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Variation with time of the leakage time constant in hydrogen at various pulse heights under sleeves discharge

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The effect of continuous aging on discharge pulses in an externally excited direct current impulse discharge through hydrogen in a Siemen's type ozonizer has been studied It is observed that the count rate increases as a result of increase in conductivity, or total charges on sleeves, of the discharge current The number of contraction pulses in a given time decreases as a result of the increase in time constant (T) and *vice versa*. The magnitude of the increase or/and decrease in T_D, *i.e.*, the ratio of the time in minutes to that for number of counts in dark measured with an electronic scaler, which depends upon (1) the voltage applied to the system, (2) value of the discriminator bias, (3) duration of non-discontinued contraction, (4) number of small elementary areas on the surface of the glass walls and the total charges on it as well as upon, (5) the equivalent resistor and the condenser of the dielectric electrode wall material, may be directly linked with the total charges on sleeves

1. INTRODUCTION

The study of aging, *i.e*., a time variation of discharge current produced when the gas is subjected to an electrical discharge at a constant applied potential to Siemen's type discharge tube, was observed by Joshi (1939, 1944, 1945) and subsequently by Deo (1945) and Goel (1947) in connection with their work on photo-variation of conductivity in the gas. Earlier work of Brodie (1873) and Lunt *et al* (1929) on the decomposition of carbon monoxide under silent electrical discharge showed that a dark brown solid deposit of the sub-oxides of carbon is formed on the electrode surface. Therefore, if Joshi effect is surface dependent, the above deposition would be affected by current and eigate effect adversely or otherwise.

As this variation with time of the current was found to be almost of the same order of magnitude as the leakage time constant variation produced by time growth. The relation for leakage time constant has recently been given by Arnikar *et al* (1968). It was, therefore, instructive to investigate, in some details, the various factors on which it depends.

2. Experimental Procedure

We describe here an experimental arrangement for observing the influence of time on leakage time constant in a gas under discharge. Pure, dry hydrogen at a pressure of 4 mm of mercury contained in the annulus of soft glass ozonizer was excited at continuous potential of 1500 V. Seven tightly wound equidistant (d = 9 mm) external electrode—sleeves, each made up of a few turns of Ag wire, were employed for producing the discharge, the four alternate sleeves being connected to earth (low tension) through a current detector and the remaining three being connected to a high potential (high tension) d.c. supply unit along with a series resistor. Figure 1, shows the circuit.

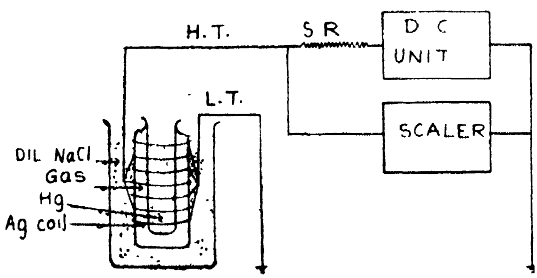


Fig-1. Experimental arrangement for the Study of the effect of time on time constant.

Interesting results can be explained by using the equations for the charges on the two thin parallel conducting coaxial rings (Schwartz *et al* 1964). Consider two sleeve-electrodes, each of radius R_s at a distance L apart The work needed to bring a charge up to their centres rather than the centre of the inner tube of the ozonizer is W_1 and W_2 respectively. The charges on the sleeves are

$$Q_1 = \frac{R_s(R_s^2+L^2)^{\frac{1}{2}}}{L^2 q} \left[(R_s^2+L^2)^{\frac{1}{2}} W_1 - R_s . W_2\right], \qquad \ldots (1)$$

$$Q_2 = \frac{R_s(R_s^2+L^2)^{\frac{1}{2}}}{L^2 q} \left[(R_s^2+L^2)^{\frac{1}{2}} W_2 - R_s W_1\right]. \qquad \ldots (2)$$

The charge on the first sleeve-electrodes, Q_1 is given by equation (1) and the charge on the second sleeve-electrode, Q_2, is given by equation (2). It is possible to calculate the total charge on external electrode-sleeves. Thus the increase or decrease in the discharge current can be interpreted using the equations of the charges on the sleeve-electrodes.

Harries & Von Engel (1951) have assumed that dielectric electrode surfaces are not equipotential but that each surface is divided into small elementary areas or 'sites' of different voltages. The contraction (discharge) externally excited system takes place between pairs of such sites on opposite walls. After one discharge is over the subsequent contraction takes place between the pair of sites after a finite time interval. The time interval between the two successive pulses is considered as the leakage time constant or simply the time constant, T. The values of T_D were obtained for only one Pyrex glass Siemen's tube of same dimension filled with dry and pure hydrogen at a definite moderate pressure. This time constant (T_D) depends essentially upon the equivalent resistance and the capacitance of the dielectric electrode wall material (Manson 1959) and is independent of the dimensions of the tube and the gas pressures (Kanitkar 1967).

