FIG. I.—LIGHTNING PHOTOGRAPHED BY DR. LOCKYER, AT GÖTTINGEN, GERMANY, 1893.
An approaching storm.

DARK LIGHTNING FLASHES.

By William J. S. Lockyer, M.A., Ph.D., F.R.A.S.

A BRILLIANT lightning flash during the night, like a total eclipse of the sun, is a most awe-inspiring phenomenon, which illustrates in a striking manner the wonderful working of Nature and her laws. To watch these magnificent flashes which stream across the sky, sometimes directly towards the earth, and at other times in inclined paths, makes one contemplate the disastrous results that would ensue if the whole firmament were let loose simultaneously on our little earth. These brilliant visitors, which seem to vie with each other in excelling in brightness and form, are admirable objects to be caught by the photographic plate, and, in fact, many beautiful flashes have in this way been entrapped, so that their peculiar forms may be studied at leisure.

As a rule, photographs of lightning flashes appear *bright*—that is, white on a dark background; but it happens sometimes that what may be termed *dark* flashes have been recorded on the photographic plate. In this article I propose to bring before the reader a few examples of these peculiar flashes, and to explain, if possible, the causes to which they are due.

If *dark* flashes do really occur in Nature, then they should be both seen and photographed, and the former one would think would be the more simple way of recording them. A difficulty, however, here arises, for if we assume that both dark and bright flashes occur during a thunderstorm, then we must be careful not to mistake retina-fatigue dark flashes for actual dark flashes, if they exist. By retina-fatigue dark flashes is meant that if an observer looks at a very bright flash, his retina becomes momentarily so tired by its suddenness and brightness that for some seconds after-

FIG. II.—LIGHTNING PHOTOGRAPHED BY DR. LOCKYER, AT GÖTTINGEN, 1893.

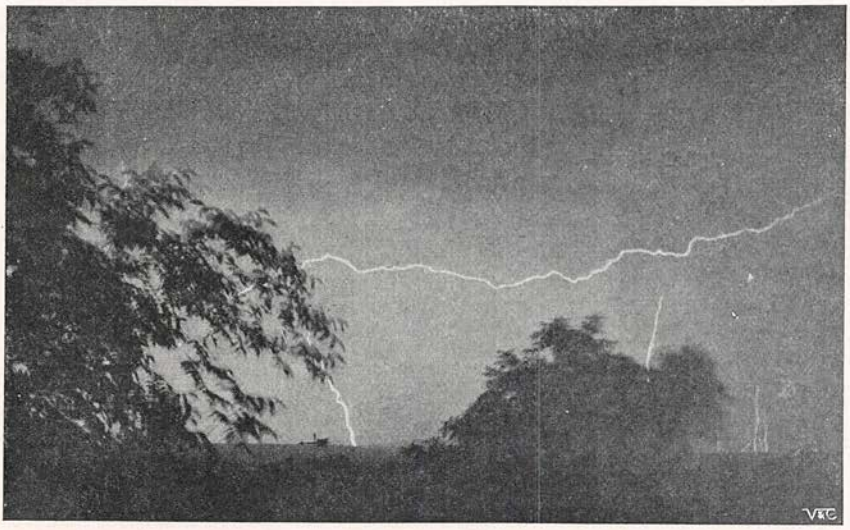

FIG. III.—LIGHTNING PHOTOGRAPHED BY DR. LOCKYER, AT GÖTTINGEN, GERMANY, 1893.

wards he sees, wherever he looks, an exact image of the bright flash, only it appears *dark*.

As far as is known, dark lightning flashes have never been seen. If we employ photography as a means of recording lightning flashes, we find that we do obtain records of dark flashes. Whether the dark flashes are simply due to some action relative to the sensitive film, or are actual images of real dark flashes, the reader will, I hope, be able to decide when he has read the present article. It may be remarked that the action of the sensitive film is generally known to be capable of giving us both bright and dark images, although the object photographed is bright.

A word or two here may not be out of place to show how lightning photographs should be secured. Everyone who has a camera can help in the elucidation of several points to be studied, and most probably bring new facts to light. The photography of lightning flashes during the night is an easy subject, for one has simply to turn the camera in the direction where the flashes occur, focus for the horizon—*i.e.*, any distant object, say a lamp some way off—remove the cap, and the lightning does all the exposing itself. Unfortunately, it is not everyone who is aware of this fact, and many instances have been recorded where observers have attempted to catch the flash by means of instantaneous shutters. Needless to remark, the flash was a thing of the past before the operator had succeeded in actuating the shutter.

