The dynamics of the BD is determined by the variation of the capacitance between the electrodes, consisting of the capacitance of the barrier and the capacitance of the gas gap, in the process of the discharge. The amplitude of the BD current pulses depends on the voltage on the electrodes and the capacitance of the barrier.

The considerable current density in the channels and the steepness of the leading fronts of the pulses make it possible to synchronously initiate a large number of autonomous discharges with its help and to form high-current, multichannel discharges.

The author thanks V. I. Bayunov and M. I. Demidov for help in conducting the experiments and I. V. Podmoshenskii, V. Ya. Aleksandrov, and E. A. Zobov for useful discussions.

LITERATURE CITED

1. Yu. V. Filippov, Yu. M. Emel'yanov, and I. A. Semiokhin, Modern Problems of Physical Chemistry, Vol. 2 [in Russian], Mosk. Gos. Univ., Moscow (1968).
2. E. N. Pavlovskaya, I. V. Podmoshenskii, and A. V. Yakovleva, "Emission of a barrier discharge with a ceramic capacitor," Zh. Prikl. Spektrosk., 20, No. 3 (1974).
3. V. Yu. Vinogradov, E. N. Pavlovskaya, I. V. Podmoshenskii, and A. V. Yakovleva, "Emission of a barrier discharge in nitrogen and its mixtures with helium," Zh. Prikl. Spektrosk., 25, No. 4 (1976).
4. V. Ya. Aleksandrov and V. P. Belosheev, "An installation for pulsed photolysis with an extended collective source of vacuum-UV radiation," Zh. Prikl. Spektrosk., 26, No. 2 (1977).
5. V. P. Belosheev, Inventor's Certificate No. 641,569, Byull. Izobr., No. 1 (1979).
6. V. P. Belosheev, "Formation of a multichannel spark discharge in air," Zh. Tekh. Fiz., 49, No. 10 (1979).
7. V. P. Belosheev, "A comparative investigation of one- and two-channel discharges as light sources," Zh. Prikl. Spektrosk., 32, No. 3 (1980).
8. S. I. Andreev, E. A. Zobov, A. N. Sidorov, and V. D. Kostousov, "Investigation of a long creepage spark," Zh. Prikl. Mekh. Tekh. Fiz., No. 1 (1980).

INVESTIGATION OF THE PLASMA STRUCTURE FORMED ON THE SURFACE OF A BODY IN FLOW OF A PARTIALLY IONIZED GAS

V. A. Shuvalov

UDC 533.95;538.4;537.523

In [1] a technique was suggested for creating artificial plasma structures around bodies in flow of a rarefied plasma by blowing a neutral gas from the surface and subsequently ionizing it by electron collision. It is of interest to understand the relationship between the structure of the plasma formations on the body surface and the function of the different systems. The present paper gives results of an investigation of the influence of the body surface potential on the shape and structure of the plasma formations generated about a metal body in flow of partially ionized nitrogen.

The experimental investigations were conducted on a gasdynamic plasma facility in flow of a rarefied plasma generated by a gas-discharge accelerator. The plasma flow reaches the working chamber in which the residual gas pressure is $7\cdot10^{-7}$–$1\cdot10^{-6}$ torr. The plasma flow parameters at a working chamber pressure of $\sim1.6\cdot10^{-5}$ torr were determined by means of movable electric probes mounted on a traverse mechanism; a single cylindrical probe, made of molybdenum wire of diameter 0.09 and length 4.0 mm; and a cylindrical probe in the form of a hot-wire anemometer [2], with a working element made of tungsten wire of diameter 0.06 and length 6.5 mm. Special attention was paid to probe cleanliness during the measurements. Immediately prior to the measurements the probes were heated up to temperatures ~1500°K, which allowed the influence of impurities on the measured results to be excluded.

Dnepopetrovsk. Translated from Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki, No. 2, pp. 48-54, March-April, 1981. Original article submitted November 1, 1979.

