# LETTERS TO THE EDITOR

## EFFECT OF EARTHING ON AC ELECTRODELESS DISCHARGE CURRENT

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It is known that RF oscillations are produced in AC electrodeless discharges[1–5]. These discharges are affected by humidity of the atmosphere surrounding the discharge tube[6]. Further the amplitude of RF wave is reduced when the discharge tube is irradiated by external light[7]. It is interesting here that only when the discharge current consists of AF pulses and RF oscillations the light effect is observed. In the absence of AF pulse and RF oscillations no light effect is observed. Hence AF pulses and RF oscillations have to be present for the light effect to be observed in the discharge tube. The grounding of one of the secondary of the transformer affects the discharge current in either side of the discharge tube circuit. It is this type of observation that is being presented in this paper.

An electrodeless sleeve discharge tube containing iodine vapour at its saturated vapour pressure is used in an AC circuit. The circuit consists of a step up transformer, one end of the secondary of which is connected to one of the external electrode of the the discharge tube. The other end of the secondary is connected to the other external electrode of the discharge tube. This end of the secondary is normally earthed. The discharge tube was mounted on two electrodes provided on the bed plate of a high vacuum pump. The bed plate was covered by a glass bell-jar so that the conditions inside the bell-jar surrounding the discharge tube could be varied. The microammeters are connected as usual as shown in Fig. 1. When sufficient 50 Hz voltage is applied to these external electrodes, the iodine vapour inside the discharge tube gets ionized and a small current of a few microamperes flows through the circuit. Two AC microammeters of the same make (Shanti, Type Co–65) and range are used as shown in Fig. 1. A microammeter $\mu A_1$ is connected between the unearthed end of the secondary of the transformer and one of the external electrodes of the discharge tube. Another AC microammeter $\mu A_2$ is connected between the earthed end of the secondary of the transformer and the other external electrode of the discharge tube. Two experiments were conducted. The first experiment was conducted when the atmosphere inside the

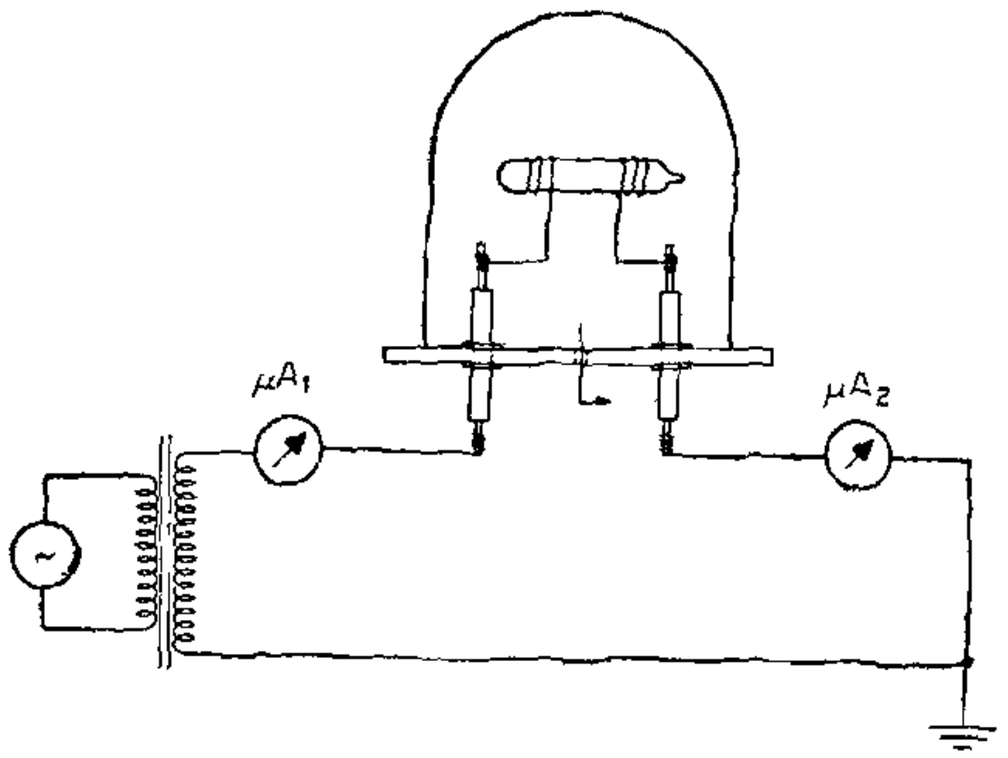


Fig. 1. Circuit used to study the difference in current observed in AC electrodeless discharge tube.

