[6] A. E. Nikiforov, ibid. 7, 1248 (1965), transl. 7, 1005 (1965).
[7] J. J. Krebs, Phys. Rev. 135A, 396 (1964).
[8] S. A. Al'tshuler and R. M. Valishev, JETP 48, 454 (1965), Soviet Phys. JETP 21, 302 (1965).

ELECTRIC BREAKDOWN THROUGH A FLAME

G. A. Askar'yan, E. Ya. Gol'ts, M. S. Rabinovich, and V. B. Studenov
P. N. Lebedev Physics Institute, USSR Academy of Sciences
Submitted 22 March 1966
ZhETF Pis'ma 3, No. 10, 404-407, 15 May 1966

An investigation of electric breakdown through a flame is of interest for gas-discharge physics, for shock-wave production under laboratory conditions, and for production of intense flashes, cumulative collapses, pinches, etc. at atmospheric pressures without surrounding the discharge with chamber walls and limiting the passage of radiation from the discharge or limiting the intensity of the resultant shock wave. (In this respect the investigated types of discharge are similar to discharges initiated by exploding wires [1,2].)

The plasma of the flame facilitates the cascade breakdown in the electric field, owing to the decrease in the density of the heated gas (the density is approximately one order of magnitude lower at a temperature of several thousand degrees than at normal temperature) as a result of thermal ionization and thermal excitation of the gas and of various emission effects on the electrodes. This decrease in the breakdown voltage makes it possible to produce breakdown in large discharge gaps with relatively low voltages.

The apparatus used for the research consisted of a battery and five capacitors of 150 μF each, charged to 5 - 10 kV and discharged through a vacuum discharge gap into the flame plasma. The discharge development was recorded by a high-speed camera (SFR). The flash of light was recorded with a photomultiplier and its energy measured with a special calorimeter. The current flowing through the plasma was measured with a Rogowski loop and reached several hundred kA.

A vertical flame jet was produced by a burner using a mixture of illuminating gas and oxygen. The temperature of such a flame usually does not exceed 2000°. One electrode was the body of the burner, and the other was a high-melting-point metal rod. To reduce heating, the electrode was placed in a stream of air which deflected the flame. The air stream was turned off prior to the discharge.

The experiment has shown that the initial breakdown voltage in the plasma is close to 1 kV/cm, which is several dozen times smaller than the breakdown voltage under normal conditions. A flame jet 10 cm long broke down regularly at 10 kV, and the flame was not extinguished after the breakdown. Figure 1 shows a series of photographs of the channel of the discharge through the flame, taken at 8 μsec intervals. The photographs show that the length of the intense-glow interval was approximately 150 μsec. Figure 2 shows a time sweep of the central part of the discharge.

