OPTIMUM CONDITIONS TO OBSERVE THE NEW LIGHT EFFECT*

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ABSTRACT. Some experimental results with electrodeless discharge tubes containing iodine vapour are conducted with special reference to ageing The results have shown that the effect of ageing is only the removal of occluded gases and vapours from the glass wall of the discharge tube. As a consequence of these experiments a new apparatus called the 'envelope tube' has been devised to obtain consistent results without waiting for ageing. From these results the optimum conditions for observing the new light effect have been worked out to be (a) ageing the envelope tube under low external pressure or heating it to a high temperature in vacuum till standard current voltage characteristics as shown are obtained; (b) sealing it under the above condition.

However, the cleaning up procedure recommended in this paper refers only to the external surface of the discharge tube.

1. INTRODUCTION

A glance through the vast literature on the new light effect discloses that consistent results have not been observed for the same substance by different experimenters. It might also be noted that none of the workers in that field has stated precisely the optimum conditions under which the effect can be observed. Moreover, the standard forms of the current voltage characteristics have not been worked out. In the present paper the inconsistency of results has been traced to the influence of occluded gases and water vapour in the glass wall of the discharge tube.

It has been observed that ageing of the discharge tube influences the effect considerably, sometimes increasing (Joshi and Bhat, 1942 and Deo, 1944) the percentage effect and sometimes reducing (Arnikar, 1944) it. In the case of mercury vapour (Prasad and Venkateswarlu, 1949) even ageing of the discharge tubes for a long period of 424 hours could not show any light effect, whereas one discharge tube with a preliminary heating upto 200°C. for 4 hours gave an effect of 60%. This shows that ageing alone is not sufficient for observing the effect. Secondly, while investigating the new light effect, it has been observed very often, that the discharge tubes which exhibited a good light effect suddenly became inactive under certain external conditions.

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The present paper concerns itself with the study of conditions under which reproducible and steady light effect can be observed. The necessary optimum conditions have been found to be (1) 'ageing' which is a cleaning up of the external surface of the discharge tube to remove the occluded water vapour as a result of passing the discharge for a long time through the tube and (2) securing a dry atmosphere surrounding the experimental tube.

2. INVESTIGATION OF OPTIMUM CONDITIONS

(*a*) *Experiments on humidity* :

A glass chamber was used in these experiments. Anhydrous calcium chloride granules were placed inside the chamber. A small paper hygrometer (Edney) was also placed inside the chamber. By adjusting the quantity of calcium chloride, the percentage humidity inside the glass chamber could be maintained at any required value. The discharge tube containing iodine vapour, at saturated vapour pressure (3 mm of mercury at 40°C), fitted with external sleeve electrodes was placed inside such a chamber. The saturated iodine vapour pressure was maintained by sealing the discharge tube with some solid iodine inside it. A 500 Watt incandescent lamp kept inside a projection lantern at a distance of 6 feet was used for irradiating the discharge tube. Precautions were taken to see that the intensity of light emitted was constant throughout the experiment. The light effect was observed with varying humidity of the air surrounding the discharge tube. The Δi values i.e. the difference between the current in dark and current under light were studied. The results are shown in Fig. 1.

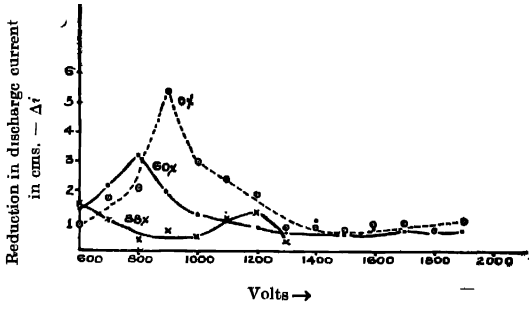

Fig. 1. Negative light effect under different humidity conditions.

The results in general have shown that the light effect and the voltage limits, in which this light effect occurs, increase as the percentage humidity of the surrounding air decreases. This shows the profound influence of humidity on the light effect.

