SEAT OF THE JOSHI EFFECT IN A.C. SILENT DISCHARGES*

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(Received for publication, April, 1952)

ABSTRACT. Some experiments on the positive and negative Joshi effects in 'sleeve' discharge tubes containing iodine vapour and hydrogen gas have been performed to study the effect of illuminating the different parts of each discharge tube successively by a narrow beam of strong light. The results of these experiments are given in the paper with an account of the experimental arrangements. The results have shown that the Joshi effect (positive and negative) is associated predominantly with the regions of the electrodes. The role of the discharge column of the tube in the production of the Joshi effect, if any, is, however, regarded as uncertain.

The effect of stray light affecting the electrodes after being scattered from the illuminated part of the discharge tube is considered in discussing the experimental results of Agashe.

1. INTRODUCTION

There is now sufficient experimental evidence to show that the Joshi effect observed with an ozonizer or with an A.C. operated 'sleeve'-discharge tube is predominantly a surface phenomenon, located on the inner glass surface of either electrode of the ozonizer or round the inner glass surface opposite to either electrode in the case of a sleeve discharge tube. Nevertheless, the posssbility of a volume effect is not altogether ruled out. The recent experimental results obtained by Agashe (1951) who used a short discharge tube with external electrodes and illuminated the different parts of the discharge tube by a narrow beam of light, indicated strongly that the positive column of the discharge has an important role in the production of the Joshi effect and that possibly the surface layer at the electrodes has little or no effect. In view of these striking experimental results, it was thought desirable to undertake an experimental study of the positive and negative Joshi effect by illuminating the different parts of the discharge tube successively by a narrow beam of strong light. The object of the present paper is to report the results of this experimental study with an account of the experimental arrangement and to make some general conclusions regarding the seat of the Joshi effect. We shall also indicate

* Communicated by Prof. S. R. Khastgir.

the reason why little or no photo-reduction of discharge current was observed by Agashe when the regions near the electrodes were illuminated. The effect of light scattered from the illuminated part of the discharge tube is also considered.

2. EXPERIMENTAL ARRANGEMENT AND PROCEDURE

A 500-watt electric lamp was placed inside a wooden box lined inside with asbestos sheets. A narrow vertical slit backed by a sheet of glass was fitted up on one side of the box at the same level as the source of light. Another narrow vertical slit was mounted in front of the first slit in a wooden frame fixed to the side of the box. The second slit was also backed by a thick plate glass. In the space between the two vertical slits was inserted a suitable shutter which could be moved in and out by pulling or releasing a string attached to the shutter with the help of a suitable pulley. The discharge tube in question was suspended with the help of a string from a fixed support, and was held with its length horizontal and parallel to the plane of either slit at the same level as the source of light inside the box. A paper scale was attached lengthwise to the suspended discharge tube. Each 'sleeve'-electrode was made of a capillary glass tube bent into a circular form and fitted up tightly round the discharge tube at either end. Sodium chloride solution was introduced into each of these circular glass

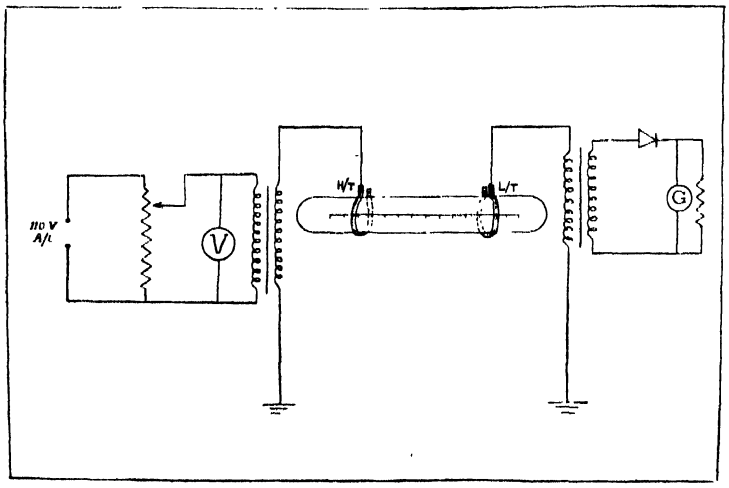

FIG. 1

tubes and connecting wires were taken from the conducting solution in the tubular glass electrodes. In some experiments, one-turn fine copper wire wound round the discharge tube was used as each electrode. The width of the beam obtained with the slit system was about 1.5 mm. The different parts of the discharge tube were illuminated successively by moving the box which was on wheels along with the slits and the shutter system, so that the narrow beam of light was made to fall on the different parts of the discharge tube which was kept fixed.

