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INVESTIGATIONS OF LONGITUDINAL HOLLOW-CATHODE DISCHARGE

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Results of investigations of a longitudinal hollow-cathode discharge are presented for a hollow cathode of 5 mm diameter and a length variable from 8 mm up to 96 mm. Hollow cathodes of such dimensions are used in discharge tubes employed in laser technology.

Axial distributions have been determined for the current density over the cathode surface, discharge current intensity and discharge plasma potential. Also voltage vs current discharge characteristics have been measured.

The measurements have been carried out for discharge in helium at a pressure ranging from 1.67 hPa to 34 hPa. The current intensity varied from 1.86 mA to 250 mA depending on the cathode length.

The investigations covered hollow-cathode discharges in the presence of one anode as well as two anodes located at the opposite ends of the cathode. An axial inhomogeneity of the discharge plasma resulting in nonuniform axial distributions of the cathode and longitudinal currents as well as nonuniform axial distribution of the discharge plasma potential was observed for both cases.

The inhomogeneity of the longitudinal hollow-cathode discharge affects the operation of the laser discharge tube. Some consequences of this inhomogeneity are discussed.

1. Introduction

In the hollow-cathode discharge tubes two principal kinds of electric discharge can be distinguished: the transverse and the longitudinal discharge [1, 2].

The transverse discharge occurs in tubes where the tube geometry and configuration of the electrodes — cathode and anode — makes the electric charge carriers, electrons and ions, move transversely to the hollow cathode axis (Fig. 1a). It is characteristic of the longitudinal discharge that electrons leaving the cathode surface move towards the anode along the hollow cathode axis (Fig. 1b).

Both the transverse and longitudinal discharge, as well as a discharge of intermediate nature, have been applied for the excitation of lasing in various media [1, 2].

The properties of longitudinal hollow-cathode discharge proved especially convenient for the forming of population inversion in the He – Cd mixture, generating the three basic spectral lines: blue, green and red, which can be mixed to produce white light [3].

The importance of this fact from the viewpoint of possible applications has increased the interest in properties of the longitudinal hollow-cathode discharge. The principal parameters of such discharge which decide whether it is applicable to the excitation of lasing media are the current density distribution over the cathode surface, the discharge plasma current distribution, the cathode fall distribution, the electron energy distribution function, the electron number density distribution, etc.

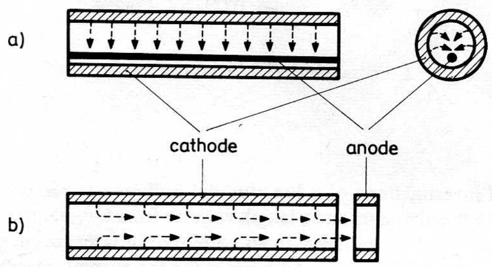

Fig. 1. Schematic diagram of typical hollow cathodes characterized by (a) transverse and (b) longitudinal discharge direction

Papers on the investigations of some of these parameters [4–11] except [9], refer to the longitudinal discharge in hollow cathodes not typical of the laser technology. As the laws of similarity do not hold for the hollow-cathode discharge, the applicability of the results published in [4–11] to the description of the longitudinal hollow-cathode discharge in laser tubes is limited.

This paper presents the results of investigations concerning some properties of the longitudinal discharge in a hollow cathode characterized by parameters typical of discharge tubes used in laser technology.

2. Measuring set-up

The dimensions of the hollow cathode and the measuring range were chosen to be typical of the longitudinal hollow-cathode discharge in lasing mixtures of helium with metal vapours (Cd, Zn, I etc.).

The discharge tube (Fig. 2) consisted of 52 independent annular segments 2 mm thick. The segments were made of stainless steel. Their inner and outer diameters were equal to 5 mm and 20 mm, respectively. Each of the segment rings was separated from the adjacent ones by mica spacers 0.05 mm thick. The rings were put in a pyrex tube in such a way that discharge could occur inside the system of rings only. Separate electric leads to each of the rings made it possible to change the ring polarity freely and to form a hollow cathode of a length variable from 2 mm up to 96 mm. The current to each of the rings could be measured. The measurements were made by measuring the voltage drops across calibrated (6 ohm) resistors connected to respective ring circuits. To