CHAPTER II

THE GENERAL EXPERIMENTAL ARRANGEMENT.
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The general experimental arrangement adopted for the present studies is described under the following heads:

I. The discharge tubes.
II. Evacuating, filling and aging.
III. Electrical connections.
IV. Oscillographic studies.

I. The discharge tubes: (a) For single probe studies with sleeve electrodes:

All the experiments recorded in Chapter III were carried out using cylindrical soda glass tubes of internal diameter 24 mms. excited by a pair of external metal sleeves which served as electrodes in this case. The sleeves consisted of tightly and closely wound bare manganin wire (fig. 9). The probe was made of a fine platinum wire of diameter 0.25 mms. sealed in the middle along the length of tube. Only the tip and a small portion of its length (approximately 2 mms.) was used for collecting charges from the discharge space, the rest of the wire being covered by a glass capillary to insulate it from the discharge space.

The intersleeve distance, $d_s$, and the distance of the probe from the common sleeve, $d_p$, could both be varied independently.

For the experiments reported in Chapter IV, the same discharge tubes were used as in the Chapter III, with this difference that in place of a metal probe a glass probe was used.
The glass capillary over the metal was directly connected to the probe circuit in place of the probe wire, keeping the charge collecting area in the discharge space the same as in the previous case. This procedure introduced not only a high resistance corresponding to the glass wall in the probe circuit but also introduced a capacity corresponding to the capillary.

(b) For single probe studies with internal metal electrodes:

Cylindrical pyrex glass tubes of internal diameter 34 mms. with internal metal electrodes were used as the discharge vessels for the experiments reported in Chapter V. The electrodes were made of identical circular plane parallel copper discs, bevelled at the edges to avoid the edge effects. The diameter of the plane portion of each electrode was 20 mms. The electrodes were mounted on a glass frame with a piece of iron (fig. 15) so that while keeping the inter-electrode distance constant the system of the two electrodes could be moved with the help of a powerful magnet, an arrangement similar to that of Wilson 66 Asten. The probe was made of a fine tungsten wire of diameter 0.15 mms. Except for the tip (2 mms.), the entire probe was insulated from the discharge space by using a glass capillary similar to that reported above. Nickel beads were also formed at the outside end of the tungsten wire to prevent the slow leakage due to the fibrous structure of the metal. The inter-electrode distance, \( d_e \), was maintained constant, while the distance of the probe from the common electrode, \( d_p \), was varied.

(c) For double probe studies:

For the results reported in Chapter VII, both types of tubes with internal and external electrodes described
above were used. In place of one probe two identical probes were inserted in the middle of the tubes.

II. Evacuating, filling and aging:

(a) Evacuating:

All the discharge tubes were cleaned thoroughly several times with concentrated chromic acid and distilled water before attaching them to the evacuating unit. The tungsten wires used for probes were also heated and cleaned with sodium or potassium nitrate to remove the sorbed impurities. The entire apparatus was evacuated by a pump and allowed to stand in the evacuated condition for more than 24 hours. If no leak was observed, the discharge tubes were partly degassed by flame treating and passing a heavy discharge for about an hour while the evacuation continued. The tube was then filled with the gas at the desired pressure and sealed.

(b) Filling:

The gas used was atmospheric air dried over calcium chloride and phosphorus pentoxide. The pressure in the tube was measured by a mercury U-tube manometer capable of reading upto 1 mm. Hg. For tubes with external sleeve electrodes, pressures below 2 mm. Hg. were not investigated. For the internal metal electrode tubes, lower pressures were also studied. Pressures below 1 mm. Hg. were computed by measuring the length of the dark space near the metal electrodes by a travelling microscope. The pressure was calculated from the relation \(pd = \text{constant}\), where \(p\) is the pressure and \(d\) the length of the dark space. The gas used was admittedly contaminated by Hg. vapour because of the use of the mercury manometer; though
attempts were made to minimise this contamination by using capillary tubes to connect the manometer, by putting a small column of oil above the mercury in the manometer and using the manometer only. When the tubes were to be filled. After filling a tube at the desired pressure, the tube was sealed off.

(c) Aging:

Each discharge tube was aged under intermittent discharge initially for more than 24 hours. Further before taking any set of observations the tube was again aged for nearly one hour under discharge at a potential well above the threshold potential (vide infra:15). This aging treatment was found necessary to get reproducible results especially for tubes with external sleeve electrodes.