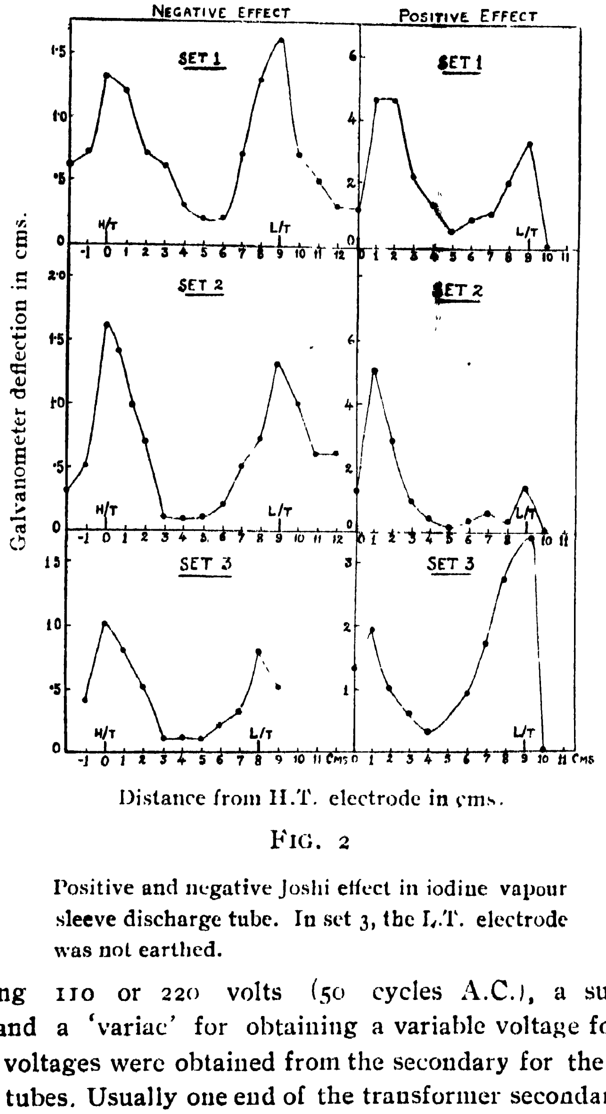

FIG. 2

Positive and negative Joshi effect in iodine vapour sleeve discharge tube. In set 3, the L.T. electrode was not earthed.

Employing 110 or 220 volts (50 cycles A.C.), a suitable step-up transformer and a 'variac' for obtaining a variable voltage for the primary, suitable high voltages were obtained from the secondary for the excitation of the discharge tubes. Usually one end of the transformer secondary was earthed and the other end was connected to one sleeve-electrode of the discharge tube, the other sleeve-electrode being earthed (see figure 1). We shall call the electrode which was earthed, the L.T. electrode and the one connected to that end of the transformer secondary which was not earthed as the H.T. electrode of the discharge tube. The discharge current was measured with a germanium crystal detector unit having a mirror galvanometer in series with the crystal circuit. Experiments were performed with (*i*) a sleeve discharge tube (length 15 cm., diameter 2 cm.) containing iodine vapour and (*ii*) a similar 'sleeve' tube (length 36 cm., diameter 1.7 cm.) containing hydrogen. With each tube, requisite voltages were applied to get the negative and positive Joshi effects. Both the negative and positive Joshi effects, observed at suitable applied voltages, were measured by the increase and reduction of the discharge current when the different parts of the discharge tube were illuminated, part by part, by the narrow beam of light.

3. EXPERIMENTAL RESULTS

The results of a few typical experiments with the iodine tube, showing negative Joshi effect for different distances of the illuminated part as measured from one of the electrodes are shown in figure 2. Some typical

