ART. XLV.—*On a peculiar form of the discharge between the Poles of the Electrical Machine;* by ARTHUR W. WRIGHT, Prof. of Physics and Chemistry in Williams College.

WHEN the Holtz electrical machine is working at a high tension, but without the condenser, if the distance between the poles be gradually increased, the discharge successively varies from the ordinary spark of an inch or two in length to a diffuse, much branched, and feebly luminous spark, which under high tension may attain a length of several inches, though it gives but a slight detonation. If the interpolar space be still further widened, either the discharge becomes finally silent, or, more commonly, one or more small jets or brushes issue from the negative pole, with a hissing or fizzing sound, if the discharge is very energetic. When this is the case the positive pole is covered with a diffuse glow, resembling that of a phosphorescent substance, or rather, so thin is the luminous stratum, the pole appears as if it were *illuminated* by a light shining from the direction of the opposite pole. The polar interval, under which the glow appears to best advantage, varies somewhat with the condition of the atmosphere, but, with the machine used in these experiments (a Holtz machine with 20-inch revolving disk), extends from three or four to seven or eight inches, depending also to a certain degree upon the tension of the machine.

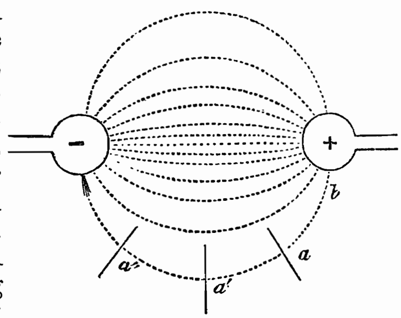
If now the finger or some other object be interposed between the poles, the glow is interrupted, and a silhouette of the object is formed upon the brass ball, which strongly resembles the shadow cast by the body when placed in a beam of luminous rays, moving as the body moves, expanding and contracting as the distance varies, and the like. So striking is the resemblance of this appearance, which may be called an *electrical shadow*, to a real shadow, that I had many times noticed it casually, when using the machine in a dimly lighted room, without suspecting that it was not actually a shadow due to light reflected from objects in the room upon the ball, and it was only when the experiments were made in a room completely darkened that its different character became clearly apparent.

The experiment succeeds best when the air is not too humid, and a single jet issues quietly from the negative. With a little care and after a few trials the shadows can be obtained with great distinctness and remarkable regularity. It is better in general to use for the interposed body some non-conducting substance, or an imperfect conductor, like paper, or wood, as when metallic objects are used they become electrified by induction, and disturb the regularity of the phenomena, or, when the tension is very high, cause the passage of diffuse sparks and brushes. With proper care, however, good results can be got with metals, though usually for much smaller polar intervals than with poor conductors.

In order to ascertain with how great accuracy of detail the figures are formed, a piece of wire gauze was used, the meshes of which were about $2{\cdot}5^{mm.}$, and the wires forming them about $1^{mm.}$ in diameter. The poles being separated about four and a half or five inches, the shadows were formed with striking distinctness, even where the gauze was two inches distant from the positive pole, growing smaller and smaller as it receded. Every peculiarity of the texture was faithfully represented, the irregularities of the wires, breaks in the gauze, and the like, being accurately reproduced, and moving with the gauze, just as in the case of true optical shadows. With a piece of still finer wire-cloth, the meshes of which were about $1{\cdot}3^{mm.}$, similar results were obtained, the distances, however, being smaller than in the previous case. When the gauze was an inch or an inch and a half from the positive, the meshes in the shadow were seen with some difficulty on account of the feeble illumination, but still appeared quite well formed and regular. Their size could not readily be ascertained by measurement, but they were estimated at from one-third to one-half a millimeter in diameter.

More interesting and varied results were obtained with a grating made of common writing paper by cutting out square apertures about $3^{mm.}$ in diameter, and the same distance apart. The piece used contained twenty-five such apertures, arranged in the form of a square with five on a side. Shadows of great sharpness and accuracy were obtained with ease even when the poles were seven or eight inches apart. As the paper was moved toward the positive side they grew smaller, and again enlarged as it approached the negative, becoming, however, somewhat indistinct when nearer the latter. When the negative jet and the center of the grating were in the line joining the two poles, the images were formed symmetrically about the vertex of the positive pole. The corner apertures in this case being more distant from the axis, had their images somewhat distorted, so that the sides of the square were represented by lines curved in such a way as to make the angles at the corners acute, just as it would happen if the square should be stretched in the direction of its diagonals.

Very frequently, in fact usually, the jet does not issue from the vertex of the negative, but is displaced to the one side or the other. In such cases the glow is also displaced in a similar manner, that is, so that its axis is inclined at an equal angle to the line between the poles with that of the negative jet. If the grating is placed before the latter, and perpendicular to it, the shadows are still formed as before, though not in general quite as perfectly. Thus if placed at *a*, as in the cut, the image appears at *b*. On moving it away from the pole to a position represented by *a′* the image still appears at *b*, but is larger, and so on at *a″*, or until it is brought within an inch or two of the negative. In this way the lines traversed by the electricity, or along which it acts, may be readily traced, and they are found to have a conformation similar in some respects to that of the voltaic arc, but far more regular and symmetrical. In their general character they are represented by the dotted lines in the cut. Issuing normally from some point of one of the poles, a line passes in a curve to the homologous point on the other pole, where also it meets the surface normally. When the jet is not far from perpendicular to the line of the poles, the curve may have an amplitude of nearly or quite half the distance between the latter, even when these are eight inches, or more, apart.



An interesting case occurs when the negative discharge takes the form of a ring. The glow likewise assumes the form of a narrow and sharply defined ring, whose size and position of course depend upon those of the other ring. The approach of any intercepting or disturbing body either breaks or bends the luminous line, and this affords, perhaps, the best means of determining the form of the curves between the poles, as the limits where the disturbance begins are pretty definitely marked, and their position can be readily determined by measurements. An easy way to secure a steady and well-defined ring, is to place upon the negative pole, first removing the ball, a common bottle cork an inch or two in diameter, well shaped and carefully smoothed, with the larger face towards the positive pole, and perpendicular to the polar axis. On putting the machine in action, the electricity issues from the sharp edge of the cork in the form of a regular and steady fringe-like ring, the radial elements of which stand at a nearly constant angle with the axis. A beautifully distinct ring is thus formed upon the opposite pole.

Comparing the forms of the curves indicated by the above experiments with the ordinary sparks and brushes, or even with the voltaic arc, a striking difference in respect to symmetry and constancy is observed; and the distinctness and beauty of some of the phenomena are very remarkable, especially when it is considered how lawless and irregular the ordinary spark and brush discharges are as to form. The glow, like the brush, is obviously caused by the discharge of electricity at the positive pole, and apparently a discharge from one pole to the other takes place, silently and without luminous effect, through or by means of the intervening air. But that the lines along which it takes place should be so constant and regular is somewhat surprising. It is to be observed that the perfection of the results depends to a considerable degree upon the condition of the air, as when this is too moist, the discharge is not sufficiently energetic, or the resistance is not sufficiently great, to bring out the glow, or to form the images with distinctness.

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