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Letters to the Editor

Two anode corona glows as sources of spectrum and interference in air

ABD EL-HALIM TURKY*, REDA EL-KORAMY*, ASCIA GABRE**

Physics Department, Faculty of Sciences, Assiut University, Assiut, Egypt.

Anode corona was obtained in a one millimetre gap between a hyperboloidal point anode and a plane cathode. The discharge appeared as two glow regions which acted as coherent sources of air spectrum, separated by the dark region. The waves spreading out from the two sources produced an interference pattern according to their optical path difference. Bright and dark rings were obtained on the cathode plate and photographed.

1. Introduction

Corona features of short gaps have been the subject of considerable interest in investigations of the active medium in various industrial applications. Corona discharge was investigated for many decades [1], not only because of its practical importance, but also because of the scientific interest in its basic mechanisms and fundamental relations. Coronas for co-axial cylindrical and point-to-plane electrode geometries of particular shape were discussed in [2]–[8]. Because of the complex interaction of the ionization processes with the resulting space charge swarms and the resulting nonuniform electric fields, the corona phenomena being rich in variation are still not well understood. One of the important features of corona glows from the point electrodes is that they include, under certain conditions, two distinct glow regions, both of which act as partially coherent sources of air spectrum. The aim of the present work is: i) to obtain two glow sources of air spectrum of possibly high degree of coherence, and ii) to find the best conditions of the pressure and the gap width under which the point anode corona acts as two sources of air spectrum and produces interference pattern.

2. Theory

Coronas occurring at potentials just above threshold are often pulsating and intermittent by nature. At higher potentials, the corona undergoes a transition to a steady state which is usually described as the steady corona regime. Since the point electrode has a small redius of curvature at its tip, the electric fields can be very high

Present address:

* Physics Department, Faculty of Arts and Education, P.O. Box 549, Zlitin, Libya.

** Girls Department, Faculty of Science, King Abd El-Aziz University, Jehddah. Saudi Arabia.

in the vicinity of the tip in the absence of space charge [9]. After initiation, the discharge evolves rapidly into a corona glow region near the highly stressed point electrode. The mechanism of this glow is closely related to the Townsend breakdown, which occurs due to photoionization of the gas being the main source of secondary electrons. This type of corona becomes stable when the dc voltage is being applied for a long period of time. Therefore, the ionizing radiation from the discharge creates photoelectrons that form a space charge cloud beyond the glow boundary. A second bright ionization region appears due to collisions of electrons with gas molecules. Thus, the successive generation of electrons makes the discharge self-sustaining.

In the air, an ample of negative space charge splits the corona glow into two regions, which are called the primary and secondary glows. Under certain conditions, both these regions act as coherent sources of air spectrum. By superimposing the waves from the two coherent sources an interference pattern is produced.

3. Measurements

A schematic diagram of the experimental arrangement is shown in Fig. 1. The main components of the apparatus and procedure have been described in detail elsewhere [10]. The anode electrode of tip radius 0.03 or 0.06 cm was made of copper, while the cathode electrode was a copper plate of 1.5 cm diameter and thickness of 0.22 cm.

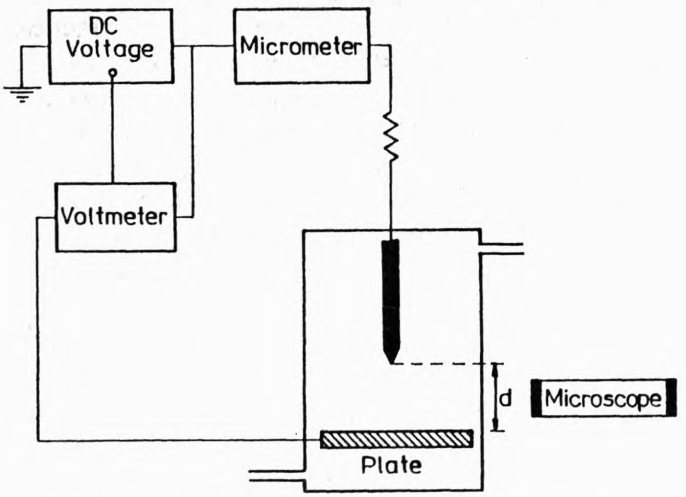

Fig. 1. Schematic diagram of the experimental arrangement

The gap width between the needle and the plate was 0.1 or 0.2 cm. It was photographed by a photomicrographic camera attached to a research microscope of Zeiss type (×90). The air pressure was reduced by using vacuum system and measured. The photomicrographs obtained are shown in Fig. 2. Pictures 1–4 of the corona glows were taken for one millimetre gap and constant pressure of 60 Torr. Pictures 5 and 6 were taken under the same conditions, but the pressure was increased up to 160 Torr. Pictures 7–12 were taken when the corona was increased