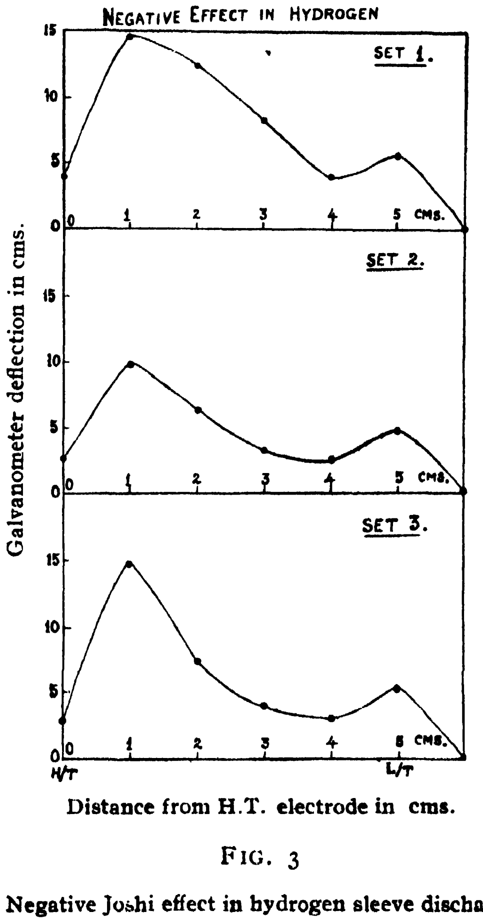

FIG. 3

Negative Joshi effect in hydrogen sleeve discharge tube. In set 3, the L.T. electrode was not earthed.

experimental results showing positive Joshi effect in the same tube for different positions of the illuminated part are also shown in the same figure. Similar experimental data for the hydrogen sleeve-discharge tube showing negative Joshi effect when the different parts of tube were successively illuminated are illustrated in figure 3. Some general features of these curves are enumerated below :

TABLE I

Negative Joshi effect in iodine vapour

	Distance from HT electrode (cms.)	Galv. readings in cms. Light off	Light on	Photo-reduction.
Set 1. Applied voltage = 1200 volts (50 cycles/sec.)	−2	46.1	45.5	0.6
	−1	46.3	45.6	0.7
	0(H.T.)	46.7	45.4	1.5
	1	46.4	45.2	1.2
	2	46.6	45.2	0.7
	3	46.5	45.9	0.6
	4	46.5	46.2	0.3
	5	46.5	46.3	0.2
	6	46.5	46.3	0.2
	7	46.8	46.1	0.7
	8	47.7	46.4	1.3
	9(L.T.)	50.5	48.9	1.6
	10	49.8	49.1	0.7
	11	50.6	50.1	0.5
	12	50.8	50.5	0.3
Set 2 Applied voltage = 1200 volts (50 cycles/sec.)	−2	48.1	47.8	0.3
	−1	48.1	47.6	0.5
	0(H.T.)	48.9	47.3	1.6
	1	48.0	46.6	1.4
	2	46.6	45.9	0.7
	3	46.7	46.6	0.1
	4	46.7	46.6	0.1
	5	46.7	46.6	0.1
	6	46.6	46.4	0.2
	7	47.1	46.6	0.5
	8	47.5	46.8	0.7
	9(L.T.)	48.8	47.5	1.3
	10	48.8	47.8	1.0
	11	49.6	49.0	0.6
	12	50.2	49.6	0.6
Set 3. Applied voltage = 1820 volts (50 cycles /sec.)	L.T. electrode not earthed			
	−1	56.6	56.2	0.4
	0(H.T.)	56.7	25.7	1.0
	1	56.6	55.8	0.8
	2	56.5	56.0	0.5
	3	56.3	56.2	0.1
	4	56.4	56.3	0.1
	5	56.5	56.4	0.1
	6	56.5	56.3	0.2
	7	56.4	56.1	0.3
	8(L.T.)	57.3	56.5	0.8
	9	57.6	57.1	0.5

TABLE II

Positive Joshi effect in iodine vapour

	Distance from H.T. electrode (cms)	Galv. readings in cms		
		Light off	Light on	Photo-increase
Set 1 Applied voltage = 700 volts (50 cycles/sec.)	0(H.T.)	9.7	10.8	1.1
	1	9.7	14.3	4.6
	2	9.7	14.3	4.6
	3	9.7	11.9	2.2
	4	9.7	11.0	1.3
	5	9.7	10.2	0.5
	6	9.7	10.5	0.8
	7	10.2	11.2	1.0
	8	10.2	12.2	2.0
	9(L.T.)	10.2	13.5	3.3
	10	10.2	10.2	0.0
Set 2 Applied voltage = 700 volts (50 cycles/sec.)	0(H.T.)	9.0	10.2	1.2
	1	9.0	14.0	5.0
	2	9.0	11.8	2.8
	3	9.0	9.9	0.9
	4	9.0	9.3	0.4
	5	9.0	9.1	0.1
	6	9.0	9.3	0.3
	7	9.0	9.5	0.5
	8	9.0	9.3	0.3
	9(L.T.)	9.0	10.3	1.3
	10	9.0	9.0	0.0
Set 3 Applied voltage = 800 volts (50 cycles/sec.)	L.T. electrode not earthed			
	0(H.T.)	14.3	15.6	1.3
	1	12.9	14.8	1.9
	2	13.0	14.0	1.0
	3	13.0	13.6	0.6
	4	13.0	13.3	0.3
	5	13.0	13.0	0.0
	6	13.0	13.9	0.9
	7	13.0	14.7	1.7
	8	13.0	15.7	2.7
	9(L.T.)	13.0	16.4	3.4
	10	13.0	13.0	0.0

(*i*) The amount of the Joshi effect (negative or positive) was found to have maximum values at (or very near) the two electrodes.