The leakage time constant in dark for 50 volts discriminator bias increased from 0 to 21·5787 in the time range 0–410 minutes. It indicates that there should be a decrease in charges on the seven sleeve-electrode (cf. Table). The observed T_D, *i.e.*, the ratio of the time in minutes to that of the counts in dark, at 5 V pulse height showed the increment in the initial and final stage, *e.g.*, T_D increased from 0 to 3·1818 and 4·3209 to 6·5079 in the time range 0–175 and 350–410 minutes, respectively. The leakage time constant in dark decreased from 3·1818 to 0·2569 in the time range 175–230 minutes. This reduction in T_D with time growth should be due to the increment in charges on the sleeve-electrodes (growth of current).

3. Results and Discussions

Several series of experiments were carried out at various values for the time and the pulse height in each of which leakage time constant in the dark was measured as a function of the time increased progressively to a maximum. It was observed that the behaviour of hydrogen at a low pressure for 50 V pulse height suggests the existence of three types of actions α, β and γ. α obtains under the discharges at room temperature (27°C) and is characterized by the occurrence of a continuity on the count rate *vs.* time curve (figure 2); the corresponding range of time was insufficient to produce a sensible steady state. During β, the curve shows markedly rapid fluctuations in the discharge pulses and an overall increased conducitivity. In γ, the count rate in dark shows a decrease in conductivity of the discharge current. The above observed existence of three types of actions are not seen under the same conditions in the case of 5 V pulse height (figure 3).

A comparison of the results of the two series of experiments for 5V and 50V pulse heights shows that at 5V disc. bias, the leakage time constant in dark is less pronounced in the presence of salt film (NaCl).

During the investigation of leakage time constant in hydrogen at 4 mm Hg under direct current impulse potential (1500V) excitation at 5V pulse height, a

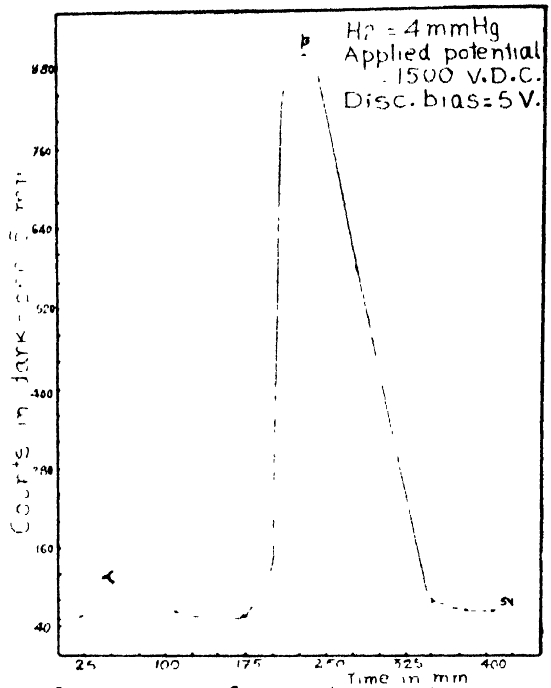


Fig 2 Variation of current in dark with time

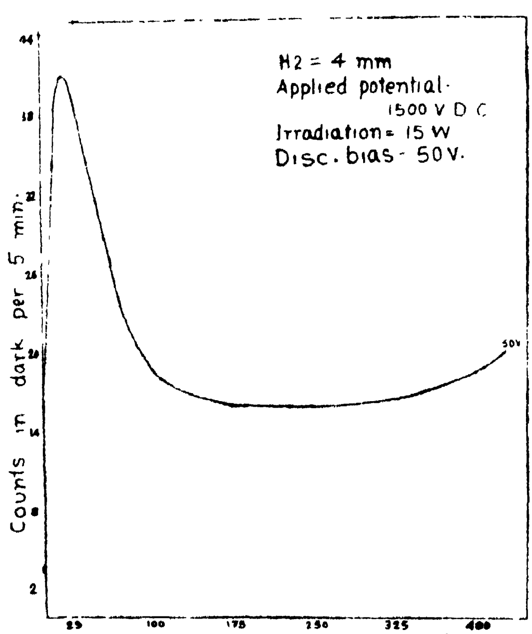


Fig. 3 Variation of count rate with time

leakage time constant increased at low T_m (time in minutes). After about 175 minutes, there is a sudden and very large increase in the charges on the sleeves, and T_D is uncertain within a limit of random variation. Once again, there is a decrease in charges in the time range 350–410 minures and hence T_D increases. The above remark applies, but more strongyly, at 50 V pulse height regarding T_D. Here after 175 minutes, the charges on the sleeves do not inccrease suddenly to a large value and, therefore, T_D does not show the uncertainty within the random variation.

