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CHARACTERISTICS OF CORONA VOLTAGE STABILIZER AND REGULATOR DEVICE

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The present work is intended to investigate the properties of a perforated cathode wire-plate corona detector when used as corona voltage stabilizer and regulator (CVSR) device. In particular it is devoted to the investigation of the dependence of the stabilization and regulation on the inter electrode spacing (h_{a-c}) and the effect of the limiting resistance.

Key words: Corona voltage, Stabilizer, Regulator.

Introduction

The growing use of the cathode rays tube as an accurate display of many types of information, the increasing applications of the photo-multiplier tube, the importance of nuclear energy measurements and a host of other recent developments have greatly multiplied the interest in the voltage stabilization and regulation of high voltage, low current power supplies. The corona type voltage stabilizer and regulator (CVSR) is ideally suited to such application. The corona type voltage regulator was first developed by Victoreen Instrument Company [1]. The corona voltage stabilizer at normal atmospheric pressure was investigated [2]. The basic mechanism of various corona modes and corona stabilization have been studied by Loeb [3]. More work has been done on the wire-plane [4,5] and gridded devices [6] for CVSR devices.

This work deels with the performance of a perforated cathode CVSR in an attempt to improve the working characteristics of the normal wire-late CVSR [7].

Experimental Set Up

The design of our CVSR is similar to that shown in Fig. (1). A highly polished stainless steel plate with thickness 3 mm and area (170 x 30 mm^2) serves as plate cathode. Through the middle zone of this cathode (of area 100 x 10mm^2) passes square holes (each of area 0.25 mm^2 and depth = 1 mm). The distance between the centeres of two successive holes is one mm. A strong spring brings the cathode tight to two metallic supports which can be used to level and move the cathode to the required position. Konstantan wire of diameter 0.35 mm is used as anode stretched tightly between two iron strips and held by scrows at both ends. A travelling microscope is used to ensure uniform separation between the electrodes. A stabilized high voltage power supply gives positive d.c. voltage from 0 to 40 kv. The relative humidity (R.H.) as well as the temperature (t) has been always kept constant i.e. R.H. = 30% and T = 25°.

A variable load resistance R_L (from 20 to 740 MΩ) was only connected between anode and cathode when the device was investigated as a voltage regulator.

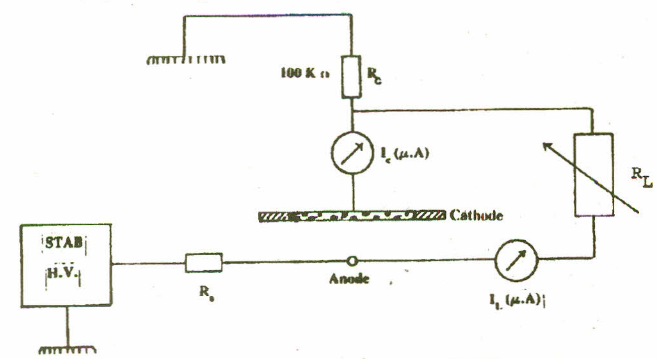

Fig. 1. The arrangement of CVSR

Results

(a) Device as Voltage Stabilizer. Figs. 2 and 3 show the relation between the applied voltage (V_a) and the corona

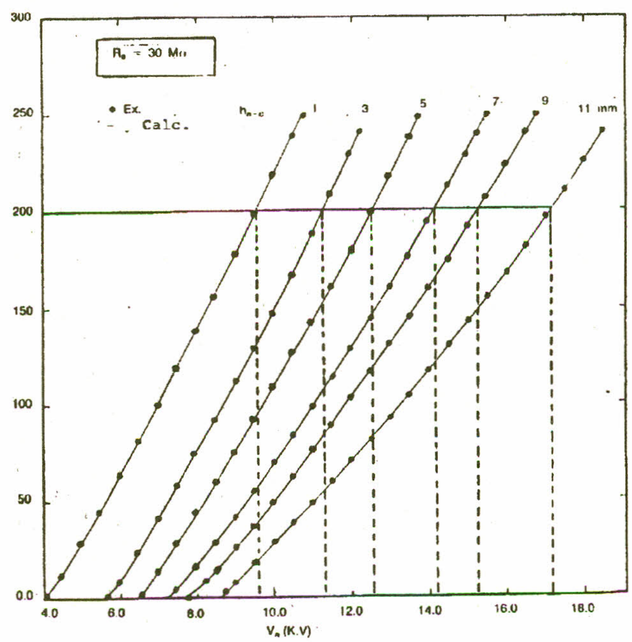

Fig. 2. I_c vs. V_a for various values of h_{a-c} when R_s = 30MΩ.

