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ELECTRON AVALANCHE IN A RADIO-FREQUENCY PLASMA TORCH

High Frequency Solid State Tesla Coil (HFSSTC), a.k.a. radio-frequency plasma torch is an atmospheric pressure plasma source that relies on high frequency oscillation of a resonator circuit to obtain a stable plasma flame. Unlike the vast majority of alternative methods, this type of circuit has only one electrode, emitting electrons into the surrounding atmosphere and causing ionization of neutral gas. The typical frequency range of the oscillator is 10MHz [1]. The ion temperature is observed to be several thousand °C. Although the mentioned device has a potential to serve a wide variety of practical applications as a stable cold plasma source (Ti <<Te) with an unshielded cross- section from one side, it remains a relatively little discovered phenomenon. This paper provides an overview of the electron avalanche effect taking place in the single electrode flame discharge.

At the moment of plasma flame initiation, a beam of electrons is emitted from a metal electrode surface. The charge propagates through the surrounding gas as a series of ionizing collisions. The electron avalanche current force equates to [2]:

$$I = \frac{I_0 e^{\alpha x}}{1-\gamma e^{\alpha x}}$$

Where $I_0 \sim n_0$ is current of initially free charged particles. However, unlike the two-electrode arc discharge, plasma torch does not facilitate the secondary electron emission due to the absence of cathode. Hence, the formula is rewritten as:

$$I = I_0 e^{\alpha x}$$

Current growth exponentially until all free-charged particles, triggered by cosmic radiation and other sources, have dissipated [2]. While in a traditional arc they reach the cathode, under the conditions of a high frequency solid state tesla coil discharge, the particles undergo the process of recombination with gaseous molecules. The plasma body, produced by a stable plasma source, is expected to exist in the atmosphere for a timeframe $t \gg 1/\omega_p$, where ω_p is plasma frequency, described as:

$$\omega_p = \sqrt{\frac{n_e e^2}{m_e \varepsilon_0}}$$

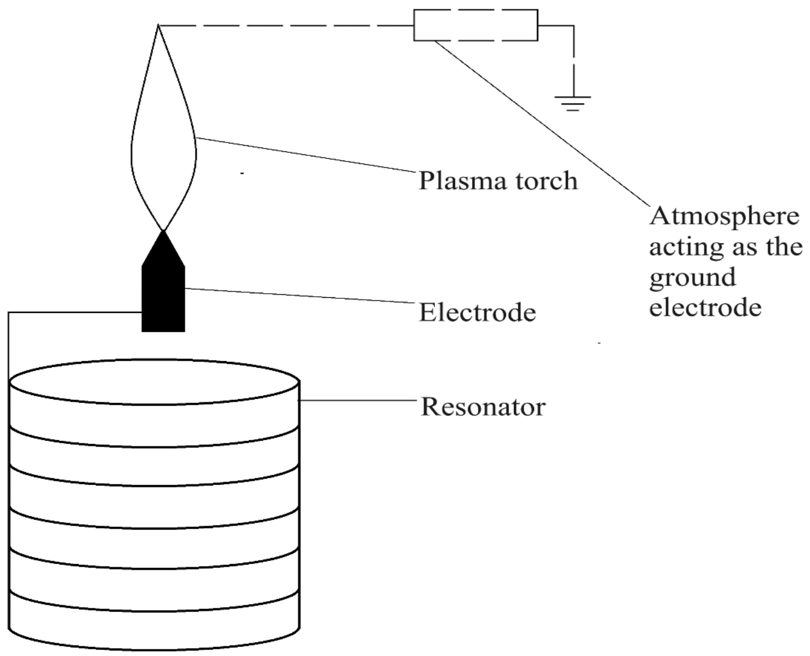

Fig. 1. Plasma flame generator

Thus, every electric pulse triggers a new formation of electron avalanche with initial current I_0 formed by not yet dispersed particles after the previous pulse. The principle of electron avalanche is sufficient for describing two observed peculiarities of the radio-frequency torch:

1. Plasma flame does not have a clear breakdown voltage value; instead, its size increases with the increase in voltage.
2. For the initiation of the torch a metal conductor is used as the ground electrode (although it is not required to be grounded, since its capacitance is sufficient). It supports the suggestion that the frequency of the resonator is higher than the plasma oscillation frequency, due to the number of free electrons formed by background radiation being less than between pulses.

The non-obstructed cross-section of the plasma body offers many advantages compared to more traditional discharges. However, since the operation of the device greatly relies on the pressure of the surrounding gas, it is not suitable for a low-pressure environment [3]. In conclusion, the radio-frequency plasma torch poses a great interest for both theoretical and practical research. Although the electronic circuit designs of such devices are well-known and diverse, the physical explanation of the process is still not fully developed. The mentioned plasma source also has many potential applications, including surface treatment, ignition, and energy transfer.

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NON-USEFUL PROPERTIES OF "USEFUL" ALUMINUM

The following facts are well-known about aluminum: it is an element of the IIIA group of the Periodic Table; it is the most abundant metal and the third most abundant element in the Earth's crust; its characteristic oxidation state is +3.

Aluminum is the most versatile and widely used metal on the planet. It is the material № 1 in aircraft construction, food industry, and the production of tableware. This success is due to the fact that it is easily separated from its ores, is resistant to corrosion and has high thermal and electrical conductivity; has a low density and is extremely plastic, as well as perfectly amenable to pressure treatment in the cold state. However, the efficiency of extraction and utilization of this metal by the aluminum industry does not align with the geochemical cyclicality of aluminum, as nearly half of it constitutes non-recyclable waste, which imposes a significant burden on landfills. The decomposition period of aluminum cans exceeds 200 years.

Therefore, there is an urgent need to understand how to live safely and efficiently with aluminum. There is an opinion that aluminum is a "safe" metal which does not have any particular negative effects on human health. However, in