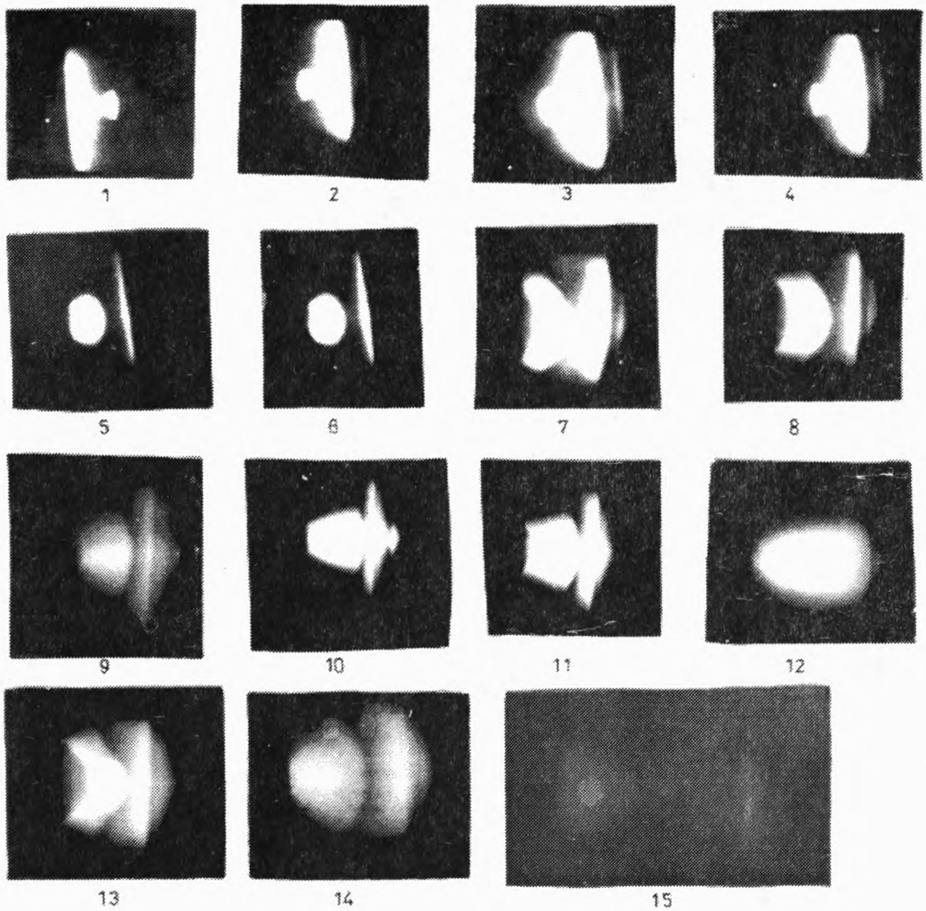

Fig. 2. Corona glow photomicrographic pictures at different corona gaps and different pressures (see the Table)

to 0.2 cm at different pressures and constant potential 2700 V. Pictures 13–15 were taken at the different gap widths equal to 0.1, 0.2 and 0.3 cm, respectively, while the anode tip radius was 0.03 cm, and constant pressure was equal to 60 Torr. After having taken each picture, the cathode plate was examined and photographed. Figure 3 shows the pictures of the cathode plate taken after each run. The Table records the data at which each picture was taken. The electric field was calculated at the anode tip by using Eyring's equation [11]. The corona glow intensity of the pictures 1–4 was measured by the Rapid Photometer SP2 and plotted in Fig. 4.

4. Results and discussion

Visually and photographically the discharge near the anode tip appears as a bright bluish white primary glow. This glow is separated by a narrow dark space from

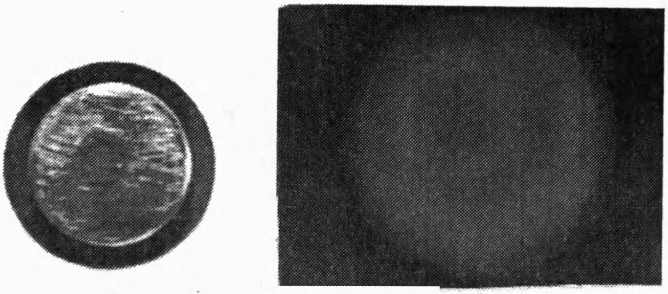

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Fig. 3. Photomicrographic pictures of the cathode plate taken after each run