0021-8944/81/2202-0181 $07.50

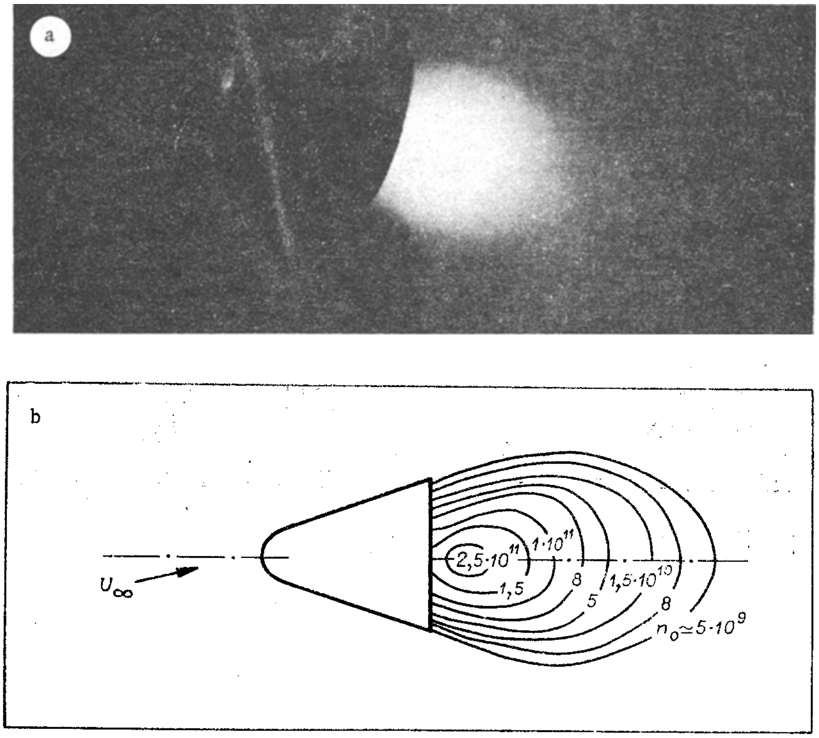
a
b
$2{,}5\cdot10^{11}$
$1\cdot10^{11}$
$1{,}5$
8
5
$1{,}5\cdot10^{10}$
8
$n_o\simeq5\cdot10^9$
U_∞

Fig. 1

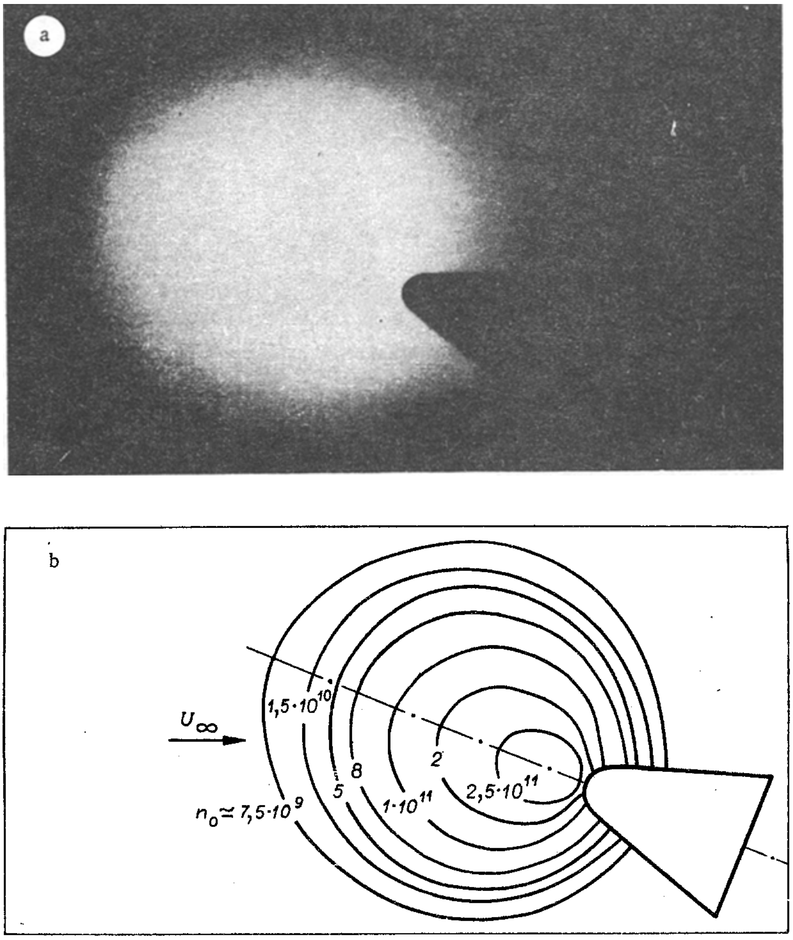
a
b
$1{,}5\cdot10^{10}$
U_∞
8
5
2
$n_o\simeq7{,}5\cdot10^9$
$1\cdot10^{11}$
$2{,}5\cdot10^{11}$