bell-jar surrounding the discharge tube was 760 mm of Hg. The second experiment was conducted when the space inside the bell-jar surrounding the discharge tube was a vacuum of the order of $10^{-4}$ torr. From both the experiments we get identical readings which evidently show that the atmospheric condition surrounding the discharge tube does not have anything to do with the earthing of one end of the transformer.

When sufficient voltage is applied between the electrodes of the discharge tube, a few microamperes of current flowing in the circuit is registered by the microammeters. The current registered in one of the typical experiments when the surrounding pressure was 760 mm of Hg is given in Table 1A. Similarly the current registered by the microammeters when the discharge tube is surrounded by a vacuum of the order of $10^{-4}$ torr is given in Table IB. The plots of voltage *versus* current for Table IA and Table IB are given in Fig. 2 From the two microammeter readings of Tables IA and IB the current in $\mu A_2$ which is the earthed end of the discharge tube is very little when compared with $\mu A_1$ which is connected to the unearthed end of the discharge tube. The large difference in the current (1 : 6) shown by the two microammeters may perhaps be explained as follows.

An insulator such as glass wall of the discharge tube is introduced in the circuit. The high tension end of the transformer gives out the charges which spread on the outer glass surface of the discharge tube. Once these charges are on the surface of the insulator they are free and are not conducted back into the high tension electrode as it is an insulator when the

TABLE I

*Values of voltage and current under 760 mm of Hg (Atmospheric Pressure) Table IA and a Vacuum of $10^{-4}$ torr surrounding the discharge tube Table IB, when one end of the transformer of the discharge tube circuit is earthed*

TABLE IA

| Voltage in kV | Current in μA | |
|---|---|---|
| | $\mu A_1$ | $\mu A_2$ |
| 0·25 | 1·0 | 0·5 |
| 0·5 | 3·0 | 0·5 |
| 0·75 | 4·5 | 0·5 |
| 1·0 | 6·0 | 1·0 |
| 1·23 | 8·0 | 1·0 |
| 1·45 | 9·0 | 1·5 |
| 1·7 | 10·5 | 1·5 |
| 1·9 | 12 | 2·0 |
| 2·2 | 14 | 2·0 |
| 2·5 | 16 | 2·0 |
| 2·7 | 17·5 | 2·5 |
| 3·0 | 19 | 3·0 |

TABLE IB

| Voltage in kV | Current in μA | |
|---|---|---|
| | $\mu A_1$ | $\mu A_2$ |
| 0·25 | 1·5 | 0·5 |
| 0·5 | 3·0 | 1·0 |
| 0·75 | 5·0 | 1·0 |
| 1·0 | 7·0 | 1·5 |
| 1·23 | 9·0 | 1·5 |
| 1·45 | 10 | 1·5 |
| 1·7 | 12 | 2·0 |
| 1·9 | 13 | 2·0 |
| 2·2 | 15 | 2·5 |
| 2·5 | 17 | 2·5 |
| 2·7 | 19 | 2·5 |
| 3·0 | 20 | 3·0 |

