THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XXIX.—*On a method of producing, by the Electric spark, figures similar to those of Lichtenberg;* by ELI W. BLAKE, Jr.

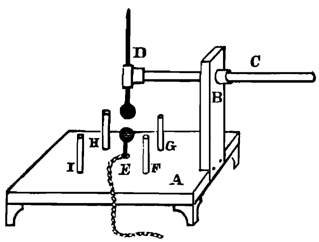
LICHTENBERG'S figures, discovered in 1777, are a result of the attraction of an electrified surface for light particles of electrified or unelectrified dust. Prof. Rood has shown that figures entirely similar in form are produced, when the spark is allowed to fall on the sensitized collodion film of an ordinary photographic plate, and the latent image is developed in the usual way.

The method I have to describe consists in throwing the discharge upon the surface of a fusible non-conducting body. If the body be near its fusing point the figure appears at once,—if cold, a latent image exists which may be "developed" by heat.

The non-conducting surface is prepared by coating a plate of metal with an even film of pitch. Pieces of sheet-tin, 3 inches square, coated with films of pitch of a thickness varying between 0·01 and 0·02 in., were used in most of my experiments. The pitch was the ordinary commercial article, freed from sand, fragments of bark, &c., by being melted and strained through a muslin bag. Shellac, rosin, Burgundy-pitch, bees-wax and Canada balsam were in turn tried as substitutes for pitch, but with unsatisfactory results.

A simple apparatus for holding the plate during the discharge, is represented in fig. 1. The upright B supports the insulating arm C,—a rod of glass, which may be turned in its bearing, but is prevented from moving longitudinally. The arm C holds the wire D. This wire slides up and down with considerable friction so as to retain any position given to it. It is graduated to tenths of an inch, and terminates, at one end, in a sharp point—at the other, in a metal ball ½ inch in diameter. Directly beneath D is a similar wire, E, passing through the board A, and held by friction. Around E, at the corners of a three-inch square, are disposed four insulating posts, upon which the prepared plate is laid.

1.



In experimenting, merely to obtain the figures, the arm C is turned so as to bring the wire D into a horizontal position,—the prepared plate is laid upon the insulating posts (for the + figure with the pitch side uppermost). The wire E is made to touch the plate below, and is put in connection with the earth. D is then made vertical, and is adjusted to the desired striking distance. An insulated connection being made between D and a charged prime conductor, the + spark passes over to the pitch. The − figure is obtained when the pitch side is beneath, D in contact with the plate, and E depressed to the proper striking distance. The discharge having taken place, D is again made horizontal, and the plate may be removed for development. This process consists in gradually warming the plate over a lamp. The metal side must be presented to the lamp, as the slightest touch of a flame on the excited pitch instantly dissipates the electricity. At a certain temperature, (in my experiments about 60° C.,) the figure will begin to appear, and in a few seconds the development is completed. The plate being now allowed to cool, the figure becomes permanent. If the plate be overheated the figure is destroyed. It may be instantly obliterated by exposure for a second to the naked flame, and the plate may then be used again. The proper temperature for development is some degrees below the real fusing point of the pitch used.

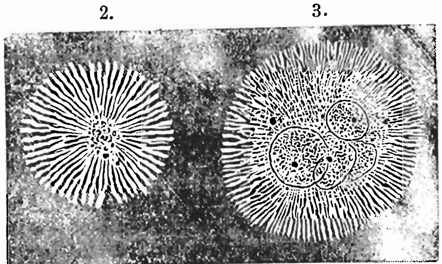
The figures, obtained as described, are formed by depressions and elevations of the excited surface. The depressions would appear to be the true figures, as they correspond exactly in form to those obtained by Lichtenberg. The plate may be dusted before development; the form thus revealed will be reproduced in depressions upon warming. The depth and sharpness of these depressions vary with the quantity of electricity, and the thickness of the film of pitch. The thinner the film, the sharper the lines. The exact depth of the depressions below the general level is very difficult to measure, owing to the elevations produced. In films of 0·015 in. thickness, the deepest lines are about 0·005.

When cold, the pitch is sufficiently hard to allow of several impressions being taken from it in printing ink. The wood-cuts given below were made from such impressions, transferred to a block, and then engraved. The white portions therefore represent depressions. The "ground," representing the level surface of the pitch, was lightened by ruling, so as to bring out the exterior ring of the negative figure.

Frictional Electricity.

Discharge from balls.—The positive spark produces the figure of a star (2 and 3). Sometimes the rays diverge almost from the center, but generally the central portion is broken up into a confusion of minute elevations, which in the cuts show as dots. The rings sometimes seen in this central portion resemble the negative figures, and suggest the idea of oscillations in the discharge.

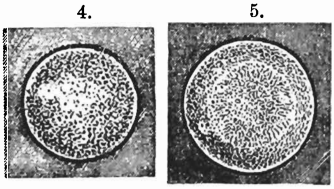
2. 3.



Positive spark from ½ inch balls. Striking distance, ⅕ inch.

The negative spark gives the figure shown in (4). An elevated ring forms the outer boundary; inside of this comes a deeply depressed circle surrounding a circular disc, whose surface is so irregular that I have not been able to determine whether it is, on the whole, above or below the general level of the pitch film. Perfectly similar figures were obtained by means of the electricity developed by the Holz machine, the electophorus and that accumulated in a Leyden jar.*

4. 5.



Negative spark from ½ inch balls. Striking distance, ⅕ inch.

