CHAPTER II

GENERAL EXPERIMENTAL ARRANGEMENT
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The general experimental set-up for the work presented in the thesis, consists of the following:

I VACUUM UNIT
II PRODUCTION OF PLASMA
III CONFINEMENT OF PLASMA
IV SONIC PROBE ARRANGEMENT.

2.1 VACUUM UNIT

The fundamental requirement for studying gaseous discharge and plasma state in the laboratory is the production of precisely controlled and accurately measurable low pressure (of the order of 1 Torr). This whole unit is an assembly of a vacuum chamber, a vacuum pump and a pressure gauge to measure the pressure.1, 2

Vacuum Chamber

In the study presented here, two different vacuum chambers were used, one big steel chamber and one small glass chamber. These chambers were designed depending upon the specific experimental study. It was observed that there was no appreciable variation of parameters, unless the chamber was very much small, so that the plasma column touched the walls. Thus the chambers were made as big as possible so that assembly of the apparatus could be kept inside it without touching the walls.
The big steel chamber was fabricated in the workshop of Government College of Engineering and Technology, Raipur, (M.). The inner diameter of the chamber was 20 cms and its height, 40 cms. The chamber was made of 1.0 cm thick cast iron. The upper portion of the chamber was covered with a sealing of perspex sheet (4mm thick) with the help of Araldite (adhesive). Electrical leads, for high voltage and other connections were also sealed with the help of Araldite, after inserting them in the drilled holes on perspex sheet. The perspex sheet used was able to sustain low pressure and it was transparent so that one could view the inside of the chamber. The chamber was kept on a platform (surface-plate) and was made vacuum-tight by applying vacuum grease locally around the base circumference of the chamber. The assembly of apparatus was kept inside the chamber. The platform was made of steel (diameter-30 cms) and provided with three outlets. One of these was connected to the leak valve.

The second small glass chamber was designed specially for observations in the presence of magnetic field. It was fabricated in the glass blowing laboratory of Bhilai Steel Plant. The chamber was made of pyrex glass tube of internal diameter 10 cms and length 20 cms. Both the ends of the tube were closed with perspex sheet, with the loudspeaker fitted on one sheet and microphone on the other. Perspex sheets were also sealed on the tube ends with the help of Araldite. Two diametrically opposite holes
were drilled on the glass tube at its middle for leads to the aluminium electrodes. The electrodes were fixed in such a way that the microphone and the loudspeaker were perpendicular to the discharge column. The discharge tube was provided with three jet holes, for connection with the vacuum pump, the vacuum gauge and the leak valve.

As the present investigations are directly concerned with the production and measurement of sound wave pressure inside the chamber, it was important to make the chamber "anechoic" so as to completely absorb the sound waves and to avoid reflections from the walls/microphone etc. and their interference with newly produced sound waves that would cause errors in the measurements. This was achieved by coating the inner walls and other equipments in the chamber with glass wool and by porous/spongy materials.

Production of Low Pressure

In the present investigation experiments were performed at a pressure ~ 1 Torr. This range of pressure was obtained by a rotary oil vacuum pump (Model SSRR 30, single stage, manufactured by Basic Synthetic Chemicals Calcutta-33). The chamber was first evacuated by the pump, later the experimental gas (dry air) was introduced [Fig.(2.1)]. The air was dried by passing it through a U-tube containing calcium chloride. The desired pressure was maintained by adjusting the valve and the fine regulator.
Measurement of Pressure

The pressure inside the chamber was measured with the help of a vacuoscope (Mc-Leod Gauge VJ/2, Basic Synthetic Chemicals Private Ltd., Calcutta-33). The vacuoscope was a miniature Mc-Leod gauge and working on the same principle. The pressure range that could be measured with the help of this gauge was 0.01 - 10 Torr. The vacuoscope gave direct readings of the pressures on a calibrated scale, provided with it.

2.2 Production of Plasma

The discharge was produced in between the two circular electrodes facing each other at a pressure ~ 1 Torr. Each electrode was made of 1 mm thick circular aluminium disc of diameter 2 cm and the interelectrode spacing was kept 3 cm. Aluminium was selected as the material for electrodes; because it gives small secondary emissions and shows little cathode sputtering. These electrodes were rounded off at the edge in order to avoid distortion of the electric field. They were thoroughly cleaned and made smooth by matching in order to get a steady state discharge.