Now, before attempting to explain the cause or causes of dark flashes of lightning, it is necessary to be equipped with a considerable amount of data. Up to the present time a great many photographs of lightning have been secured, but they are so scattered in various publications that it is only with great difficulty that they can be found. Fortunately, the photographs I have obtained at various times contain several different *types* of flashes, and these, together with a few others to which reference will be made, will help us materially to form a general idea of their variations. I will first restrict myself simply to describing briefly and pointing out the peculiarities contained in the photographs reproduced in this article.

Fig. I. was taken in Germany at the approach of a storm from the westward. It will be noticed that the flashes proceed from clouds some distance away, and that the two brightest have no ramifications or branches, but simply increase in intensity as the earth is approached. There are no dark flashes on this photograph, for the reason, as will be seen further on, that the storm was too far away, and therefore the flashes were not bright enough to produce the photographic effect. The exposure given in this case was twenty minutes, and Eastman's films were used in this and in all the other photographs described.

Fig. II. was obtained during the same storm as the preceding photograph, but from a different point of view, when the storm was much closer. It was taken during a tremendous downpour of rain, as the photograph shows. The bright flashes streaming from the cloud on the right hand side all converge and form the strong flash which

apparently does not reach the earth, but disappears behind a low cloud. The exposure was five minutes in length.

Fig. III. is interesting, as it shows how apparently intense horizontal lightning can travel. In the right hand corner the reader will notice it is practically raining flashes. There, of course, the storm was a great distance away. The exposure in this case was twenty-five minutes.

I will now describe two out of the four photographs I secured during the storm that passed over Westgate-on-Sea, Thanet, during the night of August 5th, two years ago. All four of the photographs obtained showed *dark* as well as bright flashes. The storm, I may add, passed roughly from S.E. towards N.W., and the camera was placed on a window-sill facing a north-westerly direction.

Fig. IV., showing the north-western sky, displays several flashes, the most prominent of which are bright, and two others dark. The bright flashes have no ramifications, while the strong dark flash has several dark ones. It may be that the dark flash on the left hand side is only a large ramification of the neighbouring bright flash, but it is difficult to say. The exposure in this case was fifteen minutes.

The last, and probably unique, photograph is shown in Fig. VIII. on page 419.

The negative was exposed for fifteen minutes, when the storm was, perhaps, just a little north of the camera. The two most prominent flashes are those marked A and B. B is the ordinary bright flash, with numerous bright ramifications, while A is also equally, if not more, strong, but *dark* with *dark* ramifications. Most interesting is the reversal which extends nearly the whole way up the centre—that is, the dark flash has a bright core. A *bright* flash with a *dark* core was illustrated in a recent article by Mr. Broome, the photograph having been taken by Messrs. Valentine, Blanchard and Lunn, at Cambridge.

Another flash of interest and peculiarity is that near B in Fig. VIII. This flash is quite distinct from B, but, unlike all the other bright flashes of about the same intensity, which are clear and sharply defined, this one is bounded distinctly on both sides with *dark borders*. A similar type of flash was photographed by Mr. George Primavesi, at Tooting, but it is far more intense, and the borders are more pronounced (*Knowledge*, vol. xviii., p. 224).

To sum up, then, the different appearances of lightning flashes in photographs, excluding any reference to ramifications, we have—dark flashes (simple); dark flashes with bright core; bright flashes with dark boundaries; bright flashes (simple); bright flashes with dark core.

So much, then, for actual types of photographs of lightning obtained in Nature.

FIG. IV.—LIGHTNING PHOTOGRAPHED BY DR. W. J. S. LOCKYER, AT WESTGATE-ON-SEA, AUGUST 5, 1899.

Both bright and dark flashes of lightning are shown.

Can we reproduce in the laboratory all these types? and further, do the dark flashes actually exist, or are they the result of some photographic action on the sensitive film?

Some years ago Mr. Clayden pointed out, in a series of experiments he made, that dark, as well as bright flashes, could be produced artificially on one plate. The result of his investigation led him to formulate the following theory.

If the lens of the camera be covered the moment after a flash occurs, the developed image will always come out bright, feebly or strongly, according to circumstances. If, however, the plate be exposed after the flash has acted upon it, either to the continued action of a feeble diffused light or to the powerful glare arising from one or more subsequent flashes, then on development the image of the original flash will probably come out black.