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current (I_c) for various values of electrode separation (h_{a-c}) namely 1,3,5,7,9 and 11 mm for two constant values of the limiting resistance (R_s) namely 30 MΩ and 50 MΩ respectively. It is clear from these curves that the relation between (V_a) and (I_c) is found to be an emperical formula of the second order in the form:

$$I_c = a + bV_a + cV_a^2 \qquad (1)$$

where a, b and c are constants. Applying the least-squares fits for the present experimental results represented in Fig. 2and 3 the constant values of a, b, and c corresponding to different values of (h_{a-c}) were determined and represented in tables 1 and 2.

In Fig. 2 and 3 are plotted the computed values of (I_c) vs, (V_a) (full curves), on the same figures are represented the experimental values (circles) which show good agreement. In the steady corona region the effective voltage (V_{ac}) between the anode and the cathode is given by:

$$V_{ac} = V_a - I_c R_t \qquad (2)$$

where

$$R_t = R_s + R_c \qquad (3)$$

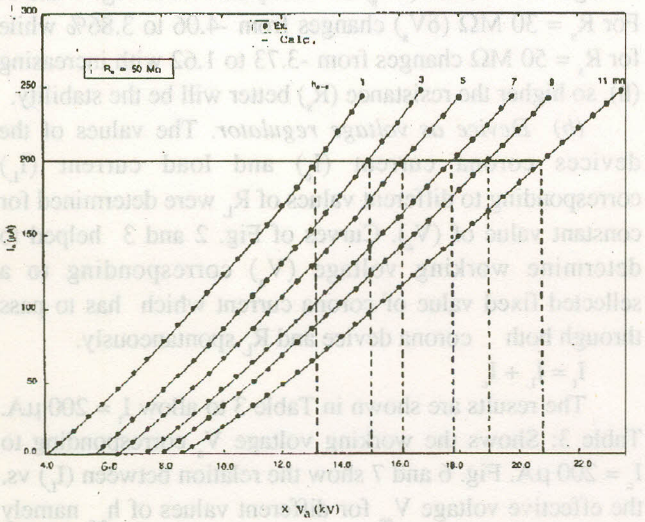

Fig. 3. I_c vs. V_a for various values of h_{a-c} when Rs=50 MΩ.

TABLE 1. R_s = 30 MΩ.

h_{a-c}(mm)	a x 10^{-6}	b x 10^{-7}	c x 10^{-12}
1	-130.4970±0.0001	0.2824±0.0001	0.6725±0.00001
3	-155.9243±0.0001	0.2266±0.0001	0.7858±0.00002
5	-167.7579±0.0001	0.2140±0.0001	0.6347±0.00002
7	-149.1901±0.0001	0.1523±0.0001	0.6660±0.00001
9	-155.8041±0.0001	0.1531±0.0001	0.5220±0.00001
11	-118.4592±0.0001	0.0911±0.0001	0.5548±0.00003

TABLE 2. R_s = 50 M Ω.

h_{a-c}(mm)	a x 10^{-6}	b x 10^{-7}	c x10^{-12}
1	-76.1982±0.0001	0.1722±0.0001	0.2730±0.00001
3	-102.0750±0.0001	0.1622±0.0001	0.2675±0.00001
5	-112.1391±0.0001	0.1559±0.0001	0.2315±0.00002
7	-110.9553±0.0001	0.1331±0.0001	0.2328±0.00001
9	-111.9864±0.0001	0.1260±0.0001	0.2039±0.00001
11	-112.5651±0.0001	0.1152±0.0001	0.1669±0.00001