Fig. 2

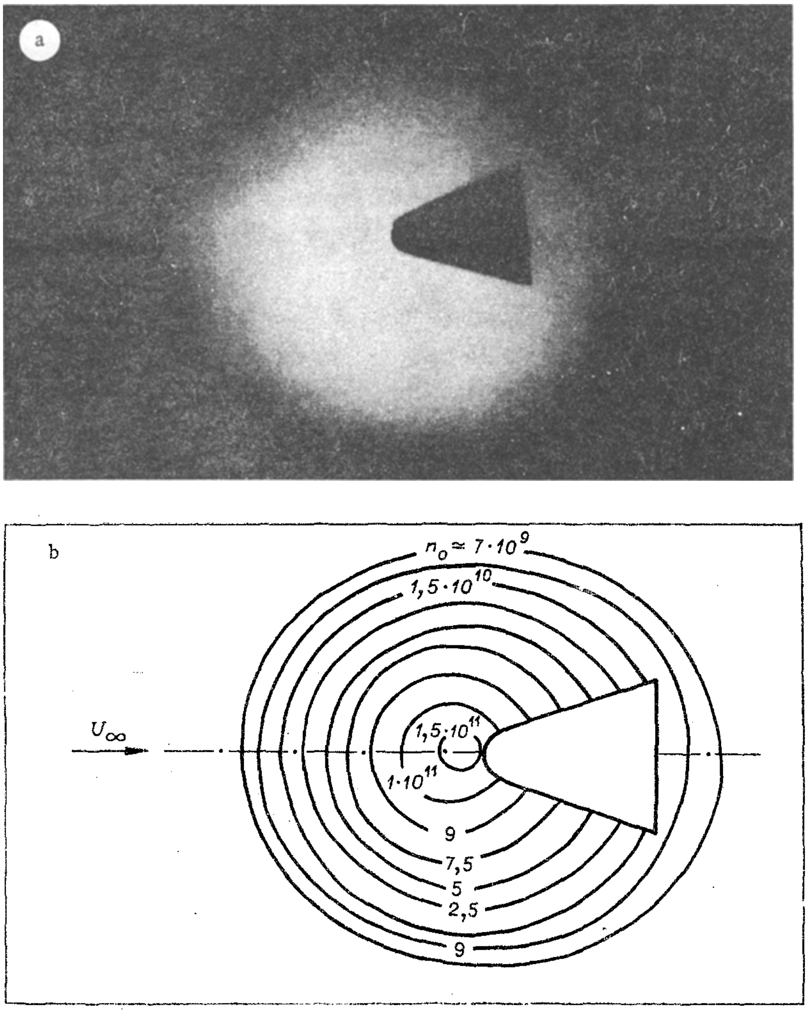

Fig. 3

The plasma potential was determined by the second-derivative method, and also from the electron branch of the probe characteristic drawn on a semilogarithmic scale. In addition, during the experiments we measured the plasma noise levels as seen by the probe to allow a supplementary check on the accuracy of the plasma potential measurement. Usually the maximum plasma noise corresponded to the potential of the chamber.

The flow ion energy was determined, to accuracy of not less than 10%, from the local plasma potential relative to the source anode. Measurements with a multielectrode analyzer probe indicated only a small scatter in ion energy.

The single probe used to measure the plasma flow parameters could rotate around horizontal and vertical axes from 0 to 212°. The vertical and horizontal rotation is necessary to obtain the absolute maximum of the ion current. The ratio $(j_i/j_i^\infty)_{\max}$ for $\theta = 0$, where $j_i^\infty = 2alN_\infty eU_\infty(\sin^2\theta - 2eV/MU_\infty^2)^{0.5}$, was used, in accordance with the theoretical end effect in a cylindrical probe, to determine the flow ion temperature [3]. It turned out that the ion temperature T_i, and also the electron temperature $T_e \simeq 4.6 \cdot 10^4$K, were practically constant in the flow, with $T_e/T_i \simeq 7$-10.

The influence of body surface potential on the structure of the plasma formations around the body was investigated in the section of a jet with a uniform distribution of parameters: The external magnetic field intensity was $H \simeq 2$ Oe, the flow mass velocity, $U_\infty \simeq 23.0$ km/sec, and the charged particle concentration, $N_\infty \simeq 3.7 \cdot 10^9$ cm^{-3}.