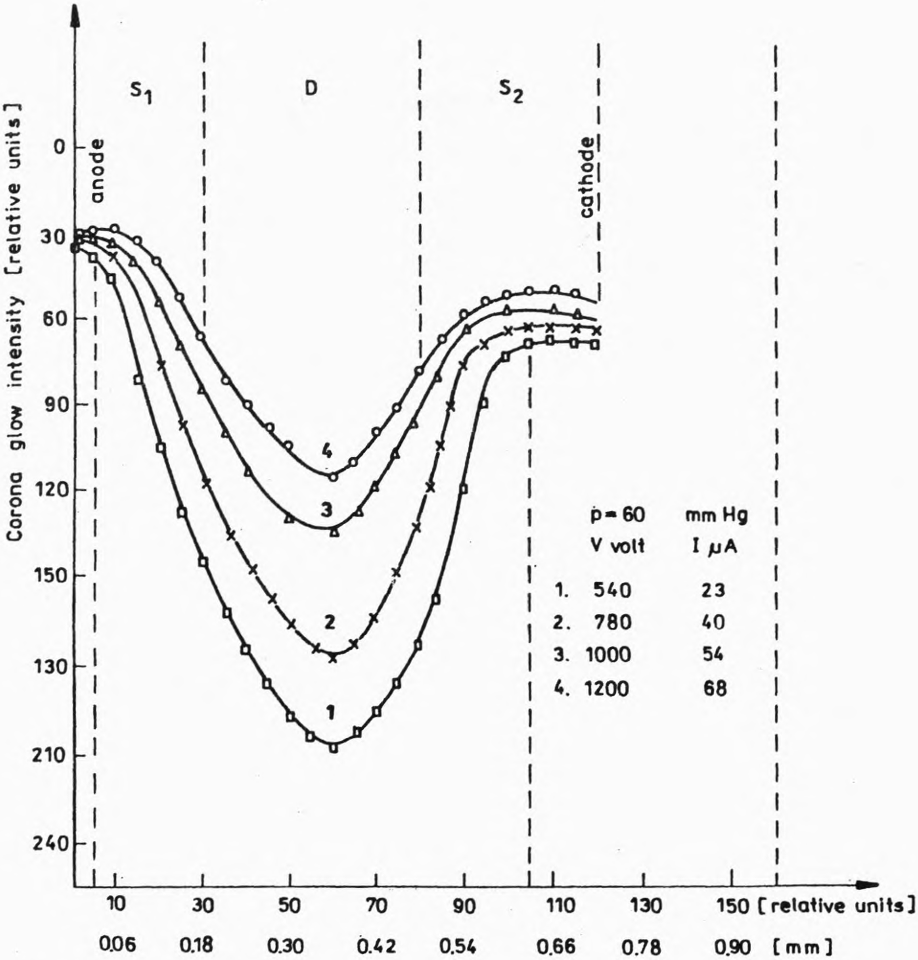

Fig. 4. Variation of corona glow intensity as a function of the distance from the anode to the cathode. S_1 – primary glow region (max. glow at 0.03 mm), S_2 – secondary glow region (max. glow at 0.63 mm), D – dark region (min. glow at 0.36 mm)

T a b l e. A review of parameters

Picture number	Gap width [cm]	Pressure [Torr]	Current [μA]	Potential [V]	Electric field [V/cm]	Length of primary glow [cm]	Length of secondary glow [cm]
1	0.1	60	22	540	9488	0.010	0.015
2	0.1	60	39	780	13705	0.01	0.020
3	0.1	60	57	1000	17570	0.01	0.023
4	0.1	60	87	1200	21547	0.01	0.027
5	0.1	160	19	650	11420	0.025	0.005
6	0.1	160	26	800	14056	0.027	0.006
7	0.2	60	180	2700	34749	0.058	0.060
8	0.2	120	176	2700	34749	0.107	0.038
9	0.2	180	170	2700	34749	0.125	0.028
10	0.2	240	163	2700	34749	0.133	0.014
11	0.2	300	154	2700	34749	0.143	0.014
12	0.2	360	150	2700	34749	0.143	0.014
13	0.1	60	59	2200	56628	0.062	0.022
14	0.2	60	104	2200	44670	0.072	0.032
15	0.3	60	104	2200	39759	0.083	0.034

a fainter glow (the secondary glow) in the gap near the cathode. Both of these two glow regions act as coherent sources of spectrum, separated by the width of the dark regions, where space charges occur. The waves spreading out from the two glow sources differ in path which will produce an interference pattern. The bright and dark rings are obtained at the centre of the cathode plate. Diffraction also leads to interference pattern when we have a row of glow sources. The point of maximum and minimum luminosity changes if pressure changes, but it remains unchanged at constant pressure when potential increases. By changing the pressure different corona glow sources are produced.

All experimental measurements were performed in air at different pressures. The structure and intensity of the anode corona are comparatively sensitive to anode needle tip radius, the gas pressure and the gap width.

As shown in the photomicrographs (Fig. 2), the region of the glow splits into nearly two equal subregions separated by the dark space, when the air pressure is 60 Torr. At the higher values of pressure, the width of the secondary glow region decreases. Equality of the widths of the primary and secondary glows is always observed at the air pressure of 60 Torr. It is still observed when the gap width is changed to 0.2 cm, while the anode tip radius is sharpened to 0.03 cm.

The best conditions at which the anode corona acts as two sources of air spectrum, which produce very obvious interference pattern are: gap width 1 mm, air pressure 60 Torr, and the anode tip radius 0.06 cm (Fig. 3, picture 17).

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