinary photographic reversal.

Next, the electrode connected to the tin foil was removed; and the other electrode and the tin foil were so arranged that they might be connected respectively to both terminals of the influence machine. And another spark gap was placed nearly in the position where a direct spark took place in the case of Fig. 5 and Fig. 6. Immediately after both terminals of the influence machine were respectively brought in contact momentaneously to the electrode on the photographic plate and the tin foil, they were connected in the circuit of the spark gap above mentioned, and an intense direct spark was seen to have passed at the spark gap. Consequently the illumination of the photographic plate by the light of this direct spark occurred one or two seconds after the impression of the discharge figure on the photographic plate had been made. The cathode figure Fig. 7 and the anode figure Fig. 8 were taken in such a manner.

Though in these cases the illumination of the photographic plate by the light emitted by the spark was comparable with that of the case of Fig. 5 and Fig. 6, no trace of the interesting phenomena before mentioned was observed. When a direct spark was made to occur one or two seconds before the occurring of the impression of the discharge figure, photographs similar to Fig. 7 and Fig. 8 were obtained, but again no trace of the phenomena before mentioned was detected. These experiments were repeated several times, both on the cathode and anode figure, with various intensities of light emitted by the spark; and the attempt to observe the phenomena before mentioned was entirely unsuccessful.

Consequently we may infer that, in order for the interesting phenomena before mentioned to take place, the illumination of the photographic plate by the light emitted by the spark should occur exactly or nearly at the same time that the discharge figure is impressed on the photographic plate. It is clearly not an ordinary photographic reversal; also it is not a Clayden effect which occurs when a photographic plate exposed to the light of an electric spark or of an intense illumination of short duration, is subsequently fogged by exposure to diffused light before developement, because the time interval between the two successive illuminations is not so important a factor in this case; and it does not belong to any kind of photographic reversal ever known.

The fact that, for the formation of the enveloping margin of the discharge figure, the illumination by the light emitted by an electric spark should be applied simultaneously with the formation of the discharge figure on the photographic plate, seems to suggest that the strong electric field applied to the sensitive film has a complex rôle on the sensitiveness of the film to the light in some direct or indirect way.

Metzner[1], by letting many sparks pass on a photographic plate placed on a sheet of tin foil, observed a phenomena similar to that of anode branches, and called such reversed branches "dunkle Funken." An explanation of this phenomenon as a Clayden effect was given by Schaum[2]. As many sparks occurred in the photograph given by Metzner, the appearance of the "dunkle Funken" is not obvious; but, probably, it is the same phenomenon as that observed by the writer, If so, the explanation of the "dunkle Funken" given by Schaum is not correct.

Metzner observed a bright thread in the "dunkle Funken," and this was also observed by the writer on some of the reversed branches

1 Verh. d. D. phys. Ges., **13**, 612 (1911).

2 Verh. d. D. phys. Ges., **13**, 676 (1911).

in the anode figure impressed on a celluloid film, which was illuminated simultaneously by a spark of a rather weak intensity. But the condition under which the bright thread is formed is not clear. In Fig. 9, such a bright thread appeared on some of the reversed anode branches.

Whether the light, by which the discharge figure was impressed on the sensitive film, was of the same nature as that of the spark or not, was next examined by the Clayden effect; and the result was affirmative. The photographic plate, a discharge figure having been impressed on it, was exposed for a short time to the diffuse light emitted by an electric lamp, and was developed, Both the cathode and the anode figure thus obtained are evidently reversed, as was seen in Fig. 10, and Fig, 11.

When the impression of the figure was preceded by exposure to the diffuse light, no trace of photographic reversal was observed, upon exposures to diffuse light of various intensity or of various duration. Figs. 12 and 13 are examples of photographs taken under such conditions.

Consequently we may conclude that the light which impresses a discharge figure on a sensitive film is of the same nature as that of a spark, so far as the Clayden effect is concerned. R. W, Wood[1] found that the intense light emitted by an electric arc was able to play the part of an electric spark in a Clayden effect, if the interval of time, in which a photographic plate was to be illuminated by it, was reduced below about 1/1000 sec, and concluded that the peculiarity of the light emitted by a spark with regard to the Clayden effect was no other than its short duration.