Table 1. Time variation of the leakage time constant in hydorogen under sleeves discharge

Pressure of hydrogen : 4·00 mm Hg.
Constant voltage applied to sleeve electrodes : 1500 V, d c
Temperature of the system : room temperature (27 C)
Current Indicator : SS361 A, Electronic Scaler

Pulse height	5V	50V
Time in minutes	T_D	T_D
	In arbitrary units	
0	0	0
20	0.3125	0.4878
50	0.4347	1.6121
110	1.7460	6.1110
175	3.1818	10.9375
230	0.2569	14.3750
350	4.3209	19.4440
380	5.8333	22.3529
410	6.5079	21.5789

It is well known that the total number of discharge counts in a given time decreases as a result of the decrease in charges on the sleeve-electrodes and *vice versa*. In this system, the discharge pulses or counts in dark depend upon the charges on the sleeve-electrodes, number of sites on the surface of the walls and the total charges on it, applied potential, pulse height and duration of continuous aging etc.; the leakage time constant under perfect dark illumination (T_D) also depends on those five factors. As the discharge pulses in dark decreases, the corresponding leakage time constant increases and T_D decreases as a result of of incremont in counts.

The above interpretation of the charges on the sleeve-electrodes is helpful in understanding the phenomenon of leakage time constant. Since the charges on the sleeve-electrodes, rather than Q_1 and Q_2 for the first and second sleeve-electrode, are composed of such counts, the decrease in charges leads to an increase

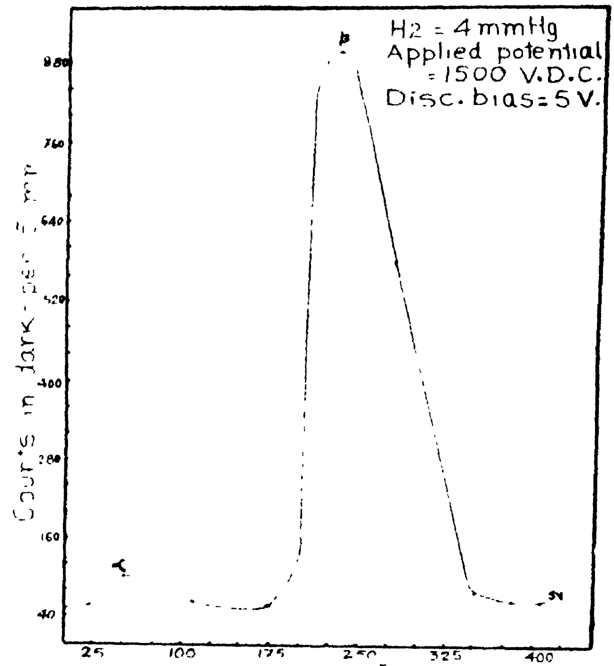
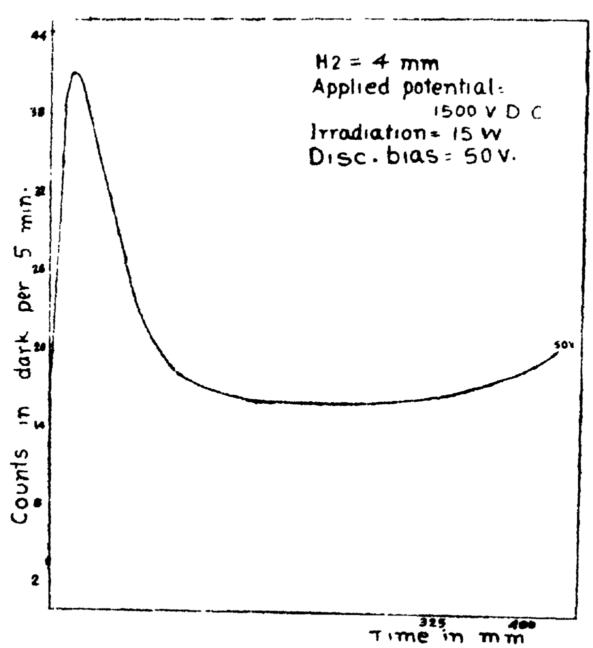


Fig 2 Variation of current in dark with time



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