Priestley Rings

By Tom Bresenhan

The introduction to the 1966 reprint of Joseph Priestley's The History of Electricity lists original observations in electricity including: the inverse square relationship of electrical force to distance; the relationship between capacitance of condensers to the area of their plates and distance between them; the relationship between conductivities of wire to their length and cross section and the comparative conductivity of metals. Priestley was not a mathematician and did not go on to quantify any of these relationships. Others did and made names for themselves.(1) Priestley was an experimenter and the merit of his work is in the excellence of descriptions based of his facility in the laboratory. The one discovery in electricity that does bear his name is "Priestley Rings". (2)

Priestley first reported the observation of a crater and circular spots on metals subjected to a spark from the discharge of Leyden jar battery in a letter to John Canton in June 1766. (3) He wrote, " … the metal first melted, then being liquid is thrown forward or rises as water would do, sometimes making bubbles that then burst giving a crater like appearance, deeper in gold than in silver." He also reports of an external circle at a distance from the crater. Fig. 1

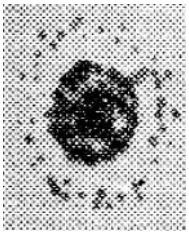

Fig. 1

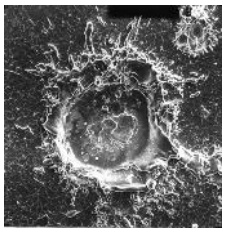

Fig. 2

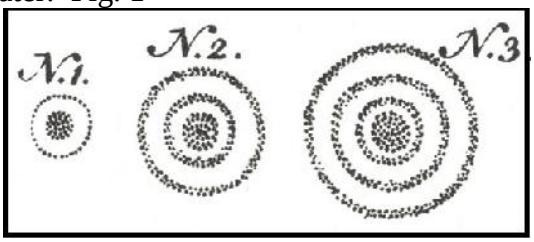

Fig. 3

Priestley's continued experiments were reported in a paper read March 1768 at the Royal Society (4) which was revised slightly when included in his *History and Present State of Electricity with Original Experiments.* (5) His investigations began with an attempt to reproduce the lateral force that lightening affected near to, but not in the path, of the stroke. Taking a spark discharge from a battery of Leyden jars through a pointed rod to a plate of metal he observed concentric colored rings appearing on the plate surrounding the spot hit by the spark. Priestley's attention was drawn to the size, intensity and color of the rings. He observed the colors under a microscope finding them in the order of the rainbow. Priestley wrote that the circle and central dot appeared to consist of cavities resembling those on the moon seen through a telescope.

In 2003 Physicist Andre Anders writing of the origin of arc plasma science commented on Priestley rings. (6) Anders reasoned that the formation of circles around the crater may be associated with damped oscillations of the electrical circuitry. He offered the image of an erosion crater of catholic arcs taken by a modern scanning electron microscope. Fig.2 Anders added, "We know that a higher discharge current causes the number of arc spots operating simultaneously to increase rather than a change in the character of individual spots. The number of spots, or current per spot also depends on the material and its surface conditions." Priestley found that the depth of the craters depended upon the electrode material beginning with the deepest: tin, lead, brass, gold, steel, iron, copper and silver. Priestley also found that the number of circles formed depended upon the distance the needle point is from the metal surface. He produced two or three circles as he withdrew the changed needle from the metal plate as shown in his drawing in Fig 3.

Priestley noted that beyond the central spot was a circle of black dust. (7) He discharged a large battery of Leyden jars through a brass chain and observed that the electric sparks between each link were intensely bright some appearing to make the chain appear like one flame. Anders comments that the electrical contacts between the links of the brass chain were insufficient to carry the high short-circuit current and thus short arcs formed. Stretching the chain tightly Priestley observed that the black dust was light and rose like a cloud. He next laid the brass chain on glass and after charging noticed the glass was marked where it touched the chain. Fig 4 shows Priestley's drawing of the charging apparatus and marks left on glass by the charged brass chain.

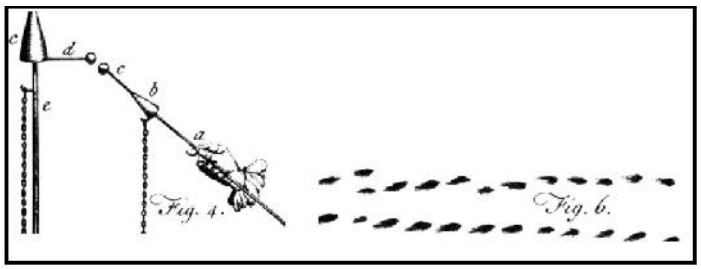

Fig. 4

Anders concludes that the limitation of energy storage in batteries of Leyden jars allowed only pulsed and oscillating discharges to exist, as no continuous discharge was yet possible. As a consequence these discharges show characteristics today associated with cathodic arc discharges: explosive emission process, formation of erosion crater, macroparticles and well-adhering coating of surfaces in the plasma stream. (8)

Priestley's writings were widely known in the 18th century however no practical application could be found and his electricity observations remained a laboratory curiosity and largely forgotten. Until, in the 1800s, Thomas Edison revived cathodic arc research for plating and was awarded several patents.

Figure captions

Fig. 1 Priestley's hand drawn sketch of crater and ring in letter to John Canton (1766).
Fig. 2 Scanning electron microscope image of erosion crater from cathodic arc discharge on copper.
Fig. 3 Plate 1, Fig. 5, History of Electricity, showing Priestley rings.
Fig. 4 Plate 1, Fig 4 & 6, History of Electricity, showing marks left by charged chain on glass

Sources:

1. R.E. Schofield, "Introduction", reprint of The History and Present State of Electricity with Original Observations, (3rd Edition, 1775), New York, Johnson Reprint Corporation, 1966
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4. J. Priestley, *"An account of rings consisting of all the prismatic colours made by electrical explosions on the surface of pieces of metal,"* Philosophical Transaction, Royal Society. January 1768.
5. J. Priestley, *"Experiments in the circular spots made on pieces of metal by large electrical explosions"*, in The History and Present State of Electricity with Original Observations, Section IX, 1775.
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