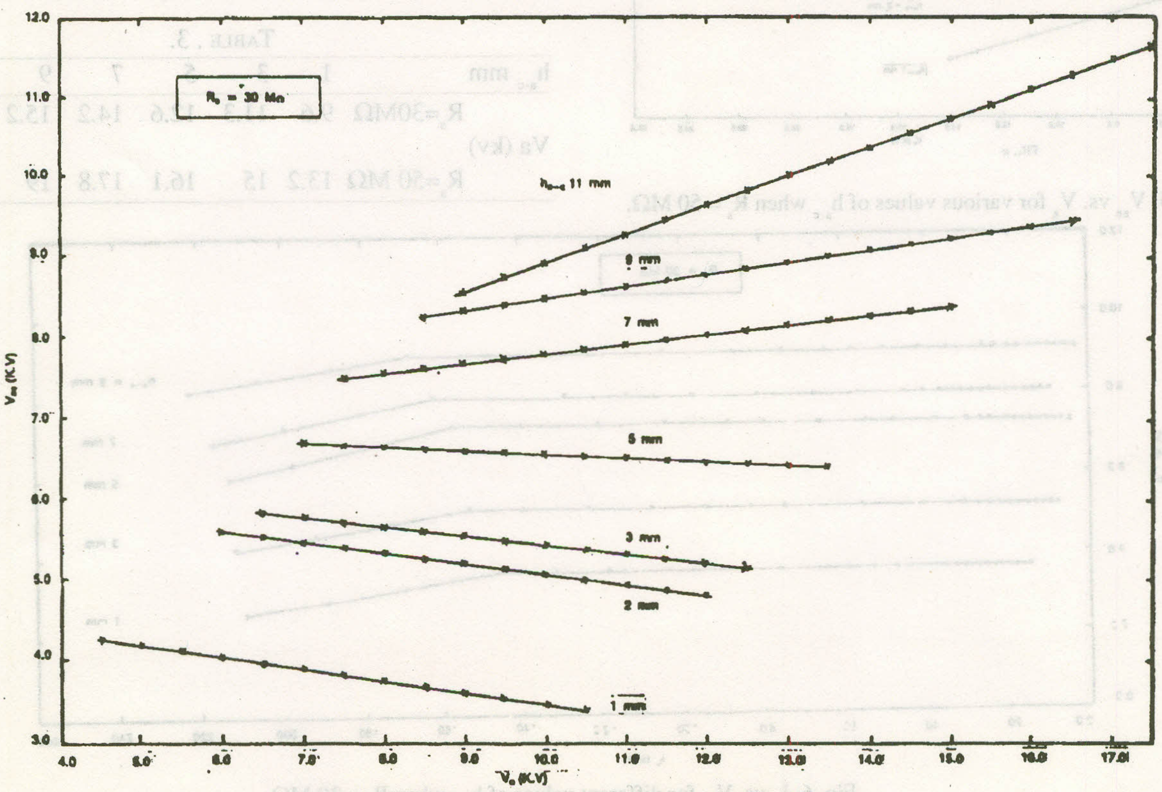

Fig. 4. V_{ae} vs. V_a for various values of h_{a-c} when R_s = 30 MΩ.

Values of V_{ae} determined by eq. (2) from the experimental results of V_a and I_c were represented vs. V_a. The portions of the obtained curves which seem to a good approximation to be linear are represented in Fig. 4 and 5 for various values of h_{a-c} when R_s = 30 and 50 MΩ respectively. It is clear that the slope of these curves dV_{ae}/dV_a are positive from h_{a-c} = 7 to 11 mm, while it is negative for h_{a-c} from 1 to 5 mm.

The relations between (dV_{ae}/dV_a) and (h_{a-c}) for R_s = 30MΩ and 50 MΩ are represented graphically and the critical electrode spacing $(h_{a-c})_c$ where dV_{ae}/dV_a = 0 are found to = 5.45 mm and 6.95 mm for R_s = 30 and 50 MΩ respectively.

Evidently when $h_{a-c} = (h_{a-c})_c$ V_{ae} practically remains constant, consequently, the device can be considered as a perfect corona stabilizer.