Discharge from Points.—When a single, instantaneous discharge, from a fine point, falls upon the film, figures similar to the foregoing, but not so regular, are obtained. If, however,

* In experimenting with a well charged Leyden jar, if the electrodes D and E (fig. 1) are connected with the coatings of the jar, the discharge is so violent as to perforate the film of pitch. Surrounding the minute perforation is a circular crack. Generally the circular fragment thus set free is thrown out, and in the center of the bright spot of tin exposed, a minute dot is seen. On examination by a magnifier, it will be seen that the tin is fused at this point. That this is not a thermo-electric action of the tin, and iron, is proved by the fact that the fusion takes place whether the discharge is positive or negative. In using such a jar for the production of figures the electrode E should be removed and the spark thrown on the insulated plate.

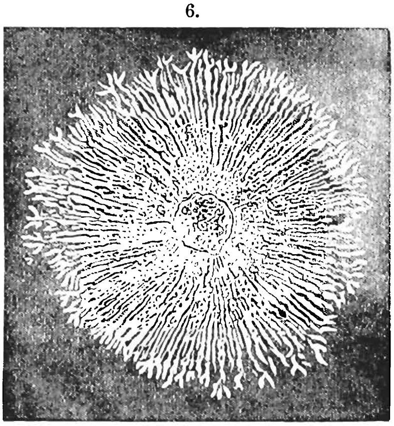
the discharge be of negative electricity, and be continued for a short time, (e. g. during a quarter-revolution of a 20-inch plate of the ordinary frictional machine,) the first effect of developing is to bring out a *star*, which might readily be mistaken for the positive figure. Inspection shows however that the rays are not *depressed*, but *elevated.* The rays are generally more or less curved, and resemble the projection on a plane of the meridians of a hemisphere. The plane of projection is different in almost every figure. Precisely such a star occurs in the figure, given below, of the negative spark from the induction coil.

If the discharge from the point be continued for some seconds, the plate, on developing, shows an infinity of minute circular depressions with no characteristic distinction between +E and −E. In developing these plates, especially those charged with −E, vivid sparks may be seen to rise from the pitch, visible even in broad day-light.

Figures produced by the Induction Coil.

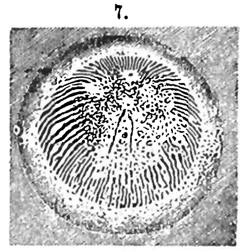
The coil used in these experiments was made at Ruhmkorff's establishment in Paris. It is capable of giving an 8-inch spark, but, by reducing the primary current, the striking distance was brought down to $\frac{1}{4}$ inch. A single Bunsen's cell was used,—the carbon being withdrawn so as barely to touch the nitric acid.

6.



Positive spark from terminal wires of the induction coil.

7.



Negative spark from terminal wires of the induction coil.

The positive figure obtained is represented in the accompanying cut (6). Except its larger size, as compared with frictional *electricity* of the same striking distance, there is nothing noticeable in it.

The corresponding negative figure is seen in (7). The central star with curved rays, referred to above, is surrounded by a deeply depressed circle, which is bounded by a slightly elevated ring. The terminal wires evidently acted here as points, for the *star* was not obtained when the discharge took place from balls.

Simultaneous production of the Positive and Negative Figures.—For this, a plate coated with pitch on both sides is required. The electrodes D and E (fig. 1) are adjusted at equal distances from the upper and lower surface of the plate. Upon connecting D with the prime-conductor the positive spark falls upon the upper, while the negative spark leaps up to the lower surface of the plate. Development by the lamp, without obliteration of one of the figures, being impossible, the plate may be heated in an air-bath to about 60°–65° C. It is more convenient, however, to throw the discharge upon the plate when warm, the figures then appear at once. By using plates of glass, or mica, instead of metal, the relative size of the figures is at once seen. The negative figure is considerably less in diameter than the positive.* This fact explains why, when +E and −E are thrown on the same spot, they do not neutralize each other and the resulting figure is a combination of the two.

An interesting fact, in connection with this subject, is the length of time that may elapse between the reception of the spark by the plates, and the development of the figure. Several plates were charged in immediate succession, and developed, one by one, at intervals of two hours. The last, developed after twelve hours, showed hardly any loss in depth or sharpness, although the weather was damp and unfavorable. Of another series, the last, developed after *seven days*, still came out distinctly.

A charged plate may be breathed upon, and the condensed moisture be allowed to evaporate, several times, without apparently injuring the latent image. To test the discharging power of a point, the following experiment was made. One end of a copper wire was filed to a sharp point; the other end was then soldered to a metal plate. This plate had two intersecting lines scratched on its surface, and was coated with pitch. The spark having been made to fall on the spot marked out by the intersection of the lines, (visible through the pitch), the copper wire was bent over so that its point was directly over the center of the latent image and very near it. After 12 hours, this plate, on developing, gave a good figure.

From the manner in which the figures are produced, it would appear that they are due to the attractions and repulsions of the

* Riess has shown (Pogg. Ann., B. lxix), that the areas of the surfaces occupied by +E and −E of equal quantity, and developed under the same conditions, are as 7 : 1.

excited surface.* This seems proved beyond doubt by the identity of the Lichtenberg figures, with the depression figures produced on developing. No chemical change of the pitch could enable it to attract dust.

As the point of temperature at which developement begins is considerably below the true fusing point of the pitch, the *work* performed by the electricity is no inconsiderable quantity. Does the electricity disappear in performing this work? The fact that the depression of the surface stops at a certain point, while the attraction for the opposite E on the metal plate should be constantly growing stronger, seems to point to an affirmative answer. As pitch, however, is said to become a conductor when fused, it may be that the two electricities are gradually transmitted and neutralize each other. Experiments have been undertaken in the hope of obtaining a decisive answer to this question, but as yet with no result worthy of publication.

Cornell Univ., Ithaca, N. Y., Feb. 6th, 1870.