As the light which had impressed a discharge figure on a photographic plate showed the Clayden effect, the duration of its illumination in every portion of the figure would be less than 1/1000 sec. In Fig. 10 and Fig. 11, where the Clayden effect occurred, the reversed cathode and anode branches have no enveloping margins as was seen in Fig. 5 and Fig. 6. This seems to be another evidence in proof that the phenomena observed in Fig. 3 and Fig. 6 are not photographic reversals of any kind ever known.

In conclusion the writer wishes to express his hearty thanks to Prof. T. Mizuno for the interest he has taken in the work.

1 Phil. Mag., **6**, 577 (1903).

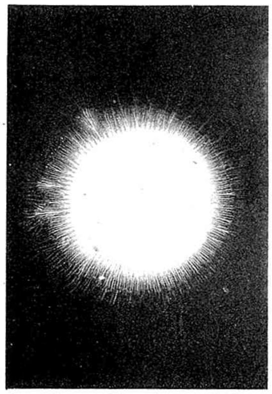

Fig. 1.

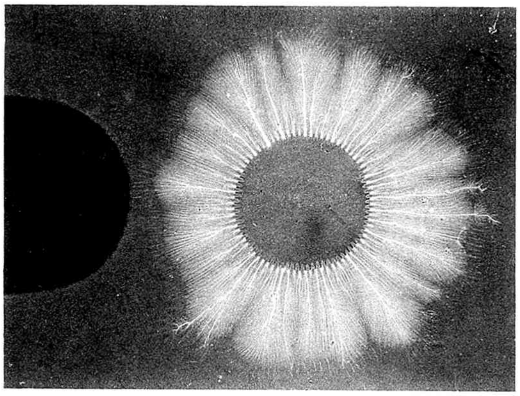

Fig. 2.

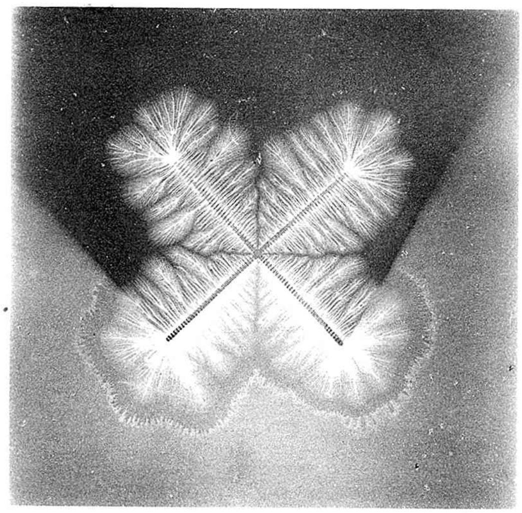

Fig. 9.

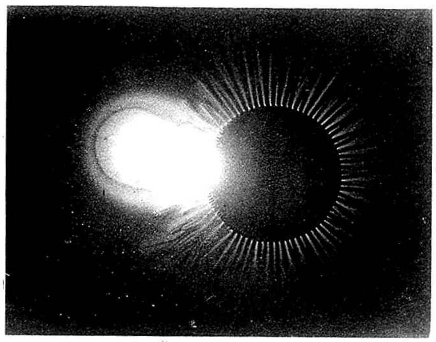

Fig. 3.

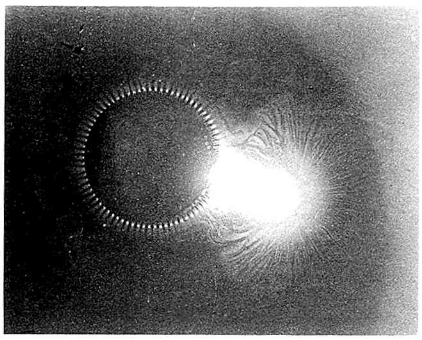

Fig. 4.