III. Electrical connections:

(a) For single probe studies:

The electrical circuit for single probe studies is shown in fig. 14. Stabilised single phase 50 c/s a.c. potentials were obtained from a constant voltage transformer connected to the a.c. mains and were fed to the auto-transformer with two variable outputs which supplied the potentials applied to the primaries of two identical H.T. transformers. These potentials were read accurately by a.c. voltmeters. The potential difference across the secondaries of the transformers were computed from a knowledge of the potential difference across the primary and the step-up ratio of the transformer. This latter was determined in preliminary experiment. This method of computing the secondary voltage is similar to that of Thornton.
One of the transformer, \( T_1 \), called the tube transformer, was used to excite the discharge tube while the other, \( T_2 \), called the probe transformer supplied the potential to the probe. One of the secondaries of the probe transformer, \( T_2 \), was connected to one electrode of the discharge tube hereafter called the H.T. electrode. The other secondary terminal of \( T_2 \) was earthed. The probe was also earthed through the current detectors. A triode (1H5GT of RCA30), used as a diode (grid and plate connected together) was used as a current detector. It was coupled to the probe across a resistance. The value of the coupling resistance was changed from a few to a few tens of kilo ohms. The current in the plate circuit of the detector was measured by a sensitive moving coil galvanometer (sensitivity \( 10^{-9} \) amp/mm) properly shunted wherever necessary. To measure the current in the probe in both the halves of the a.c. cycle simultaneously, two detectors (with galvanometers \( G_1 \) and \( G_2 \)) of this type with equal coupling resistances were used.

The H.T. electrode of the discharge tube was also connected to one secondary of the tube transformer, \( T_1 \), while the other electrode, hereafter called the L.T. electrode, was connected to the other secondary of the tube transformer, \( T_1 \), through another current detector (with galvanometer \( G \)) similar to the one described above. Preliminary experiment indicated that the tube current in both the halves of the a.c. cycle was sensibly the same when identical electrodes were used, as in the present case. This is further borne out by the studies of the rectification in this laboratory. The tube current was,
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220V 50 C/s
therefore, measured only in one half of the a.c. cycle. For comparison in some cases, measurements were also made in the other half. Due to their essential similarity they are not reported here.

For studies with single probe a water resistance of the order of \(10^9\) ohms was included in the probe circuit in the H.T. line, to make the resistance in the probe circuit large as compared with the resistance of the gas column. In addition, for tubes with internal metal electrodes, a resistance of \(10^6\) ohms was connected in the tube circuit to control the current and to prevent the discharge from developing into an arc.

(b) For double probe studies:

Fig. 15 shows the electrical circuit for studies using floating double probes. This was essentially similar to that of Johnson and Malter. For exciting the discharge tubes, the arrangement was the same as that used for single probe studies. In the present case also, the electrode connected to the detector is called the L.T. electrode while the other is called the H.T. electrode. For the floating double probes, d.c. potentials were obtained from dry batteries. The potential applied to the probes was measured by a sensitive d.c. voltmeter and the probe current was measured by a sensitive moving coil galvanometer, inserted in the probe circuit.

IV. Oscillographic studies:

To investigate the time delineation of the probe current, the probe potential and the tube potential, a cathode ray oscillograph (Precision No. E-S-520) was used for single probe
To investigate the waveform of the probe current, the probe was earthed through a carbon resistance. The potential drop across this resistance was fed to the vertical input of the C.R.O. and the internal time base of the oscilloscope was used. For wave forms of the potential or the tube potential a very high non-inductive resistance was connected across the secondary of the probe or the tube transformer respectively, and the potential drop across a part of it was fed to the vertical input of the C.R.O. Here again the internal oscillator of the C.R.O. was used for the time base.

Some observations have also been made by applying the probe potential across the tube horizontal input and the probe current in the vertical input for the tubes excited by the external sleeve electrodes. The probe was earthed through a carbon resistance and the potential drop across the resistance was fed to the vertical input of the C.R.O. Further a high non-inductive resistance was connected across the secondary of the probe transformer and the potential drop across a part of it was fed to the horizontal input of the C.R.O. This arrangement gives on the screen a Lissajous figure from which it is possible to measure the difference between the probe potential corresponding to the minimum in the capacitive current and the minimum pulse current, and also the phase difference between the probe potential and the probe current.

An essentially similar arrangement using a single beam cathode ray oscillograph was used to ensure that the probe and tube potentials are in phase. This was further checked by
Du Mont No. 322A Double beam cathode ray oscillograph in which the potentials from the tube and the probe transformers were fed to the two vertical inputs. A common time base was used. This was found necessary for all the measurements for single probe studies.