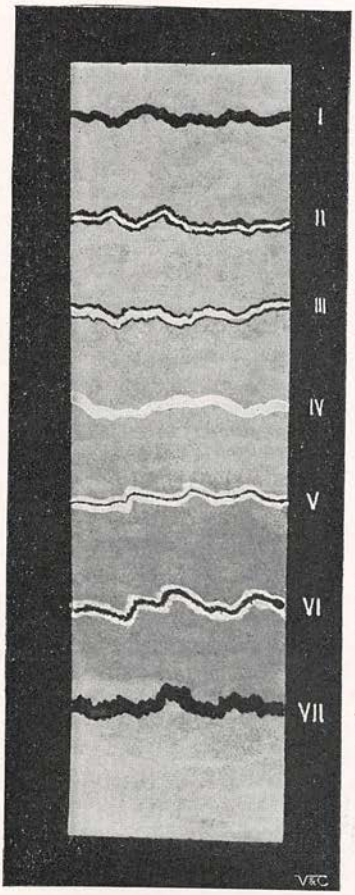

FIG. V.—DIAGRAM SHOWING THE EVOLUTION OF A LIGHTNING FLASH.

The effect, then, according to Mr. Clayden, is a purely chemical one, or, in other words, actual dark lightning flashes do not exist in Nature.

Now, although Mr. Clayden has shown that simple dark flashes can be artificially produced, the question then arose, how about dark flashes with bright cores, and bright flashes with dark boundaries, which have been photographed? Can these types also be produced artificially on Mr. Clayden's theory? No photographs of sparks produced in the laboratory had, as far as I know, displayed any of these peculiarities.

To investigate this question, laboratory experiments were made on the following lines.

In a darkened room an exposure on a single spark from an induction coil against a white cardboard background was made. On development this bright flash came out *bright*. This is what one would naturally expect. A new film was next inserted and the same experiment repeated, except that the film was not removed or developed. After moving the poles between which the spark passed, two more sparks were allowed to pass. The poles were again moved and then four sparks passed, but during the passage of these four sparks, the background was illuminated by burning magnesium wire. On development the sparks appeared as shown in Fig. VI.

A is the first spark, B the two sparks after the first movement of the poles, and C the last four flashes when the background was artificially illuminated. The illumination of the background has thus reversed the bright sparks A and B into dark ones, while even the two bright flashes in C have attempted to alter the remaining two in C, but have given them only dark borders.

In this one experiment we have thus produced dark flashes with bright cores, bright flashes with dark boundaries, and simple white flashes, reproductions practically of the lightning flashes illustrated in the previous photographs.

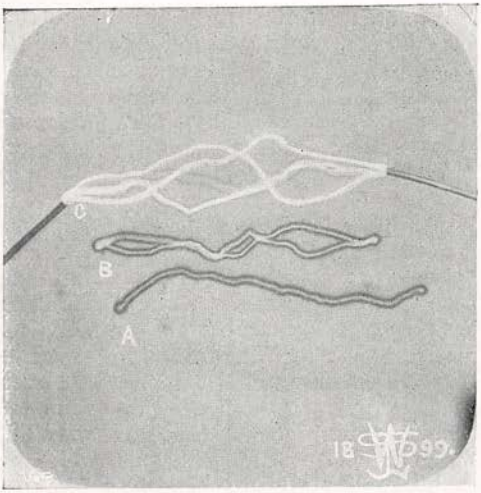

FIG. VI.—SHOWING THREE SERIES OF SPARKS ON ONE PLATE AGAINST A WHITE BACKGROUND.

During the passage of the sparks at C the background was artificially illuminated.

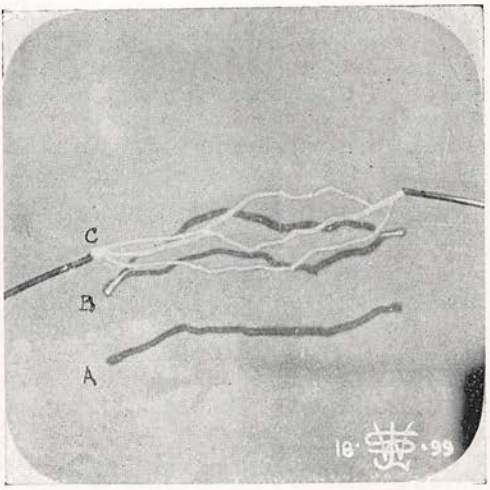

FIG. VII.—SAME AS FIG. VI., BUT BACKGROUND DURING EXPOSURE OF C ILLUMINATED TO A DIFFERENT DEGREE.

There seemed evidence, therefore, to conclude that, irrespective of the brightness of the first flash, subsequent bright flashes tended to reverse or make dark or partially make dark the previous flashes photographed.

Another similar experiment was made, but the background was illuminated to a different degree; the result is shown in Fig. VII. Here it will be noticed that the flashes that have been rendered dark at A and B have much smaller cores, while the three flashes at C are none of them simply bright, but each has dark boundaries.

