state is very efficient, since in this case a very large fraction of the energy given to the active medium by fast electrons is converted to quanta of stimulated emission.

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EXPERIMENTAL OBSERVATION OF THE TUNNEL EFFECT FOR COOPER PAIRS WITH THE EMISSION OF PHOTONS

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IT has been pointed out earlier[1] that the initial part of the volt-ampere characteristic for superconducting tunnel structures of the type Sn-SnO_2-Sn has steps characterized by a current increase at nearly constant potential. These steps occur for tunnel structures which have a sufficiently thin and uniform oxide layer between the films. For such structures a constant superconducting tunnel current is observed, the amplitude of which oscillates as the constant magnetic field is varied. The height of the step on the volt-ampere characteristic also depends on the constant magnetic field and oscillates as the latter is changed. The position of the step on the voltage axis, however, remains nearly constant, being probably determined by the dimensions of the transition layer, since structures with the same dimensions exhibit similar systems of steps, whereas altering the dimensions changed the system of steps. In[1] the statement was made that the system of steps on the volt-ampere characteristic of Sn—SnO_2—Sn superconducting tunnel structures owed its existence to the generation of

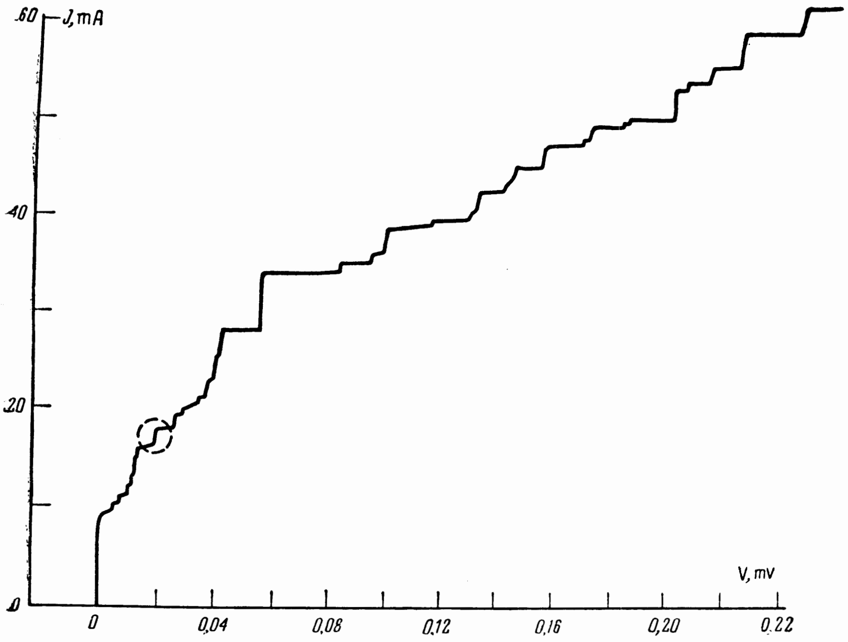

FIG. 1. Volt-ampere characteristic of the tunnel structure Sn–SnO_2–Sn at T = 1.57°K, H = 1.5 Oe. The step with frequency inside the transmission band of the detector is shown by the circle.

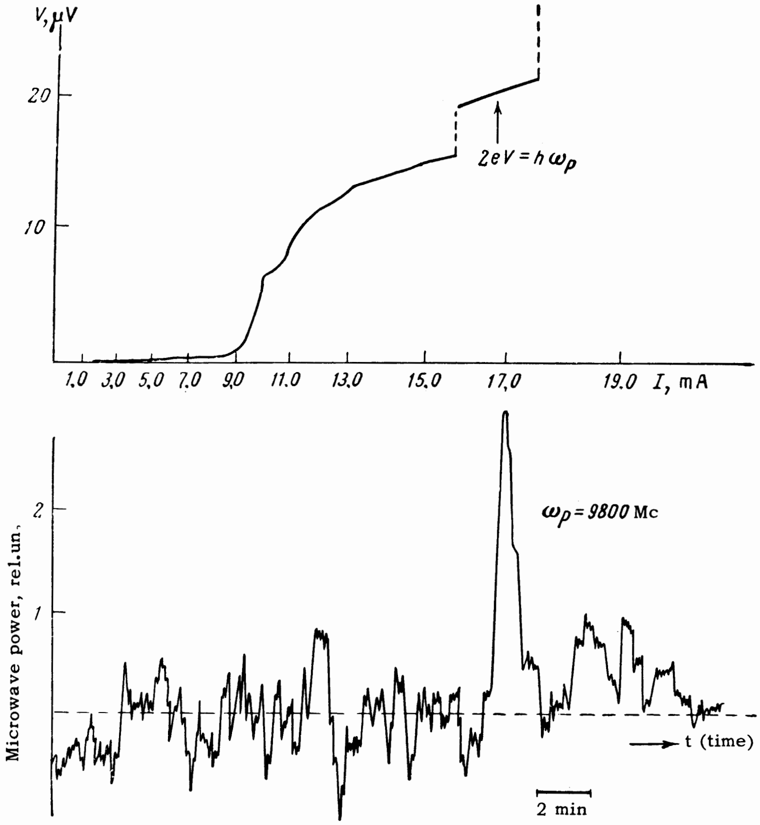

FIG. 2. Initial part of the volt-ampere characteristic (above) and output signal of the detector (below), synchronized in time. The tunnel structure is Sn–SnO$_2$–Sn, T = 1.57°K, H = 1.5 Oe. The resonant frequency of the tuned detector is ω_p = 9800 Mc.

an alternating superconduction current. According to Josephson[2] the onset of an alternating superconduction current should be accompanied by the emission (or absorption) of photons, satisfying Josephson's frequency relation

$$2eV = \hbar\omega, \quad (1)$$

where V is the potential applied to the tunnel junction.