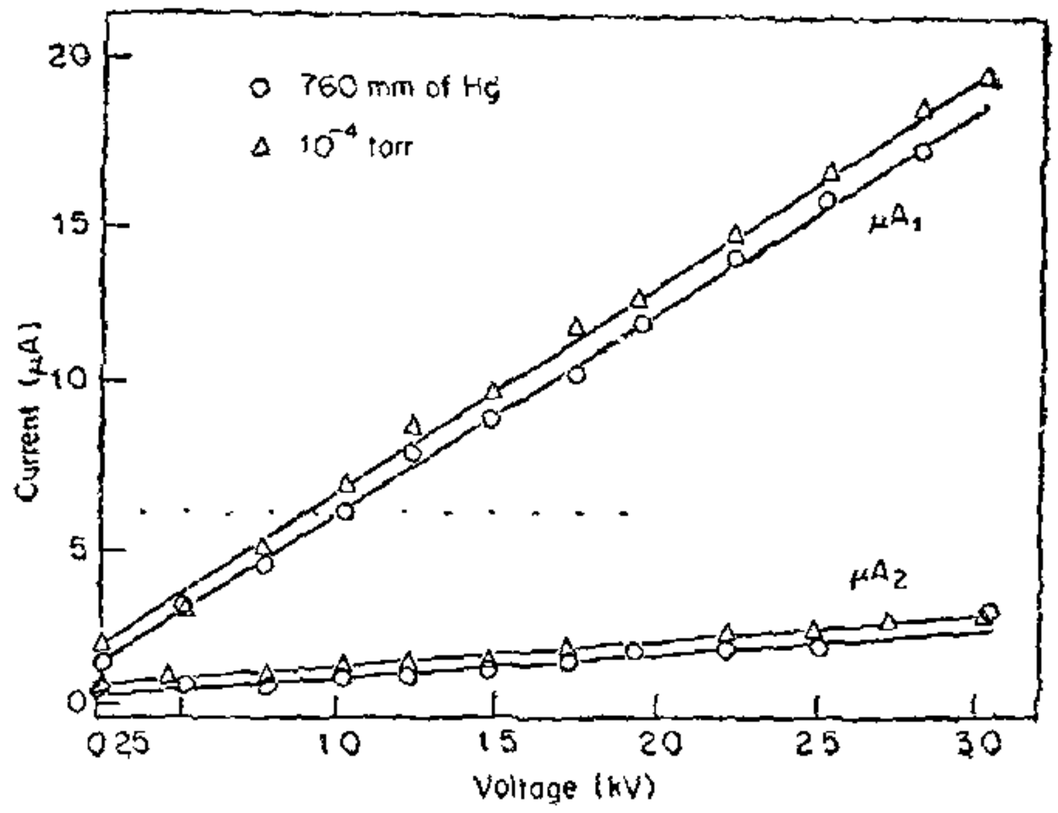


FIG. 2. Plots of voltage *versus* current when one end of the transformer of the discharge tube circuit is earthed. ○ 760 mm of Hg. △ Vacuum of the order of $10^{-4}$ torr.