(*b*) *Bell-jar experiments* :

A discharge tube containing iodine vapour at its saturated vapour pressure (3mm of Hg at 40°C) was fitted with two sleeve electrodes, of a few turns of copper wire each, kept at about 5 cm apart. This discharge tube was suspended inside a bell-jar of volume 4000 cc. by means of two copper wires connected to the sleeve electrodes. The bell-jar was kept on a bed plate with arrangements for removing air from or introducing dry air into the bell-jar.

To dry the atmospheric air a system consisting of drying agents, anhydrous calcium chloride, concentrated sulphuric acid, and phosphorus pentoxide in series was rigged up. The air, after passing through these drying agents, was introduced into the bell jar whenever necessary.

A Cenco hyvac pump was used to evacuate the bell-jar

A paper hygrometer (Edney) which gave the relative humidity of the air directly was kept inside the bell-jar to read the humidity A mercury manometer was attached to the system to read the pressure inside the bell jar

3. EXPERIMENTAL PROCEDURE AND RESULTS

The experiment consisted in removing the humid air from inside the bell-jar and filling it again with dry air whenever necessary. Under these conditions readings for the light effect were taken using the conventional circuit The results of a typical experiment are given below in Table I.

TABLE I

Date	Time	Ageing	% Humidity	Maximum % light effect	Remarks
29-10-58	1 00 P.M.	--	53	Nil	No effect
,,	1.30 P.M.	30 Min.	53	Nil	,,
,,	1 40 P.M.	—	0 (Dry air)	18	Small & Irregular
,,	2 15 P.M.	15 Min.	0	15 4	Fairly regular
30-10-58	12 Noon	—	25	16.6	Small & regular
31-10-58	12 Noon		30	12	,,
,,	1.15 P.M.	75 Min.	30	12	Not good
,,	3 00 P.M.	—	20	18	Better results
1-11-58	12 Noon	—	24	16	,,
,,	1.30 P.M.	90 Min.	24	23	,,
,,	2.00 P.M.	Kept under low atm. pr. for 30 Min.	—	25	,,
4-11-58	12 Noon	—	0 (Dry air)	23	,,

At this stage the maximum improvement of the light effect by the reduction of humidity alone was reached. In order to remove occluded water vapour the pressure of air in the bell-jar was reduced, from 68 cm of Hg to 8 cm of Hg, in steps of 10 cm of Hg and at each step the readings for light effect were taken. As the pressure of the air decreased the light effect was found to improve gradually. After each series of experiments the bell-jar was filled with dry air. This experiment was repeated for about 3 or 4 days. By then the discharge tube had developed a large and regular light effect. The experimental results after this date are given in Table II.

TABLE II

Date	Time	% Humidity	Maximum % light effect	Remarks
7-11-58	12 Noon	0 (Dry air)	52	Large & regular
12-11-58	,,	30	61	A bit irregular
14-11-58	,,	0 (Dry air)	65	Large & regular
17-11-58	2.00 P.M	23 5	50	Reduced
,,	3 00 P.M.	0 (Dry air)	68	Better results
18-11-58	12 Noon	0	69	,,
19-11-58	,,	0	65	,,
21-11-58	,,	26	69	Consistent reproducible results (shown in Fig. 3).

The current voltage characteristic and the Δi voltage characteristic as obtained till November 19, 1958 are shown by a set of typical curves in Fig. 2.

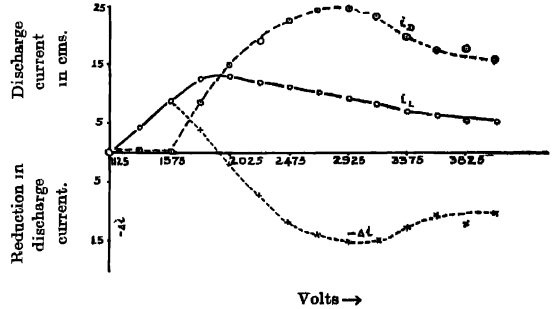

Fig. 2. Characteristic curves not under optimum conditions.

