Å. A structure of this type, as indicated above, is produced under ordinary conditions only upon crystallization of non-stoichiometric tantalum nitride $TaN_{0.8-0.9}$. This fact, and also the values of the obtained unit-cell parameters, points to the possible violation of the stoichiometry of tantalum mononitride under the aforementioned temperature and pressure conditions.

Heating of tantalum nitride, which has a structure of NaCl type, for four hours at 1200°C in a vacuum not worse than 10^{-5} mm Hg causes a complete transition to the phase with the WC structure.

Measurements of the critical temperature of the obtained samples was performed by a magnetic method down to 4.2°K. The phase with the NaCl structure has an average critical temperature of transition into the superconducting state of 6.5°K, and for most samples the width of the trnasition is about 1.0°K. The phase with the WC structure has no transition to the superconducting state down to 4.2°K. Nor was a superconducting transition observed in Ta_2N down to this temperature, in agreement with the data of [1].

Thus, the use of high pressure makes it possible to obtain a new phase of tantalum nitride with superconducting properties. We note that the phase synthesized under the aforementioned pressure and temperature conditions has a lower critical temperature than tantalum carbide, whereas for niobium nitrides and carbides obtained in the usual manner the ratio of the critical temperatures is reversed. One cannot exclude the possibility that this circumstance is connected with the aforementioned possible violation of the stoichiometric composition; such a deviation from stoichiometry should lead, as is well known from the published data, to a lowering of the superconducting transition temperature.

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OBSERVATION OF "ANDREEV" REFLECTION OF ELECTRONS FROM THE BOUNDARY BETWEEN A NORMAL AND SUPERCONDUCTING PHASE, USING THE RADIO-FREQUENCY SIZE EFFECT

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As shown by Andreev [1], reflection of excitations (electrons, holes) coming from the normal (n) phase to the boundary with the superconducting (s) phase is accompanied by reversal of the signs of the velocity vector, mass, and charge of the excitations, and the probability of reflection is equal to unity for quasiparticles with energy lower than the width of the gap in the spectrum of the superconductor.

Measurements of the integral characteristics of the intermediate state, namely the thermal conductivity [2], the specific heat [3], and the electric conductivity [4], confirm the validity of Andreev's theory. However, a more direct observation of the phenomenon of electron reflection from the n-s boundary is also possible. In measurements of the surface impedance of an n-layer that borders on one side with vacuum and on the other side with the s-phase, in the case when the electrons have a large mean free path, the reflection of the electrons from the n-s boundary and their return to the skin layer should exert an influence on the value of the surface impedance and should lead to the occurrence of radio-frequency size effects (RSE) of a new type.

In our experiment (see Fig. 1), the n-layer was deposited on the internal surface of a hollow cylindrical sample 5 under the influence of a magnetic field of a current I flowing through conductor 2. A single-crystal sample of diameter 12 mm, length 15 mm, and with an aperture having a radius r = 3.10 mm was cast from tin 99.9999% pure in a glass tube with an

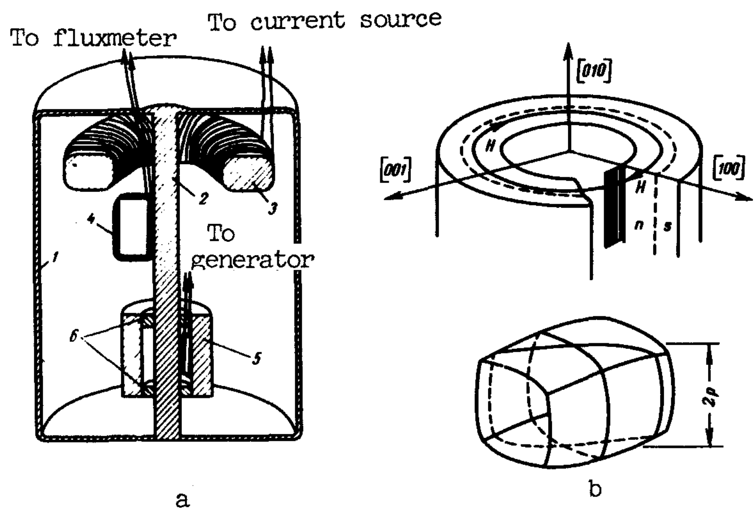

Fig. 1

insert of rock salt. Owing to the difference between the thermal coefficients of the salt and of the tin, the insert could be freely extracted from the sample. The sample was secured relative to the wire 2 with the aid of duraluminum washers 6. The employed apparatus has made it possible to obtain an n-layer of cylindrical form and to vary its thickness by varying the value of I. To obtain the required strong currents (up to 600 A), a superconducting transformer was used, in which the secondary winding was made up of wire 2 and envelope 1, made of lead. The primary winding of 215 turns of 65BT wire was wound on a permalloy core 3. The current I was proportional to the current J in the primary winding, as monitored by means of coil 4 connected to an F-18 flux meter.

Pressed against the internal surface of the sample was the coil of the tank circuit of a radio-frequency generator operating at a frequency $f \approx 10$ MHz. The position of the coil, which had the form of a flat spiral, and the direction of the field near the coil relative to the crystal axes of the sample, shown in Fig. 1b, were the same as in Gantmakher's experiment [1] on the observation of the most intense RSE line in flat tin samples in the n-state. We used the usual modulation procedure of observing the RSE [5], with a signal proportional to $\partial f/\partial J$ recorded on an automatic plotter.