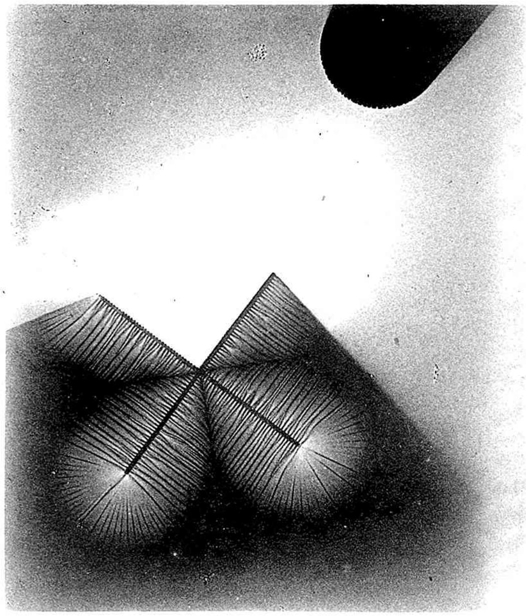

Fig. 5.

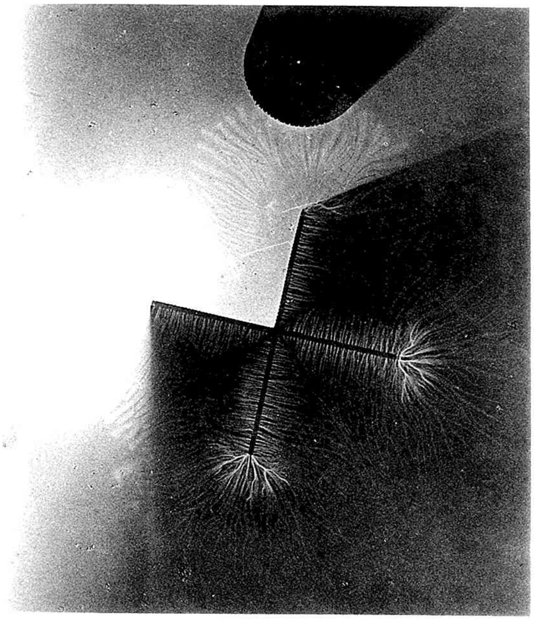

Fig. 6

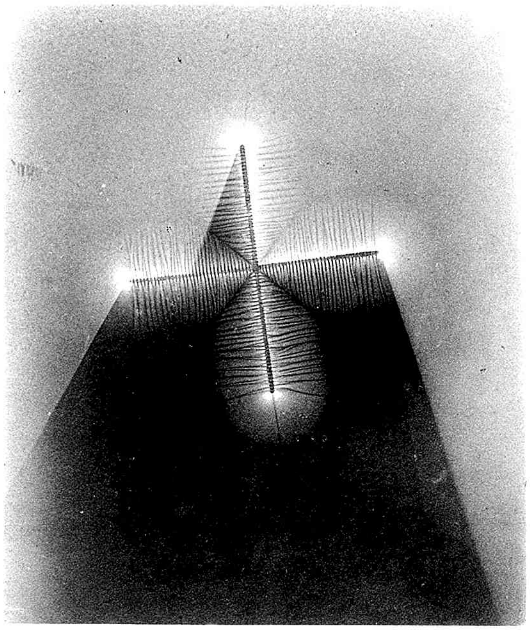

Fig. 7.

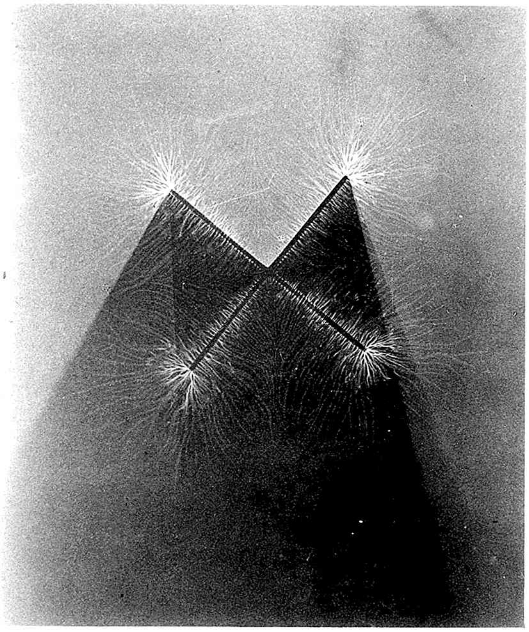

Fig. 8.