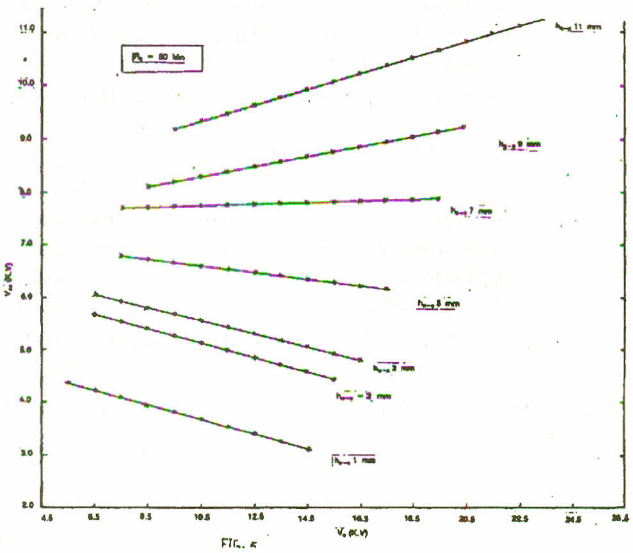

Fig. 5. V_{ae} vs. V_a for various values of h_{a-c} when R_s = 50 MΩ.

However when plotting the relation between (V_{ac}) vs. dV_{ae}/dV_a when V_a = 10 kV, $(V_{ae})_c$ are found to = 6.7 and 7.3 kV for R_s = 30 and 50 MΩ respectively. This result shows that $(V_{ae})_c$ increases with the increase of (R_s). However a high limting resistance tends to reduce the corona current very much. so a comprimise between $(V_{ae})_c$ attained and the corona current output available should be made.

The voltage stability (δV_s) is defined as the percentage change in the stabilized voltage for 10 % change in the line voltage. The values (δV_s) are computed from Fig. 4 and 5. For R_s = 30 MΩ (δV_s) changes from -4.06 to 3.86% while for R_s = 50 MΩ changes from -3.73 to 1.62 with increasing (h), so higher the resistance (R_s) better will be the stability.

(b) Device as voltage regulator. The values of the devices corona current (I_c) and load current (I_L) corresponding to different values of R_L were determined for constant value of (V_a). Curves of Fig. 2 and 3 helped to determine working voltage (V_a) corresponding to a sellected fixed value of corona current which has to pass through both corona device and R_L spontaneously.

$I_t = I_L + I_c$

The results are shown in Table 3 to allow I_t = 200 μA. Table 3: Shows the working voltage V_a corresponding to I_c = 200 μA. Fig. 6 and 7 show the relation between (I_L) vs. the effective voltage V_{ae} for different values of h_{a-c} namely 1,3,5,7,9 and 11 mm when R_s = 30 and 50 MΩ

Table . 3.

h_{a-c} mm		1	3	5	7	9	11
Va (kv)	R_s=30MΩ	9.6	11.3	12.6	14.2	15.2	17.1
	R_s=50 MΩ	13.2	15	16.1	17.8	19	20.8