The model was a brass cone of base diameter 56 mm, cone angle ~11°, and with slight blunting in the form of an intersecting sphere of radius ~6.5 mm. To the body of the model was attached a device with the working substance (in our case polymerized epoxy resin) of the type in [1]. The blunted cone nose was insulated from the body by the drain electrode. At the base of the cone there is also a metal drain element, insulated from the body. The technique of [1] was used to generate the plasma formations. During an experiment

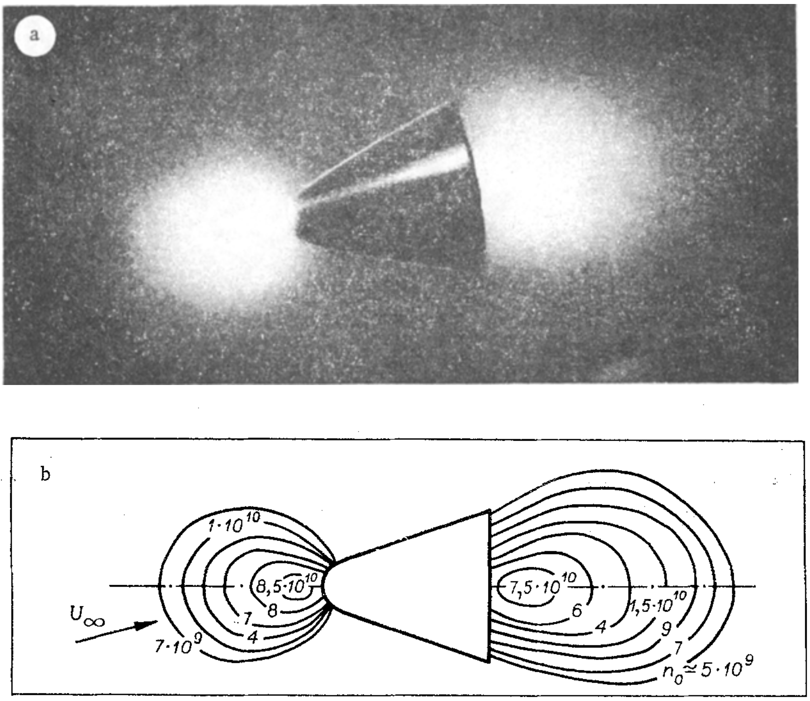
a
b
1·10^10
8,5·10^10
7
8
4
7·10^9
U∞
7,5·10^10
6
4
1,5·10^10
9
7
n0 ≃ 5·10^9

Fig. 4

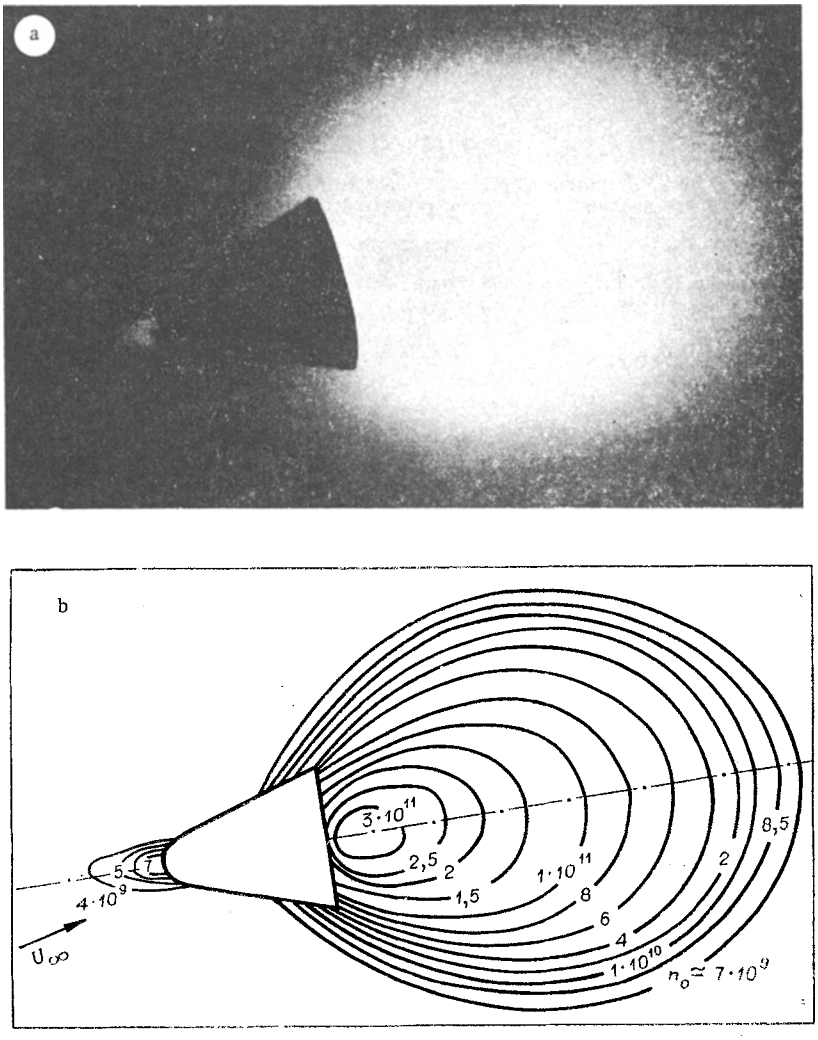
a
b
3·10^11
2,5
2
1,5
1·10^11
8
6
4
1·10^10
n0 ≃ 7·10^9
8,5
2
7
5
4·10^9
U∞

