

boned; but the flashes in a picture need not have occurred simultaneously. The committee have not yet in their possession any conclusive evidence as to whether the same flash may be normal in one portion and ribboned in another portion of its course. In one picture there is a bright streak on the top of the flash; then about an eighth of an inch of ribbon-like light, the folds following the sinuosities of the bright streak; then a dark band parallel to and following every irregularity of the bright streak, and then nearly another $\frac{1}{8}$ th of an inch of ribbon-like light. In another picture a very thin beaded flash has a precisely similar beaded streak, rather fainter than itself, running parallel to it at a distance of about $\frac{1}{8}$ th of an inch on the paper. It might be suggested that the second fainter image was formed by internal reflection from the back surface of the glass plate; but it should be noticed that sometimes very thin flashes, which are not particularly bright, are so duplicated. A far more probable cause is the double image formed by the internal reflections of doublet photographic lenses. All doublets are essentially two meniscus lenses, mounted with their concave surfaces facing one another. The greater portion of a strong point of light, passing through both lenses, forms the usual image on the plate, but a smaller portion is reflected from the concave surface of the front lens, and from thence back through the rear lens to the sensitive plate. The amount of displacement depends on the angle formed between the direction of the bright point and the optical axis of the lens.

"M. C. Moussette, of Paris, showed some photographs of the sun, in which this double reflection image was very conspicuous; and there is not the slightest doubt that some lightning flashes are bright enough to give this secondary image. M. Moussette also showed the photograph of a flash in which the centre of the flash was the whitest, with a darker edge on either side. This may have been produced either by a double reflection from the lens or by internal reflection from the back of the glass plate. Two bands of light—the primary and secondary images—slightly overlapping would form an extra bright band where the overlap took place.

"In the majority of cases, the folds of the ribbon formation are most obvious when the course of the flash is square to the width of the folds, and they are but slightly pronounced when in a line with them. This would suggest the idea of a shaking of the camera in the direction of the folds of the ribbon; but, if this is so, the duration of a lightning flash must be much longer than is supposed. The committee hope to have the opportunity of making some experiments on the photography of sparks from a coil or electrical influence machine. In the meantime, they defer expressing an opinion as to whether lightning ever really takes a ribbon-like form, till further evidence is available, but would point out that both sources of error—the duplication of the image either by reflection inside the lens or by reflection from the back of the plate—would be avoided by the use of single lenses, and of paper, instead of glass, supported films. The committee also forbear for the present from publishing a reproduction of a ribbon-like flash till they are satisfied that such a form of lightning really exists, and that the whole appearance is not due to photographic causes."

Some two years ago, while experimenting with electricity, I obtained a photograph, showing the dividing and twisting rotary motion of the electrical current. My plate was not quite in focus, but the image is sufficiently sharp to show that the current divides and rotates, not only on itself, but upon its fellow.

Knowing, as we do now, that the current has a rotary mo-

tion, we can see in the main track indications of this motion that would be impossible for any jarring of the camera to produce. Further investigation disclosed the three motions before mentioned, to illustrate which I have, by permission of A. H. Binden, taken his remarkable photographs of many flashes of lightning, about which it was truly said in the *Boston Herald* of July 29th, 1888—"Mr. Binden has been singularly fortunate in securing, with his two plates, photographic reproductions of all the typical forms of lightning flashes mentioned in the committee's report."

The lightning flash, examined as a whole, is seen to leave the cloud and reach the earth in an irregular, twisting, rotary manner, throwing off branches as it goes; these also twisting, rotating, and sub-dividing into the sinuous, ramified, meandering, beaded or chapleted, and ribbon lightning, mentioned in the Meteorological Society's report, while the main current, rotating as it goes, finally enters the earth in a divided form, which plainly shows this twisting rotary motion in the main current as well as in its branches.

Stream lightning is well described by its name alone. In this form I find what I have called the straightforward motion. Its photographs show almost straight lines, without the curves indicating the rotary motion.

Sinuous, ramified, and meandering lightning are all very much alike, if we grant that which we can hardly doubt, viz.: that they all may divide and sub-divide as they advance. In all of these we find a rotary motion, with a direction either from left to right, or right to left; in some branches both motions are found, and when well defined resemble the twist of a rope.

Beaded lightning has that about it that is much more interesting from a speculative point than either of the others. The explanation given in the Royal Meteorological Society's report of the beaded form hardly explains all that we find in and on both sides of this bead; for we see the rotary motion of this current before entering the bead to be in one direction, and immediately after leaving the bead to be in the opposite direction, plainly indicating that the motion sometimes changes in the bead.

Ribbon lightning has what I have designated the curled motion. In this one sees the resemblance to a curled ribbon. This current is evidently flat, with a motion that forms this ribbon into a curl. It somewhat resembles the beaded form, inasmuch as it is seen to change its direction, thus forming curls twisted in opposite directions and united, not by a bead, as in the beaded lightning, but by a white edge where the process of reversing its motion goes on, while at another point it presents the appearance of a curl pulled sidewise, being thin and narrow; afterward proceeding in a more regular manner than before. No possible shaking of the camera could produce this curled appearance.

That currents of electricity are influenced by the medium through or upon which they travel, is also seen, and to the well-known theory that the resistance of the air changes its direction, may be added, that the current changes in size and contracts in volume as it enters the earth.

If we compare the size of these currents with the trees or other known objects, seen in the same photograph, taking into consideration the distance each one is from the lens, one must, by comparison, judge the size of large currents to be, while passing through the air, several feet in diameter; distance must always be considered in judging the size, for as the current goes from the lens its image on the negative gets smaller, and larger as it approaches it.

Sparks from an induction coil or Holtz and other machines