The discharge was excited by stabilized high voltage d.c. and a.c. (50 Hz) fields. A schematic diagram with essential elements is shown in Fig.(2.2).

D.C. Discharge

A direct current high voltage was obtained by using a high voltage power supply unit (Model dV 200, Max. voltage
2 kV at 1 mA, manufactured by Trombay Electronic Instruments). The voltage was varied with the help of 'coarse' and 'fine' variable knobs provided with the power-supply unit. The voltage applied was measured with the help of a volt meter provided with the unit.

The discharge circuit, as illustrated in Fig. (2.2), was made by connecting the high tension terminal to one electrode and the second electrode was connected to the negative (earthed) terminal of the power supply, through a resistance of 10 KΩ in order to limit the current. The discharge current was measured with the help of a calibrated reflection type moving coil galvanometer with lamp and scale arrangement.

A. C. Discharge

An alternating high voltage was obtained with the help of a step-up transformer (Type A 717, Kir. Voltage 230 volts, Spec. Voltage 10 kV, Radio Sound, Bombay). The voltage to the primary of the transformer was fed by a variable (0-250 volts) auto-transformer (Dimmerstat, Type T 1264/7731, AMPL, Bombay). The a.c. discharge circuit consisted of similar elements as those in a.c. discharge circuit. The electrodes were directly connected to the step-up terminals of the transformer, through a resistance of 10 KΩ. The discharge voltage was measured with the help of a high impedance vacuum tube voltmeter (V. T. V. M. SM 6009, Philips, India). The discharge current was measured by a calibrated galvanometer in the circuit containing a
rectifier (U, 70) across the resistance of 10 k as shown in the Fig. (2.2).

2.3 Plasma Confinement

The plasma was confined longitudinally with the help of a uniform magnetic field applied parallel to the electric field. The magnetic field was produced by means of a pair of Helmholtz's coils and varied between the range 0-250 Gauss.

The Helmholtz's pair [Fig. (2.3)] were two similar wire bounded coils of same radius separated by a distance r, equal to the radius of the either. The coils were connected in series so that current flows in both of these coils in the same direction. Thus a fairly constant magnetic field around a distance r/2 was obtained.

The magnetic field was varied by varying the current in the coils, and was measured with the help of a search coil and a galvanometer. The measurement of magnetic field at different points showed that the field was fairly uniform around r/2.

2.4 Sonic Probe Arrangement

The sonic probe technique\textsuperscript{11, 12} consists essentially of two parts, the first part of which involves generation and transmission of sound signals, and the second part involves reception and measurement of pressure amplitude of the transmitted signal, as shown in Fig. (2.4).
Sinusoidal sound waves were generated with the help of an audio frequency oscillator (Advance type -II, model 1, made in U.K.) with output voltage between 0 to 25 volts and frequency range 20 Hz - 20 KHz. They were amplified with the help of an audio frequency amplifier (type 6503, Philips, India). Amplified sound waves were fed to a small size moving coil loudspeaker kept at right angles to the discharge column.

A moving coil microphone kept in the line of the loudspeaker received the transmitted waves. The waves were amplified by a second audio frequency amplifier Type 201 A, Madart). The amplified waves were detected and measured by a V.T.V.M. after due amplification.

The procedure of measuring sound wave pressure was as follows : (i) in air and (ii) with plasma.

(i) A suitable sound wave pressure was adjusted at the receiving end by manipulating the output of the audio oscillator and the audio amplifiers. Let the voltage as read by V.T.V.M. be $V_1$ (volts).

(ii) Now, the plasma was created by passing an electrical discharge through air. Let the magnitude of the voltage at the receiving end as recorded by V.T.V.M. be, $V_2$ ($< V_1$).

The experiment was repeated by changing, (1) the frequency of the audio signal and (2) the state of ionization (by changing the voltage at the electrodes in the discharge tube).
Using $V_1$ and $V_2$ (proportional to the incident and transmitted signal currents $i$ and $i'$ respectively), the attenuation of sound waves was calculated. This gave the value of characteristic impedance $r$. From the knowledge of $r$ the value of electron temperature was calculated in the experiment concerned.

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REFERENCES


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