

Lightning Wheel

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Charge density tends to be very high on sharp points of a conductor¹⁻⁵ if it is connected to a high voltage source. The electric field strength immediately above a charged surface is proportional to the surface density of charge². So electric field near the sharp points can attain a very high value. Since electrostatic pressure on a charged body increases with surface density of charge⁴, leakage of charge becomes more effective at sharp points.

Normally air does not conduct electricity. However, it contains a small number of charged particles produced by ionizing radiation^{2,6}. Such a particle close to the charged conductor is accelerated by the electric field. If the field is very intense, it picks up enough speed and ionizes other air particles¹. As a result, more ions are produced. The ions having similar charges to that of the charge on the conductor are strongly repelled by it. This constitutes an electric wind^{2,3}, the action of which is used in lightning conductors^{5,6}. The charge particles with opposite sign are attracted to the sharp points and neutralize its charge. So the conductor loses charge to the surrounding air². The motion of the charged particles may constitute a discharge or leads to a lightning spark.

A working exhibit has been developed based on this principle. The exhibit comprises of a set of two similar wheels of 56 cm diameter each as shown in the schematic diagram in (fig.1). Each wheel comprises of

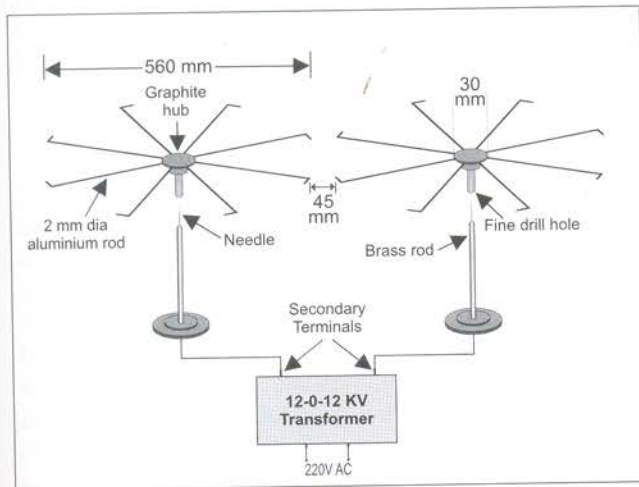


Fig. 1. Schematic diagram of the experimental set up

eight spokes, and is made of light weight material, aluminium. The ends of the spokes are bent at 90° and the tips are made sharp. The central hub that holds the

spokes is made of graphite. The choice of graphite is obvious, a conducting, light weight and lubricating material. It offers very less frictional resistance. A small hole is made at the bottom of the hub for pivoting. The graphite-hub supporting the wheel can rest on the tip of a fine needle; the other end of the needle is supported on a vertical stand. Accordingly, the wheels are quite free to rotate on a horizontal plane. Arrangement is made to vary the gap between the wheels. However, under this experimentation the gap is always maintained at 4.5 cm.

The wheels were connected to the secondary terminals of a 12-0-12 KV transformer under different experimental conditions. At first, only one wheel was connected to one of the terminals, leaving the other floating. The wheel was found to rotate when the device was switched on. Secondly, both the wheels were connected to one terminal leaving the other floating as in the first case. It was found that both the wheels rotate, but this time rotational speed was found to be less than the first case. Thirdly, the two wheels were connected to two separate terminals so that at any moment when one of them turned positive the other turned negative. This time interesting things happened. Both the wheels were seen to rotate with greater speed and at the same time they produced sparks within them. The sparks resembled intermittent lightning, tracing their zigzag paths in air (fig. 2) and generating intrinsic sound of its own kind.

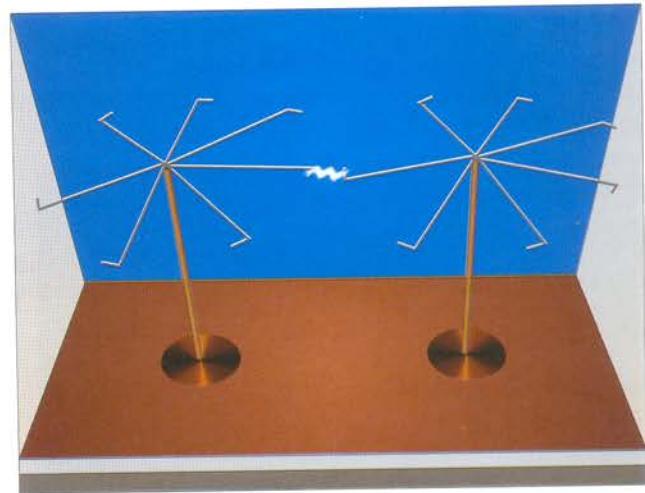


Fig. 2. A Lightning Spark

The variation of rotational speed in different cases may be analyzed in the light of accumulation of charges in the surrounding air. In the second case, when

both the wheels are connected to only one terminal, at any given time they either become positive or negative. The winds are therefore set up by same kind of ions and they repel each other. Consequently, for a short while, accumulation of charges take place in the gap between the wheels, hindering the winds therein to flow freely. Reaction force is therefore reduced to some extent. The wheels thus rotate slowly. In the last case the wheels are charged oppositely because they are connected to two opposite terminals of the transformer. The ions in the electric wind of one wheel are therefore attracted by the other. The wheels thus rotate faster because of the greater reaction force. Simultaneously, they produce spark within the gap.

To study the leakage of charges, current flowing through the device was measured under different conditions. It is to be mentioned that relative humidity while performing the experiment was sixty five percent. The primary voltage was kept at 220V. When only one wheel was connected to one terminal of the transformer, average primary current was found to be 2.32 mA. When both the wheels were connected to a single terminal, primary current was 2.46 mA. Current does not increase in that way though number of sharp points becomes double in this case. This shows that leakage of charges from the wheels takes place at a slower rate. On the other hand, when they were connected to two opposite terminals, primary current was found to be 2.80 mA. It agrees with the observable fact of increasing rotational speed of the wheels. This happens due to enhanced leakage of charges under this

condition. However, the current jumped to 7.0 mA or even more when sparks were created. They break intermittently due to increase in spark length since the gap between the spokes continuously goes on changing. The sparks resemble a lightning phenomenon. However, unlike normal spark discharges⁷, in most cases more than one spark were produced.

The demonstration is simple and the working principle is exciting in the way to understand electricity. Without using any expensive equipment like electrostatic generator or Tesla coil, rotary motion in a set of wheels with spectacular lightning effect can be generated by using an ordinary step-up transformer.

References:

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