

# INVESTIGATION OF GAS FLOWS BY ELECTRON-BEAM METHODS

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**Abstract**

**Full Text**

**MECHANICS**

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## **INVESTIGATION OF GAS FLOWS BY ELECTRON-BEAM METHODS**

*(Presented by Academician S. A. Khristianovich, 10 III 1964)*

This article considers the question of determining the velocity and density of a gas by electron-beam methods.

In investigating flows of gases possessing a long afterglow, such as helium, fluorescent tracing has been used. For this purpose, in the required region of the flow under investigation, a fluorescent mark is created by pulsed irradiation with a thin, well-focused beam of electrons, and the motion of this mark, which is part of the flow, is recorded by optical methods. As it moves away from the place of formation, the mark, which has the appearance of a luminous cord, becomes curved, taking the form of the profile of the velocity field. Photographing the mark by means of an electron-optical converter operating in a stroboscopic regime makes it possible to find the velocity field, while the use of a photomultiplier with a diaphragm having one or two small apertures makes it possible to determine the local velocity from the flight time of the mark over a given base. The spatial resolution of this method is very high. It reaches fractions of a millimeter. The error of the measurements does not exceed 1-5%, depending on the degree of perfection of the recording instruments.

In investigating gases of the air type, which possess a short afterglow, the Doppler shift of the spectral lines of fluorescence is used. The spatial resolution in this case is determined by the diameter of the electron beam. The Doppler shift of the spectral lines of radiation is at present used rather widely for measuring the velocity of a self-luminous plasma. The method used by the author makes it possible to apply it to the investigation of cold gases and, most importantly, makes it possible to obtain the value of the velocity at a point, whereas the methods currently used give values averaged over the entire line of observation. Since, upon excitation of fluorescence by a beam of electrons, there are bright lines not observed in a thermal plasma, the method is also applicable to the investigation of plasma, especially if radiation lines lying in the x-ray region are used.

For visualizing streamlines and measuring the velocity along them, the author used a sweeping beam of electrons. Particles of phosphor were introduced into the flow under investigation. Intersecting the moving particle at each sweep, the electron beam produces a bright flash. Thus the trajectory of motion of

each particle in the plane of sweep of the electron beam is recorded in the form of a dashed line (Fig. 1). If the magnetic field deflecting the beam varies in a sawtooth manner with constant frequency, then the distances between the dashes are proportional to the local velocity of the particle and, consequently, with a certain degree of approximation, to the local velocity of the gas.

For measuring the local density of a gas, the author used x-radiation arising when the fast electrons of the beam are decelerated by the gas. In a steady irradiation regime, the intensity of the x-radiation emitted by an elementary volume is proportional to the number of gas particles contained in it and does not depend on any other pa—

To the article by A. M. Trokhan.

**Fig. 1.** Example of visualization of the flow of a gas containing suspended luminophore dust particles by means of a thin beam of electrons oscillating in a specified plane

**Fig. 2.** Luminescence of a free gas jet (flow from right to left) intersected by a beam of 30-keV electrons. *a* —luminescence in visible rays, *b* —in X-rays

**Fig. 3.** Photograph of a gas jet about 2 mm in diameter, intersected in the axial plane by an oscillating electron beam. *a* —image in X-rays, *b* —in visible rays

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parameters, if the composition of the gas is constant, which cannot be said of visible radiation, where quenching of fluorescence, depending on the state of the gas, plays a substantial role. Measurements by this method can be carried out both in a cold gas and in a plasma. The spatial resolution can reach a value on the order of fractions of a millimeter.

Figure 2 shows photographs of the glow excited in a cold gas in the region where a free jet about 2 mm in diameter is intersected by a beam of fast electrons. In photograph *a* there is a photograph of the visible radiation. The bands in the right-hand part of the photograph are caused by the afterglow of the gas in the accompanying stream. Photograph *b* is an X-ray image. The jet has a heavier composition, which is reflected in a sharp peak in the intensity of the X-ray radiation.

Figure 3 shows photographs of an analogous jet, obtained in visible and X-ray rays by means of a scanning electron beam (*a* is the X-ray photograph). X-ray photography was carried out using a camera obscura with an aperture 0.3 mm in diameter, covered with aluminized mica. Photometry of the negatives makes it possible to determine the density field of the gas under investigation. Measurements are possible even in an optically black plasma. The method described can also be used for visualization of flows in specified planes, in particular for studying the processes of gas mixing and flow past models. In the case where the

pressure in the medium and its composition are constant, this method makes it possible to determine the temperature fields of the plasma and gas.

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*Note: Figure translations are in progress. See original paper for figures.*

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