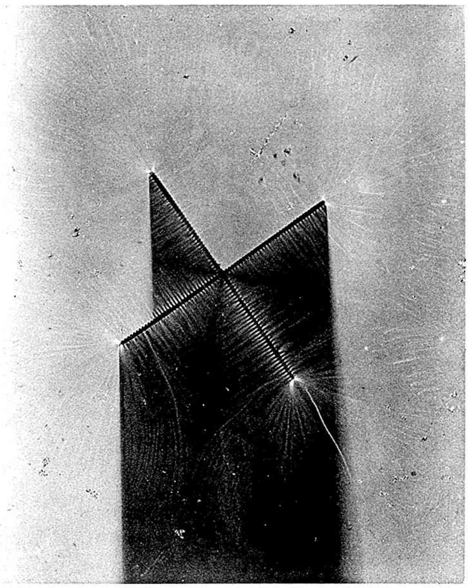

Fig. 10.

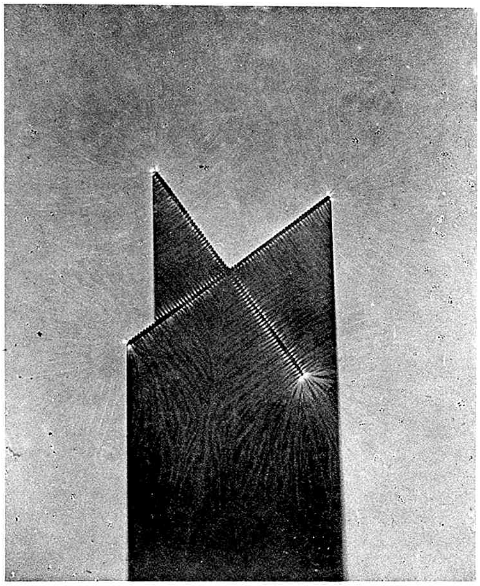

Fig. 11.

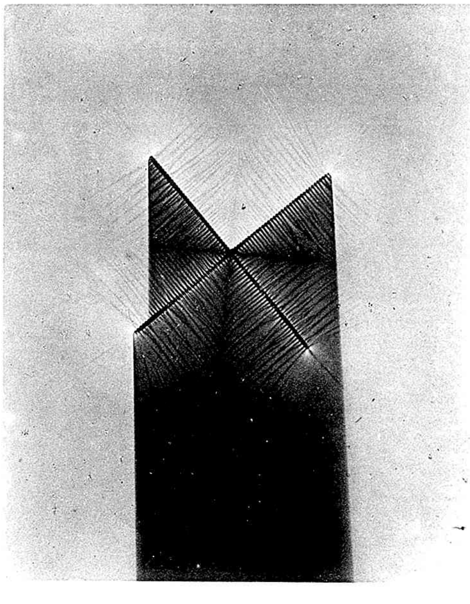

Fig. 12.

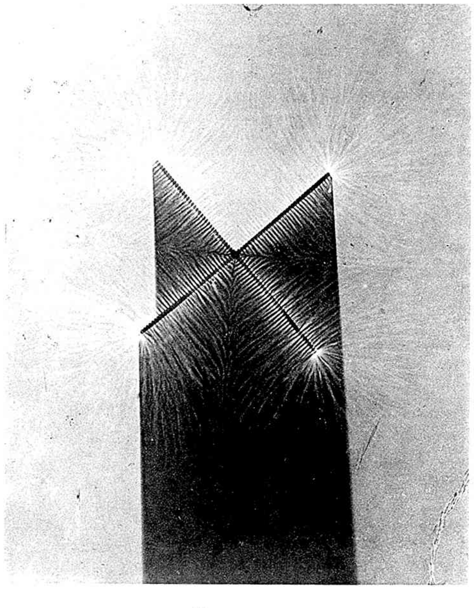

Fig. 13.