Fig. 5

the model, positioned on the traverse mechanism, could be rotated around a vertical axis. For fixed values of the model surface potential and that of the leakage elements the plasma formation structure was practically independent of the model orientation relative to the flow velocity vector. The dimensions and structure of the plasma formation changed appreciably with change of the potential of the drain element through which the neutral gas is blown.

Figure 1 shows the plasma formation at the base of the cone (viewed from above) in a supersonic flow of partially ionized nitrogen, obtained with $\Phi_{\text{element o}} = e\varphi_{\text{element o}}/kT_e \simeq +7.6$ (where $\varphi_{\text{element o}}$ is the potential of the drain element at the cone base relative to the plasma potential) and the potential of the rest of the model surface "floating".* The cone was at a small angle of attack, ~15°, relative to the velocity vector of the oncoming stream. When the plasma formation appeared the pressure in the working chamber increased to $\sim 3.5 \cdot 10^{-5}$ torr. Figure 1b shows the distribution of charged particle concentration (lines of equal concentration) in the horizontal plane of the flow, measured by the cylindrical probe in hot-wire-anemometer form. Figure 2a shows the plasma formation at the blunted cone nose for $\Phi_{\text{el.nose}} \simeq +11.3$ and with the rest of the model surface at "floating" potential. The angle of attack in this case was ~16.5°. The corresponding distribution of charged particle concentration is shown in Fig. 2b. From the probe measurement results we can see two groups of electrons in the plasma cloud: one with temperature equal to that of the electrons in the oncoming flow, and the other with temperature $T_e \simeq 2.5 \cdot 10^4$K.

Figure 3 shows the plasma formation obtained at the model surface due to a change (compared with the case of Fig. 2) of the body potential to $\Phi_s = \Phi_{\text{el.nose}} = \Phi_{\text{element o}} \simeq +13.1$. Here also the neutral gas was blown through the cone nose. The formation is near spherical (Fig. 3b). By decreasing the model surface potential to $\Phi_s \simeq +10.4$ we can transform this cloud into an ellipsoid.

Figure 4 shows the plasma formations created about the model with two-sided blowing of neutral gas for $\Phi_{\text{el.nose}} = \varphi_{\text{element o}} \simeq +5.7$ and with "floating" potential of the lateral cone surface. By changing the potentials of the drain electrodes to values $\Phi_{\text{el. nose}} \simeq +1.9$ and $\Phi_{\text{element o}} \simeq +13.8$ with the cone lateral surface potential floating, the plasma formations were transformed to that of Fig. 5.

The investigations performed show that when artificial plasma formations are created around a body in supersonic flow of a rarefied plasma by blowing neutral gas from the surface and subsequently ionizing it by electron collision, the structure of the formations depends appreciably on the potential of the body and its elements.

LITERATURE CITED

1. V. V. Gubin, V. M. Kovtunenko, N. P. Reznichenko, and V. A. Shuvalov, "Generation of plasma formations on body surfaces in flow of a partially ionized gas," Teplofiz. Vysok. Temp., 15, No. 4 (1977).
2. A. M. Khazen and V. A. Shuvalov, "Determination of the parameters of a partially ionized gas by means of a thermal anemometer," Zh. Tekh. Fiz., 36, No. 2 (1966).
3. I. R. Sanmartin, "End effect in Langmuir probe response under ionospheric satellite conditions," Phys. Fluids, 15, No. 6 (1972).

---

*"Floating" is the equilibrium negative potential which the body acquires in flow of a rarefied plasma.