In studying Fig. VIII. in the light of these

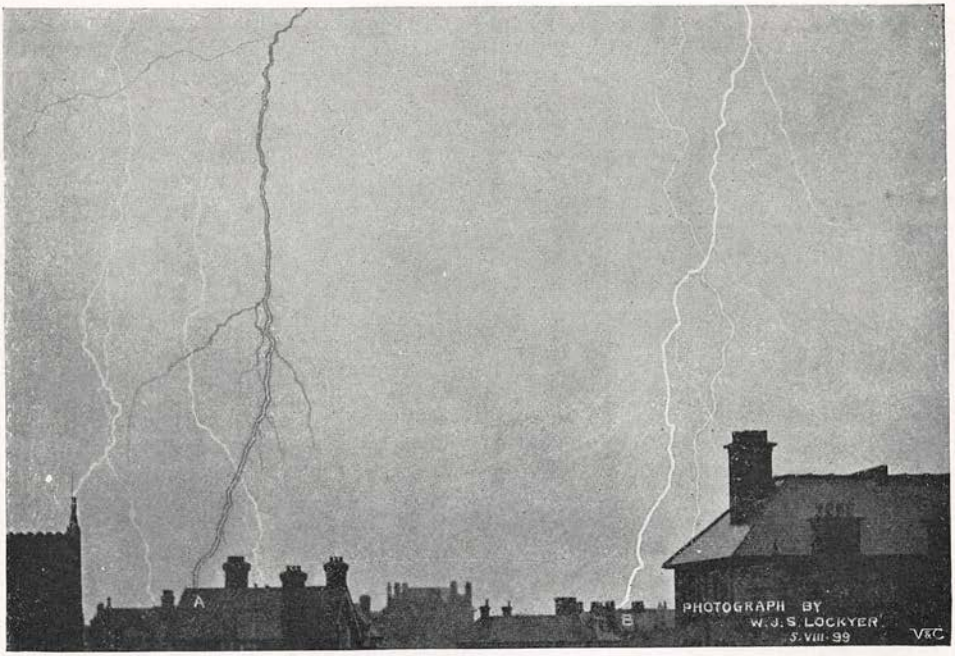

FIG. VIII.—PHOTOGRAPH TAKEN BY DR. W. J. S. LOCKYER, AT WESTGATE-ON-SEA, DURING THE THUNDERSTORM ON THE NIGHT OF AUGUST 5, 1899.

Both bright and dark flashes of lightning are shown. Exposure fifteen minutes.

results we can form an idea of the order of appearance of the flashes. That marked A was undoubtedly the first to occur. Then the flash B made its appearance, and, being so intense, illuminated the neighbouring region (similarly to the magnesium wire and white cardboard) round A that the image on the film was affected chemically and rendered A dark. The flash near B was probably the next in order, but, being more distant and therefore fainter, did not have any effect on A or B. It, however, was affected by subsequent flashes, which were not bright enough to alter A or B, but were sufficiently intense to give it dark borders. The above order of appearance is, to a great extent, corroborated by the apparent distances of the flashes, as can be gathered from their points of first appearance in the photographs.

There seems little doubt now that we have here the true solution of the problem of dark lightning flashes, and we must consider their appearance on the photographic film as due to chemical action, as Mr. Clayden first suggested.

It is, further, very interesting to study the cycle or evolution which a flash undergoes when photographed on the same plate with other flashes. Such an evolution is shown in diagrammatic form in Fig. V.

Commencing with Type I. we have the extraordinary *dark* flash ; this has been rendered dark by subsequent bright flashes, as previously explained. Type II. is a dark flash which has a small white core. Notice that the core now increases at the expense of the dark portion. Type III. shows the core very strongly developed ; this flash may be described as either a bright flash with dark boundaries, or a dark flash with a very intense bright core. Greater intensity of the core gives us a simple bright flash, as shown in Type IV. Now, for moderately intense flashes a double reversion takes place, and we get such a type as V.—that is, a bright flash with a dark core. A more brilliant flash would show probably a still broader dark core, as Type VI., while one can imagine that the intensity of a flash could be such that it would be totally reversed, and we should obtain the appearance as in Type VII., which is similar to Type I. with which we commenced. It is probable, however, that the core seldom develops sufficiently to produce a dark flash like Type VII., but that the simple dark flashes usually recorded are generally after Type I. and caused by the Clayden effect. Types I.–III. should be only produced when more than one flash is photographed on a single plate, but Types IV.–VII. could be obtained by photographing single flashes.

Readers of this article who have unmounted photographs of interesting lightning flashes, and who would be willing to exchange them for any of the above from the original negatives, would confer a great favour on the writer of this article.

"THE OLD PASTURES."

A photographic study by Charles Reid, Wishaw.