The readings for light effect taken after reaching the steady state showed a definite change in current voltage characteristics giving the standard forms of these curves. They are shown in Fig. 3 from which it is obvious that an ageing process extended over about a fortnight enabled consistent results to be obtained with the tube inside the bell-jar. It is interesting to note that when the discharge tube was removed from the bell-jar the same characteristics could not be obtained.

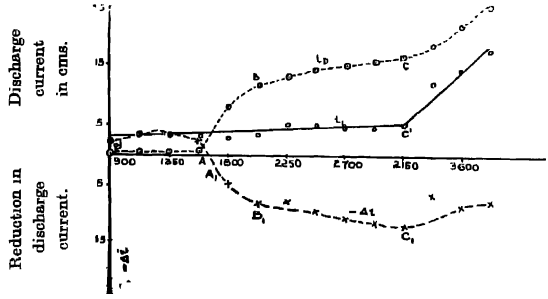

Fig. 3. Characteristic curves under optimum conditions.

The above account shows that consistent results can be obtained by the removal of occluded water vapour from the walls of the discharge tube after a tedious process extending over a large period. To obviate this difficulty a new apparatus was devised which may be called 'envelope tube' whose description and working is given below.

4 ENVELOPE TUBE EXPERIMENT

A short note giving a preliminary description of the envelope tube and its working was published recently (Setty, 1959). The discharge tube (Fig. 4) is a co-axial double tube in which the space between the inner and the outer could be evacuated while the inner tube serves as the discharge tube. The sleeve

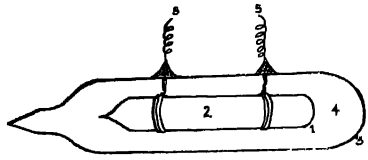

Fig. 4. Envelope Tube.
(1) Discharge tube. (2) Iodine vapour. (3) Envelope. (4) Perfectly dry air in between discharge tube and envelope (5) Electrodes.

electrodes wound round the discharge tube were brought out by sealing them through the glass envelope. The whole apparatus was heated to a temperature

of 400°C and the envelope was evacuated using an oil diffusion pump for sufficient period and then refilled with dry air to the required pressure and sealed off. In some tubes the space was left as a vacuum. After the discharge tube cooled to the room temperature it was tried for the light effect. Results obtained with both types of tubes agree. A typical result obtained under these conditions is given in Fig. 5 which resembles Fig. 3 pertaining to bell-jar experiments in every respect.

5. EXPERIMENTAL RESULTS

A comparison of Figs. 3 and 5 shows that both of them are almost identical But a distinct difference is observed between these and results in Fig. 2.

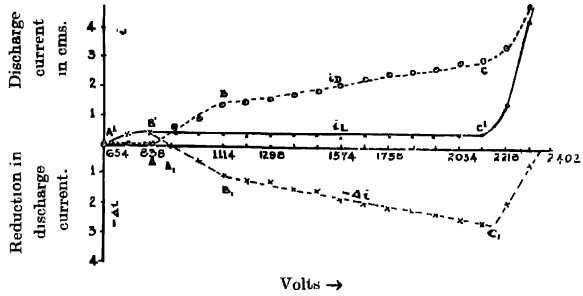

Fig. 5 Characteristic curves under optimum conditions with envelope tube.

In Fig 2 all the characteristics (i_D. i_L and $-\Delta i$) start at some particular voltage and reach a maximum at a higher voltage beyond which they diminish considerably.

In Figs. 3 and 5 the characteristic i_D starts at a particular voltage A, increases rapidly upto a higher voltage B, beyond which the increase is gradual throughout the voltage up to C After this point C the characteristic i_D suddenly shoots up The characteristic i_L starts at a particular voltage A', increases rapidly upto a higher voltage B' beyond which it is almost parallel to X axis till the point C'' After the point C'' this also shoots up and meets i_D characteristic. Thus i_D and i_L do not show any tendency of diminishing at any voltage.

