Origin of Positive Rays in Cathode Ray Discharge Tubes Having Hollow Cathodes (demonstration)

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The exact origin of the positive rays in a hollow cathode has become a moot question. Formerly the view was held, in the case of a hollow cylindrical cathode with an opening along the axis, that they had their origin in the negative glow just beyond the Crookes dark space, and fell, under the action of the strong electric field, towards the cathode, passed through it, and emerged as a compact beam of positive rays. A more recent view is that the positive rays have their origin *within* the hollow cathode itself. By mounting a mica vane on a track in front of the cathode face, the true origin of the rays can readily be demonstrated.

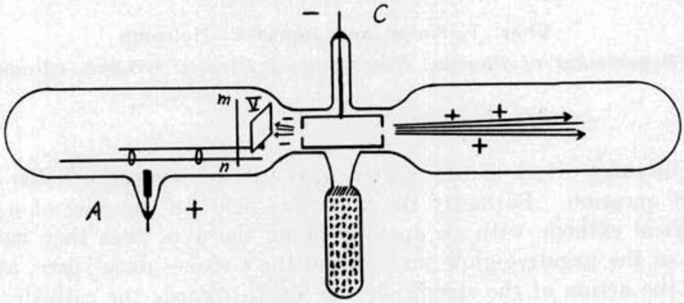
Two forms of positive ray tubes were used.

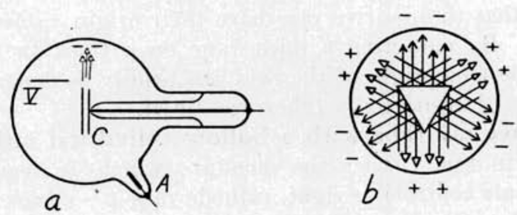
A. Positive ray tube with a hollow cylindrical cathode.—This form is shown in Fig. 1 when the vacuum (which is regulated by a charcoal-liquid air control) is right, cathode rays (—) leave the cathode surface normally and pass along the tube to the left. The position of the Crookes dark space is shown by the plane mn. The positive rays (+) emerge from the opening in the other end of the cylindrical cathode and pass along the tube to the right.

For the purpose of our demonstration a vane V was mounted on a carriage, carried on a track (shown in elevation in Fig. 1). By tilting the tube as a whole, the vane could be moved along the track and made to occupy any position out in front of the cathode, and thus intercept the cathode ray beam at any point along its path. This procedure should give us information as to the origin of the positive rays. If the origin is within the negative glow, then the vane when placed between that and the cathode face should cut off the positive ray beam. This was found *not* to be the case. The beam seemed to be as bright as before. The conclusion from this experiment follows that the positive rays have their origin *within* the hollow cathode.

This experiment, however, was not very conclusive, since the presence of the vane so near the cathode (for technical reasons) interfers with the total electrical energy passing between the electrodes A and C. Further experimentation with another form of positive ray tube seemed desirable.

B. Kunz[1] positive ray tube with hollow triangular cathodes.—The form of cathode consists of two triangular sheets of aluminium spaced about 2 mm. apart and riveted together. The term "hollow" relates to the space between. This structure constitutes the hollow cathode and is mounted as shown in side elevation in Fig. 2a, and in front elevation in Fig. 2b. The front and back faces of this hollow





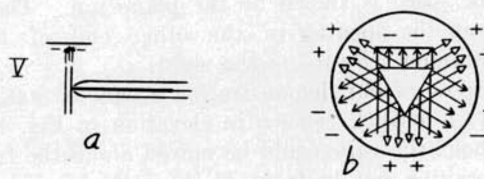


Fig. 1 (Top).—CYLINDRICAL HOLLOW CATHODE.

Fig. 2 (Center).—KUNZ HOLLOW TRIANGULAR CATHODE.

Fig. 3 (Bottom).—KUNZ HOLLOW TRIANGULAR CATHODE WITH VANE V IN PLACE.

cathode are usually covered with sheet mica to prevent electrical discharges from them. When the discharge tube is exhausted to the proper degree and a high direct potential is applied to the anode and cathode, as shown in Fig. 2a, there result cathode rays and positive rays as shown in Fig. 2b. When the residual gas in the tube is helium, the cathode rays appear apple green in color, while the positive rays are a bright

[1] Phil. Mag., VI, XVI, p. 161, 1908.

red. The cathode rays issue perpendicularly from the edges of the hollow triangle, and are shown in the figure by closed arrows. The positive rays are shown with open heads and are, as in the experiment with the hollow cylindrical cathode, in the opposite direction of the corresponding cathode rays, thus emerging seemingly from the apexes of the hollow trianglar cathode. The relation of the positive rays to the cathode rays is thus the same as for the hollow cylindrical cathode (A) above, with the important difference that there are three sets of rays radiating out from the hollow triangular cathode at the same time, so that screening one set has but little effect on the electrical energy flowing through the tube. It should therefore be comparatively easy and reliable to study the origin of the positive rays by interposing a mica vane in the cathode rays of one set.

The position of the vane, V, drawn to one side so as not to interfere with the cathode rays coming from that edge of the hollow cathode, is also shown in Fig. 2a. The vane was then moved into position shown in Fig. 3a while the discharge was passing. The resultant arrangement of the beams is shown in Fig. 3b. The interception of the cathode ray beam did not in any way alter the positive ray beam in arrangement or in intensity. Nor was the brightness of the remaining two sets of beams around the triangle affected in any way.

This experiment demonstrates conclusively that the positive rays in these forms of positive ray tubes have their origin *within* the hollow space of the cathode.

The phenomenon, using the Kunz tube was demonstrated during the presentation of this paper.