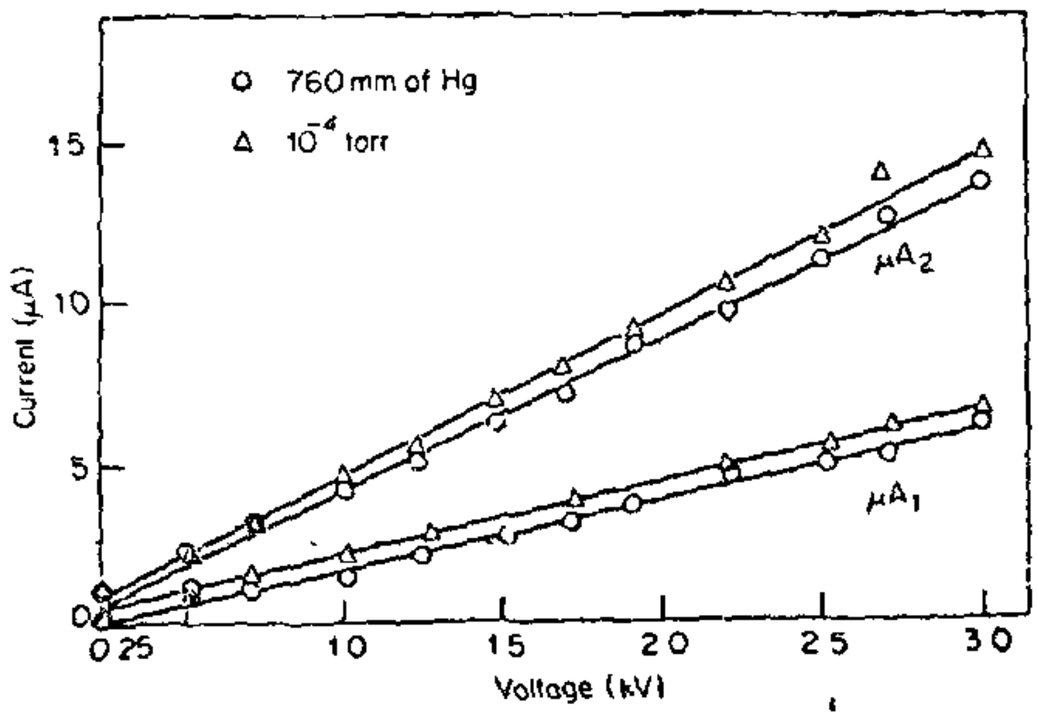


FIG. 3. Plots of voltage *versus* current when one end of the transformer of the discharge tube circuit is *not earthed*. ○ 760 mm of Hg. △ Vacuum of the order of $10^{-4}$ torr.

polarity of applied voltage changes. And as such the free electrons enter a few layers of the glass on the surface, or they fill up the conduction bands of the surface layers of glass as donors[8-9]. This view-point seems to be in better accord with the observed dependence upon the nature of wall medium. The results in this paper also support the same view-point. These electrons are in an excited state. It is this extra energy which makes it fill the conduction bands of the surface layers of the glass. When these excited electrons return to the normal state, the extra energy is radiated, which is a well-known fact. This radiation emitted by the electrons could be in the form of radio frequency oscillations and the frequency of oscillations depends on the band gap[10] of the material given by the formula $\lambda$ 1·24/Eg where $\lambda$ is wavelength in meters and Eg is band gap in electron volts. A similar

TABLE II

*Values of voltage and current under 760 mm of Hg Table II.1 and vacuum of $10^{-4}$ torr surrounding the discharge tube Table IIB, when one end of the transformer of the discharge tube circuit is not earthed*

TABLE IIA

| Voltage in kV | Current in μA | |
|---|---|---|
| | $\mu A_1$ | $\mu A_2$ |
| 0·25 | 0·0 | 1·0 |
| 0·5 | 1·0 | 2·0 |
| 0·75 | 1·0 | 3 0 |
| 1·0 | 1·5 | 4·0 |
| 1·23 | 2·0 | 5·0 |
| 1·45 | 2·5 | 6·0 |
| 1·7 | 3·0 | 7·0 |
| 1·9 | 3·5 | 8·5 |
| 2·2 | 4·5 | 9·5 |
| 2·5 | 5·0 | 11 |
| 2·7 | 5·0 | 12·5 |
| 3 0 | 6·0 | 13·5 |

TABLE IIB

| Voltage in kV | Current in μA | |
|---|---|---|
| | $\mu A_1$ | $\mu A_2$ |
| 0·25 | 1·0 | 0·5 |
| 0·5 | 1·0 | 2 0 |
| 0·75 | 1·5 | 3·0 |
| 1·0 | 2·0 | 4·5 |
| 1·23 | 3·0 | 5·5 |
| 1·45 | 3·0 | 7·0 |
| 1·7 | 3·5 | 8·0 |
| 1·9 | 4·5 | 9·0 |
| 2·2 | 5·0 | 10·5 |
| 2·5 | 5·5 | 12 |
| 2·7 | 6·0 | 14 |
| 3·0 | 6·0 | 15 |

action takes place on the inner surface of the glass of the discharge tube as electrons accumulate on the inner glass surface when the gas is ionized. Further, it has been shown[11] that during silent discharges the glass of the discharge tube gets heated up from which it is concluded that the glass acts as a high resistance. It is only under this condition that RF oscillations are observed.

Earth forms low resistance current path[12] to shunt off the free electrons and hence we observe large difference in the readings of the two microammeters.

The earth connection of one electrode of the discharge tube is removed and the current reading of the microammeters under (*a*) 760 mm of Hg (*b*) vacuum of the order of $10^{-4}$ torr surrounding the discharge tube are observed. These readings are given in Table IIA and Table IIB.

From these microammeter readings of Table IIA and Table IIB it is clear that the difference is little (1 : 2). This difference may be due to deliberate and or stray disturbance. The plots of voltage *versus* current of Table IIA and Table IIB are practically linear suggesting that it obeys ohms law.

As the current in the discharge tube circuit consists of a few kilo Hertz to about 30 MHz, the effect of earthing on discharge current is important for further analysis of the electrodeless discharge phenomena.

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