Fig. 1

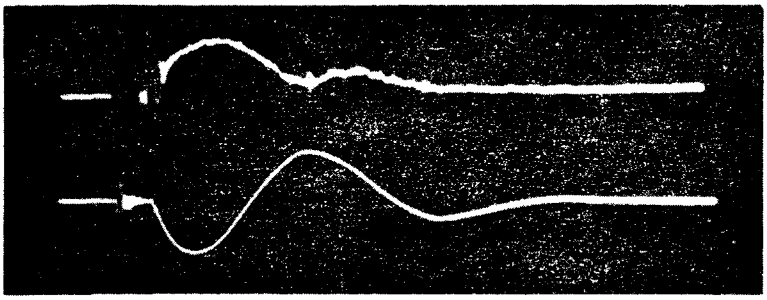

Fig. 2

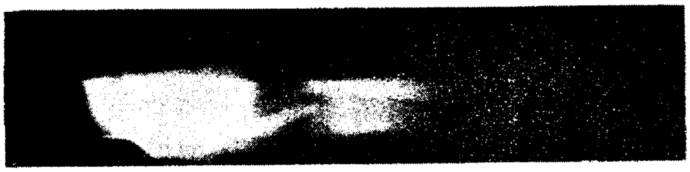

Fig. 3

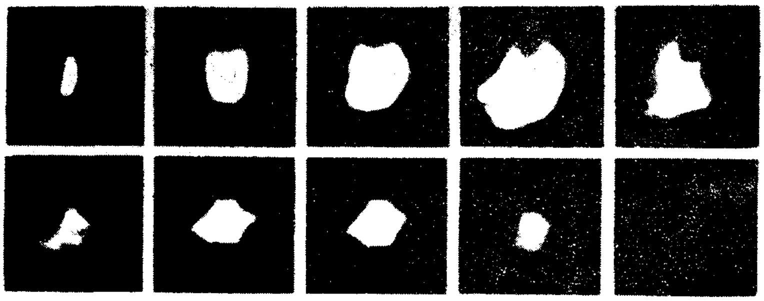

Figure 3 shows oscillograms of the signals from the photomultiplier (used to record the glow from the discharge plasma) and of the current through the discharge (150 μsec sweep). From a comparison of these data it is seen that the buildup and glow times are commensurate with the growth and duration of the discharge currents. The glowing region occupied a volume much larger than the initial volume of the gas-discharge gap.

The optical radiation was compared with the flash energy produced by discharging the same capacitor bank through an exploding wire. The energies radiated in the visible part of the spectrum by the discharges through the wire and through the flame turned out to be approximately equal. This indicates apparently that the essential stage for the radiation in the given section of the spectrum is not the initial one, but the subsequent development of the discharge, in view of the long duration of the process of discharging the capacitor bank.

Along with the usual methods of facilitating the breakdown of long gaps (sharpening of electrodes, preliminary breakdown by a leading pulse of high voltage, etc.), the use of a flame from one or several burners makes it possible to increase further the linear dimensions of the breakdown path without resorting to the inconvenient frequent replacement of contacts (foils and wires) that are prone to overheating for the purpose of initially shaping the long gaps of the discharge channel.

Discharge through a tubular flame can cause cumulative collapse and heating of the gas on the axis.

Discharge through a flame is also of practical interest for intensification of chemical reactions in flames and increasing the effect of flames on materials and minerals, and also for physics of atmospheric phenomena, such as the discharge of lightning through a flame, through a jet engine, through fire from tubes or from explosions, for the production of flame electrodes, contact to carry large currents, etc.

In conclusion, the authors thank V. P. Solov'ev, B. P. Shurukhin, and A. V. Chirkov for help in creating the installation.

[1] Exploding Wires, ed. by W. G. Chase and H. K. Moore, vol. 1, Plenum Press, 1959.
[2] Op. Cit. [1], vol. 2, Plenum Press, 1962.

MAGNETIC RESONANCE IN $RbNiF_3$ SINGLE CRYSTALS

E. I. Golovenchits, A. G. Gurevich, and V. A. Sanina
Semiconductor Institute, USSR Academy of Sciences
Submitted 25 March 1966
ZhETF Pis'ma 3, No. 10, 408-410, 15 May 1966

The magnetic properties of single-crystal $RbNiF_3$ were investigated by Smolenskii et al. [1]. We present here results of measurements of electron magnetic resonance in these crystals below the point of transition into the magnetically-rodered state (145°K).

The measurements were made in the frequency range 7.7 - 43.2 Gcs at 77°K in constant and pulsed magnetic fields. The samples were spheres of 0.5 - 0.9 mm diameter.

The magnetic structure of $RbNiF_3$ has not yet been fully explained. However, our results are in agreement with the simple model of a uniaxial ferromagnet with negative anisotropy. For this model the frequency of homogeneous resonance (with account of the first anisotropy constant only) is given by

$$\frac{\omega}{\gamma} = \{[H \cos(\theta_H - \theta_M) + H_A \cos 2\theta_M][H \cos(\theta_M - \theta_H) + H_A \cos^2\theta_M]\}^{\frac{1}{2}} \quad (1)$$

under the condition

$$H_A \sin 2\theta_M = 2H \sin(\theta_M - \theta_H). \quad (2)$$

Here θ_H is the angle between the external magnetic field $\vec{H}$ and the crystal axis, θ_M is the angle between the equilibrium magnetization $\vec{M}_0$ and the crystal axis, and

$$H_A = 2K_1/M_0 \qquad (K_1 < 0).$$

Figure 1 shows the measured dependence of the resonance frequency on the field, and also a plot of $\omega(H)$ calculated from formulas (1) and (2) with $\theta_H = 90°$ (continuous line). The parameters H_A and $\gamma = ge/2mc$ were chosen such as to ensure best agreement between the curve and the experimental points: $g = 2.07$, $H_A = 20.5$ kOe. As seen from Fig. 1, a difference between experiment and calculation occurs only in the region of small fields and may be connected with the presence of a domain structure.