Two plots of $\partial f(J)/\partial J$ at different temperatures are shown in Fig. 2. A series of RSE lines was observed to the right of the maximum connected with the appearance of the n-layer on the surface of the sample at $J - J_c$ (plotted at a sensitivity decreased by a factor of 400). The thickness d of the n-layer, corresponding to the line observed at the current J, can be determined from the formula $d = r(J - J_c)/J_c + \sqrt{\xi \cdot rJ/J_c}$, where the second term, approximately equal to 0.003 cm, takes into account the role of the surface energy $\xi H_c^2/8\pi$ of the n–s boundary (see [6]). The distribution of the field in the n-layer was determined from the condition $H - H_c$ on the n–s boundary (we have neglected a correction on the order of $H_c \xi/r$). In our experiment $d \leq 10^{-1} r$, and thus the inhomogeneity of the field in the n-layer is relatively small. The presence of inhomogeneity should lead to a slight drift of the electrons along the sample axis, and the dimension of the trajectory in the radial direction, D, can be determined

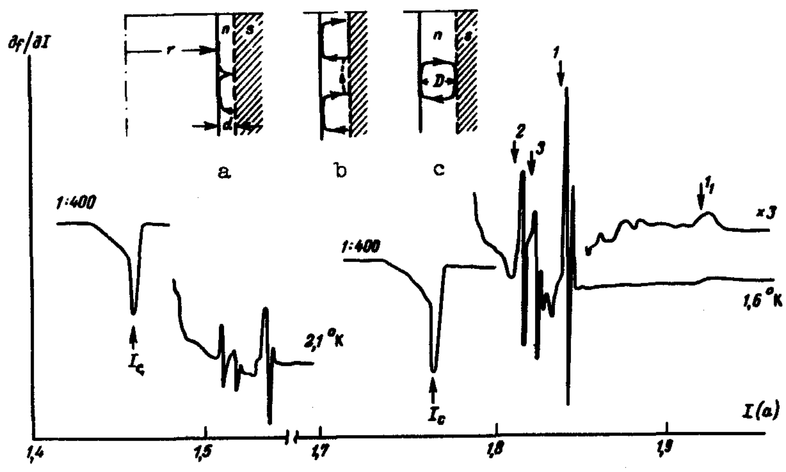

Fig. 2

with sufficient accuracy from the formula D = 2pc/eH, where H is the field at the mean distance from the sample axis, and 2p is the dimension of the orbit in momentum space in the direction of the axis. It is easy to see that in the case when the orbit is located on a convex side of the Fermi surface, the maximum value of D will be the same for a finite interval of field directions in the sample (see Fig. 1b, in the bottom of which is shown part of the Fermi surface with the orbits corresponding to different sections of the sample.

When d < D, the effective electrons accelerated in the skin layer collide with the n-s boundary and at the investigated temperatures they should be reflected almost completely. If d > D/2, the electrons return to the skin layer after a twofold reflection, making practically the same contribution to the current as in the case when d > D (scheme b of Fig. 2).

When J decreases to a value such that the radial dimension of the trajectory of the reflected quasiparticles becomes comparable with d, the particle fall in the skin layer after the first reflection, making a contribution of opposite sign to the surface current (scheme a in Fig. 1), and this should lead to the occurrence of the SRE line at a value of J determined by the condition d(J) = pc/eH, where H is the field at a distance d/2 from the surface of the sample. This line should obviously be missing in the usual specular reflection.

The numbers 1, 2, and 3 on the curve for T = 1.6°K on Fig. 2 denote the positions of the lines calculated from the values of p for the sections 1_1, 2_1, and 3_1 from [1]. The close agreement between the line positions and the calculated ones confirms the reflection law proposed by Andreev.

When the sensitivity is increased threefold, the curve of Fig. 2 shows clearly the RSE peak at d = D for the total cross section 1 (scheme c of Fig. 2). The appearance of this line is apparently connected with a change of the structure of the "burst" of the radio-frequency current (see [7]), which is present in the metal at a distance D from the surface, when the region of the burst crosses the n-s boundary, with the reflected part of the burst superimposed on the non-reflected part. It is obviously possible to observe an entire series of lines with rapidly decreasing intensities in those cases when x the n-layer thickness subtends m/2 extremal orbits (m is an integer).

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BIRESONANT FREQUENCY DOUBLING BY AN ANTIFERROMAGNET

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We have observed experimentally "biresonant" frequently doubling by an antiferromagnet, predicted by Ozhogin [1]. This effect is connected essentially with the form of the antiferromagnetic resonance (AFMR) spectrum, and can be observed in antiferromagnets having an anisotropy of the "easy plane" type.

From the solution of the linearized Landau-Lifshitz equations for the two sublattice model of such an antiferromagnet it follows that the AFMR spectrum [2] consists of two branches, whose frequencies are determined as follows (when $H \perp C$):

$$(\nu_1/\gamma)^2 = H(H + H_D) + H_\Delta^2 \quad (1)$$

$$(\nu_2/\gamma)^2 = 2H_A H_E + HH_D \quad . \quad (2)$$

It follows from the same equations, in addition, that different components of the vectors $\vec{\ell} = \vec{\ell}_0 + \vec{\lambda}$ and $\vec{m} = \vec{m}_0 + \vec{\mu}$ take part in the oscillations of the spins corresponding to the first