(*ii*) The effect showed an abrupt fall on either side of the region of each electrode.

(*iii*) The effect observed for the middle region was found to be minimum. The minimum value, in some cases, was not inappreciable.

(*iv*) The observed maximum effects in the electrode regions were not, in general, equal in value. In many cases, the effect, when the H.T. electrode was illuminated, was found to be greater than that when the other electrode was illuminated.

TABLE III

Negative Joshi effect in hydrogen. Applied voltage = 6800 volts, 50C/s

	Distance from H.T electrode (cms)	Galv readings in cms. Light off	Light on	Photo-reduction
Set 1	0(H.T.)	47.5	43.5	4.0
	1	47.5	33.0	14.5
	2	47.5	35.2	12.3
	3	46.5	38.3	8.2
	4	46.5	42.5	4.0
	5(L.T.)	46.5	41.3	5.2
	6	45.0	45.0	0.0
Set 2	0(H.T.)	45.5	43.0	2.5
	1	46.5	36.7	9.8
	2	46.5	40.1	6.4
	3	46.0	42.7	3.3
	4	47.0	44.5	2.5
	5(L.T.)	47.5	43.0	8.5
	6	46.5	46.5	0.0
Set 3	0(H.T.)	40.5	37.6	2.9
	1	41.5	26.8	14.7
	2	41.5	34.2	7.3
	3	41.0	37.0	4.0
	4	40.5	37.4	3.1
	5(L.T.)	40.5	35.3	5.2
	6	40.5	40.5	0.0

The experimental data for the iodine vapour discharge tube showing negative and positive Joshi effects are given in Tables I and II. In Table III are given the data for the hydrogen discharge tube showing negative Joshi effect.

4. CONCLUSION AND DISCUSSION

It is abundently clear from the experimental results that both the positive and negative Joshi effects should be associated *predominantly* with the regions of the electrodes. With regard to (*iv*), it can be said that the wall charges on the outer surface of the discharge tube were definitely different near the H.T. electrode from those near the electrode which was earthed. This would perhaps explain the difference in the effects observed at the two electrodes. When earth connections were removed and the secondary terminals were directly connected to the two electrodes of the discharge tube, the effects were, in general, found to be of about the same order for the two electrodes in the case of the negative Joshi effect. Further experiments on the effect of wall charges are in progress.

The small amount of photo effect observed when the middle region of the discharge tube was illuminated could be attributed to the stray light reaching the electrode regions after being scattered from the illuminated glass side of the discharge tube. Whether or not this should be regarded as a contribution of the discharge column is indeed difficult to say with any certainty. It is, however, definite that such contribution, if any, must be quite small.

With regard to the experimental results of Agashe, we shall now point out certain features in the lay-out of the experiments which must be taken into consideration in making any final conclusion. It should be noted that the electrodes in Agashe's experiments were plane metal electrodes fitted on to the flat ends of the discharge tube and that when either of the electrodes was illuminated by the beam of light, the latter grazed the surface of either electrode, the angle of incidence being 90°. Under such circumstances, according to the cosine-law of intensity variation, the intensity of light falling on either electrode should be minimum and there should be practically no Joshi effect. We are inclined to believe that little or no photo-reduction of discharge current observed by Agashe, when the electrode regions were illuminated, is to be attributed to this cause. It should also be noted that the length of the discharge tube in Agashe's experiments was as small as 4.5 cm. With such a short discharge tube, there must be some diffused or scattered light from the illuminated glass side of the discharge tube (and also from the attached paper scale) reaching either electrode and this should certainly contribute to some extent to the net photo-reduction of the discharge current. The light scattered from the gas or vapour at low pressure must, however, be too small to produce any appreciable effect. In view of the above considerations regarding the effect of light scattered from the illuminated glass side of the discharge tube to either electrode and in consideration of our experimental results with the sleeve-discharge tubes filled with iodine vapour and hydrogen, we can only say that the experimental evidence substantiating the role of the positive column in the production of Joshi effect should be considered inconclusive.

A short note on the subject has already been published elsewhere (Khastgir, 1952).

ACKNOWLEDGMENT

Our sincere thanks are due to Dr. S. R. Khastgir, D.Sc. (Edin.) F.N.I., under whose guidance the present experiments were carried out.

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