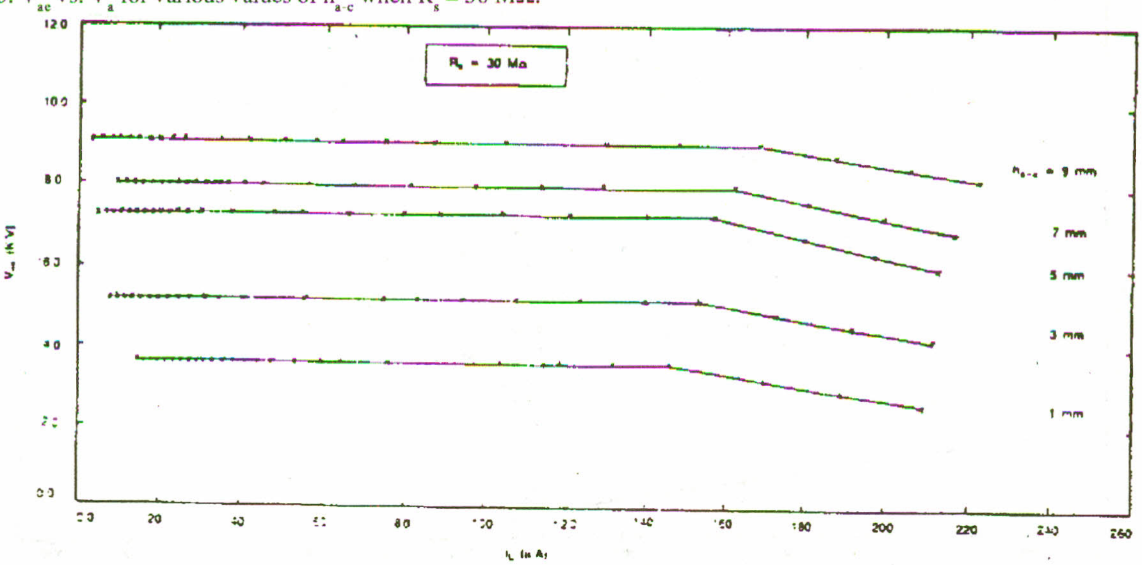

Fig. 6. I_L vs. V_{ae} for different values of h_{a-c} when R_s = 30 MΩ.

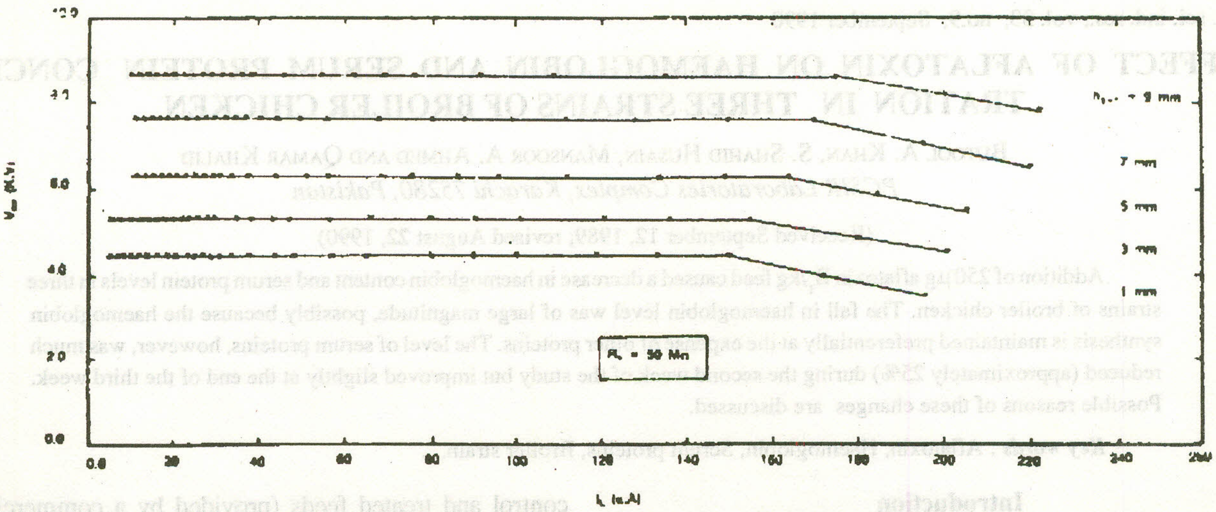

Fig. 7. I_L vs. V_{ac} for different values of h_{a-c} when $R_s = 50$ MΩ.

respectively. Curves of these two figures have flat plateaux which indicate good regulation. The maximum current passing through (R_L) while keeping regulation corresponds to the end of the plateau. Its value increases with the increase of (h_{a-c}).

It could be concluded that in the present CVSR system the anode-cathode separation as well as the load resistance are controlling elements of the steady corona current conformation and hence of the value of the stabilization voltage. The satisfactory profile of the stabilization plateaux and the strong dependance of their slopes on the adapted electrode separation and load resistance is evident. Besides the perforated CVSR gives better characteristics than the normal CVSR [7]. It confines wider stabilization zone and higher stabilization voltage.

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