Results are presented of an experimental investigation of a plasma source the central electrode of which consists of a combination of a copper cylindrical cathode with a heated tungsten cathode at the end; the tests were conducted in argon and helium at currents of 0.4–3.0 kA.

Coaxial plasma sources with cooled copper electrodes and magnetic stabilization of the arc are widely used to heat gases, e.g., air [1], argon, helium [2]. The point of attachment of the arc to the central electrode can be displaced to the end in response to the gas flow; then the interaction of the arc with the external axial magnetic field is reduced, and the rate of arc wander is much lower. This may lead to electrode burnout at high currents.

An additional solenoid within the central electrode provides improved performance in a coaxial plasma source [3]. The internal magnetic field in this electrode provides for the movement of the point of attachment of the arc over the end surface, which eases considerably the operation of the electrode and reduces the contamination of the gas flow by electrode material.

We have examined such a source having a central electrode containing two turns as a coil, these turns being connected in series with the power circuit, and the tests showed that the arc-burning voltage was higher than that for a simple electrode, especially at arc currents above 1.5 kA, but of course there was also a substantially increased heat loss to the external electrode.

We have examined the parameters of a plasma source the central electrode of which consisted of a cooled copper cylindrical cathode with a heated tungsten cathode at the end; depending on the gas flow rate

Fig. 1. The apparatus: 1) copper cathode; 2) heated tungsten cathode; 3) insulator; 4) arc rotation transducer; 5) anode chamber; 6) solenoid; 7 and 8) mirrors; 9) lens; 10) spectrograph; 11) pyrometer; 12) cine camera; 13) arc length transducer; 14) arc; 15) gas inlet.
and the strength and configuration of the external magnetic field, the arc could be struck between the copper electrodes (coaxial system) or between the tungsten cathode and the copper cylindrical anode (end-face system).

The apparatus is shown in Fig. 1. The arc discharge between the central electrode (cathode) 1 and the body (anode) 5 was struck by exploding a wire; the plasma source and the coil 6 were fed from separate power supplies. The internal diameter of the arc chamber was 70 mm, while the body of the cathode had a diameter of 40 mm. The heated cathode 2 consisted of lanthanum-treated tungsten in the form of a rod 10 mm in diameter.

The effects of the magnetic field on the operation were examined with various solenoids composed of identical sections, each section having 960 turns. The various forms of the external magnetic fields are shown in Fig. 2. We measured various parameters of the source during tests.

We measured the arc rotation speed with the photodiode system 4 (Fig. 1) having a narrow acceptance angle [4].

We measured the axial component of the arc length by means of two narrow-angle transducers 13 (DF-2), which were similar in design to the arc-rotation detector. During the measurements, the transducers were positioned on the wall of the arc chamber at distances $l_1$ and $l_2$ from the plane of the cathode.

We measured the temperature of the tungsten cathode by means of the specially developed BFEP-1 fast photoelectric micropyrometer [5].

The sighting aperture of the pyrometer was 1:700, while the error of measurement was about $±1\%$; the instrument provided temperature recording with a delay of less than $10^{-3}$ sec in the range $1700-4300\,\text{K}$. We measured the radiation from an area 3 mm in diameter. The detector could also receive light from the arc column, which could lead to overestimation of the temperature.