In this note we describe an experiment aimed at observing photon emission upon occurrence of alternating superconduction current. Tin films having width 1.17 mm and thickness of about 2000 Å were evaporated on a glass substrate at a right angle. A thin oxide layer was formed between the films. The tunnel structure was placed in a rectangular waveguide parallel to its wide wall at a distance of $\lambda/4$ from the short-circuiting plunger (λ is the wavelength in the waveguide), one of the films being directed along the wave propagation vector in the waveguide. A small constant magnetic field, produced by a single-layer solenoid, was applied in the same direction. The entire system was placed in a cryostat filled with liquid helium. The structure together with the waveguide was oriented so that the influence of the earth's magnetic field was minimal, but no special measures for screening against it were taken. The current and potential leads from the structure were led out of the cryostat and connected to a system for automatically recording the volt-ampere characteristic on a two-coordinate automatic-recording potentiometer. The temperature was lowered to 1.57°K by pumping out helium vapor. A P5-10 (IMSh-1) meter for measuring low microwave power in the 3-cm range with sensitivity fluctuation threshold of not more than 1.5×10^{-16} W, was attached to the waveguide. The output signal from the meter was registered with an automatic potentiometer. A parametrized family of volt-ampere characteristic curves was obtained, the parameter being the constant magnetic field in steps of 0.035 Oe. A step at a bias of 19.8 μV, corresponding to a wavelength of the order of 3 cm, was observed at a magnetic field of about 1.5 Oe (see Fig. 1). Synchronized traces of both automatic potentiometers are shown in Fig. 2. It is seen that when the potential on the step reaches the value satisfying relation (1), with $\omega = \omega_p$ (ω_p is the resonant frequency of the tuned detector), we observe an increase in signal from the detector. This effect could be repeatedly seen both by gradually increasing the current through the structure and by decreasing it. The level of radiated power observed was of the order of 10^{-14} W which, apparently, is a consequence of the sharp disparity in wave resistance of the tunnel structure as a transmission line and the waveguide. At other values of the constant magnetic field, other steps can be observed at potentials not far from that for the case described; however, no increase in signal power is noted, since the frequency relation (1) is not satisfied within the transmission band of the receiver. Therefore the possibility of Cooper pairs tunneling between two superconductors with the emission of photons has been directly demonstrated by a direct experiment.

The inverse experiment, where the tunnel structure is irradiated by an external microwave generator, was also carried out. The results were, on the whole, analogous to the behavior described in Shapiro's work[3,4].

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MAGNETOSTRICTION OF RARE-EARTH FERRITE GARNETS AT LOW TEMPERATURES

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THERE are as yet no published data on the magnetostriction of rare-earth ferrite garnets below the temperature of liquid nitrogen. In the present study, the differential capacitor method was used to measure the magnetostriction of polycrystalline ferrite garnets, $R_3Fe_5O_{12}$ (R = Gd, Tb, Dy, Ho, Er, Yb), in the temperature range 4.2—100°K. The ferrites were prepared by the usual ceramic technique; the purity of the initial oxides was not less than 99.98%, and the average density of the prepared samples was 4.8 g/cm^3.

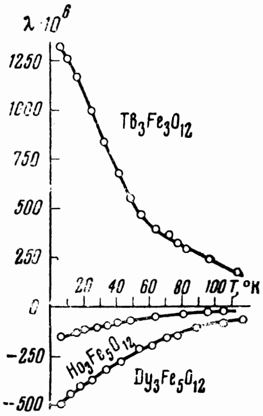

FIG. 1.

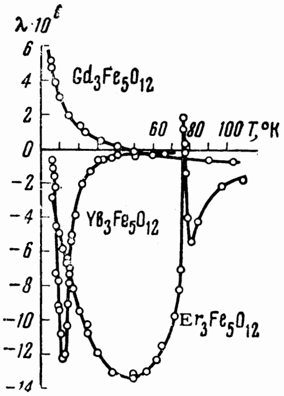

FIG. 2.

Figures 1 and 2 give the temperature dependences of the magnetostriction in a longitudinal magnetic field H = 5000 Oe. It is evident that the magnetostriction of the Gd and Tb ferrites is positive and that of the other ferrites is negative. It should be mentioned that, in the temperature range 4.2—25°K and a magnetic field of 5000 Oe, the ferrite garnets of Dy, Ho, and particularly Tb were far from saturation. Nevertheless, even in this field, the magnetostriction of Tb, Dy, and Ho reaches enormous values. The value of the magnetostriction of the Tb ferrite garnet at 78°K was in good agreement with the results for a single crystal of this ferrite.[1] In the Tb, Dy, and Ho ferrite garnets, the magnetoelastic energy makes a considerable contribution to the magnetic anisotropy energy. Thus, for the Tb ferrite, the magnetoelastic energy is of the order of 10^7 erg/cm^3. At helium temperatures, the Tb, Dy, and Ho ferrites exhibited considerable magnetostriction hysteresis. Thus, the "remanent" magnetostriction of the holmium ferrite garnet at helium temperatures amounted to 45×10^{-6} (according to our measurements, the coercive force of the holmium garnet exceeded 1000 Oe at these temperatures).

In the present study, the magnetostriction was measured only up to 100°K. The compensation points of the majority of the investigated ferrites lay above this temperature, and only in the case of the Yb and Er ferrites were they below 100°K. The compensation point of the Yb ferrite garnet lay in the immediate vicinity of 0°K and therefore the magnetostriction of this ferrite was found to drop rapidly on approach to liquid helium temperature (Fig. 2). The compensation point of the Er ferrite lay approximately at 80°K; it is evident from Fig. 2 that the magnetostriction decreased