$-\Delta i$ characteristic starts at a particular voltage A_1, increases rapidly upto the point B_1 beyond which the increase is gradual upto C_1. But after C_1 it suddenly diminishes and meets the X axis showing the absence of light effect.

6. DISCUSSION

The first set of experiments with the tube inside the glass chamber reveals that the humidity of the atmosphere surrounding the tube brings down the light

effect in accordance with Fig. 1. It is clear from Fig. 1 that the maximum value of the negative light effect ($-\Delta i$) goes on decreasing with the increase of the percentage humidity of the surrounding atmosphere. The second peak for 88% humidity at 1200 volts is a non-repeatable one, showing that the conditions for observing the light effect are not optimum. The second set of experiments points out the influence of gases and vapours occluded in the walls of the discharge tube, the results on the releasing of which is indicated in Figs. 2 and 3. The curves in Fig. 2 establish beyond doubt that as the occluded gases and vapours are removed from the walls of the discharge tube, the light effect observed not only goes on increasing but the voltage limits in which it occurs also increase enormously. That the process of ageing heats the discharge tube is supported by Mackinnon (1928) and Viswanathan (1951) That the occluded gases and

TABLE III

Percentage light effect observed with the Envelope Tube at different intervals

Volts	% light effect			
	11-2-59 (I)	11-2 59 (II)	19-2-59	25-2-59
1001	54.5	44 4	—	38.0
1092	69.7	63.0	50 0	60.0
1183	70.0	69 7	59.3	68.0
1274	73 5	74.4	63 0	71.4
1365	74.5	70.8	65.5	73.8
1456	75.5	74.5	67.0	75.2
1547	76.0	78 4	70 5	74 4
1638	78.4	78 0	71 6	74.0
1729	76.8	75.4	75 0	74.0
1820	75.4	72 9	75.7	71.4
1911	75.0	73 0	76.0	69 4
2002	74.0	71.7	79.4	72.0
2093	74.3	73.6	80.5	71.7
2184	67.0	69.0	77.4	70.0
2275	45.8	39.0	67.4	67.6
2366	0	0	53.2	53.1
2457	0	0	0	0

vapours are liberated when heated in vacuum is supported by Jnanananda (1947) Hence it might be gathered that the removal of water vapour and occluded gases is a pre-requisite for obtaining consistent results in light effect experiments. Reproducibility of results becomes difficult because one has to wait for ageing each time the experiment is started.

The new apparatus devised remove the above difficulty of ageing once and for all. The envelope tube can be used at any time and consistent results are obtained without any preliminary drying or ageing. The consistency of the results are considered here only from the point of view of the form of the curves and not from the voltage characteristics as the thickness of the wall of the discharge tube may interfere with the voltage The readings of the percentage light effect observed with the envelope tube at different intervals but under the same experimental conditions shown in Table III clearly indicate that the results are consistent.

It is suggested that much of the previous work (Joshi and Bhat, 1942, Arnikar, 1949; Deo, 1944, Prasad and Venkateswarlu, 1949; Joshi and Kuppuswamy, 1941, Joshi and Deshmukh, 1942; Joshi and Murty, 1942, and Gopalaswamy and Viswanathan, 1949) yielding somewhat contradictory results be repeated with this new apparatus so that a theoretical explanation of the light effect becomes possible.

Thus the optimum conditions for the observation of the new light effect in A/C silent discharges are the following :

1. The envelope tube should either be aged under low external pressure or heated in a vacuum till it gives most likely the standard characteristics as shown in Fig 5

2 Under the above condition the envelop is sealed with a perfectly dry air at the required pressure or sealed with a perfect vacuum.

7. ACKNOWLEDGMENT

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