the peaks in the curves become higher as the N shell is emptied. These shell effects as well as departures from equilibrium have also been observed with other stripping materials and will be reported elsewhere.

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USE OF POINT CONTACTS TO OBTAIN DIRECT EVIDENCE OF FLUX MOTION IN SUPERCONDUCTORS*

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Recently, a number of experiments[1-3] have claimed to provide evidence that the resistive state of superconductors is a dynamic one, in the sense that the regions of normal material (domains containing one or more flux quanta) are supposed to be set into continuous motion by the transport current. Further, in a related experiment, Pearl[4] has attempted to establish that domain motion is associated with a potential difference in the case that it is produced by a changing magnetic field, rather than a steady transport current. Unfortunately, the potentials observed in Pearl's experiment are not necessarily connected with domain motion, as shown by Meincke,[5] so that, apart from the resistive evidence,[6,7] the only support we have at present for the dynamic model comes from thin-film experiments[1,2] and the point contact method. Using the latter, Sharvin[3] observed oscillations of the resistance of a small area of a superconducting tin disk and inferred that normal domains were in continuous motion across his sample. We have made an experimental study of this effect and find that oscillations such as Sharvin observed can occur very generally when current is passed via a point contact into a superconductor. The phenomena are complex and the application of a magnetic field further complicates the spectrum of oscillations obtainable, but is not a necessary condition for their appearance. From this fact, and others which are discussed below, we conclude that oscillations can arise from an instability of the normal-superconducting interface in the region of the contact and so do not necessarily involve domain motion as envisaged by Sharvin.

The inset of Fig. 1 shows schematically a simple point-contact configuration which we have found to exhibit oscillations. S is a (superconducting) tantalum wire, 0.007 cm diameter, 99.9% purity, with a point affixed by sparking to a (normal) tin plate. Current I is obtained from a constant-current supply. A V-I characteristic for such a point at $T=4.2^\circ$K is shown on Fig. 1. (The voltage drop due to the normal tin has been subtracted from the observed V.) Recorder traces of the voltage fluctuations are shown with increased gain at a number of points on the characteristic. At high currents the fluctuations observed appear completely irregular, but at low currents there is a certain limited current range over which the amplitude and frequency are relatively constant. The actual shape of the fluctuations, as well as the current range over which they are uniform, varies according to the character of the contact, which can be modified by discharging a capacitor through it during the experiment. Resistance fluctuations in the current-induced intermediate state are well known and have been observed on many occasions (see, e.g., Weber[8] and Lalevic[9]), but this appears to be the first observation that they can be made regular by injecting the current at a point.

If the superconductor and normal metal ex-

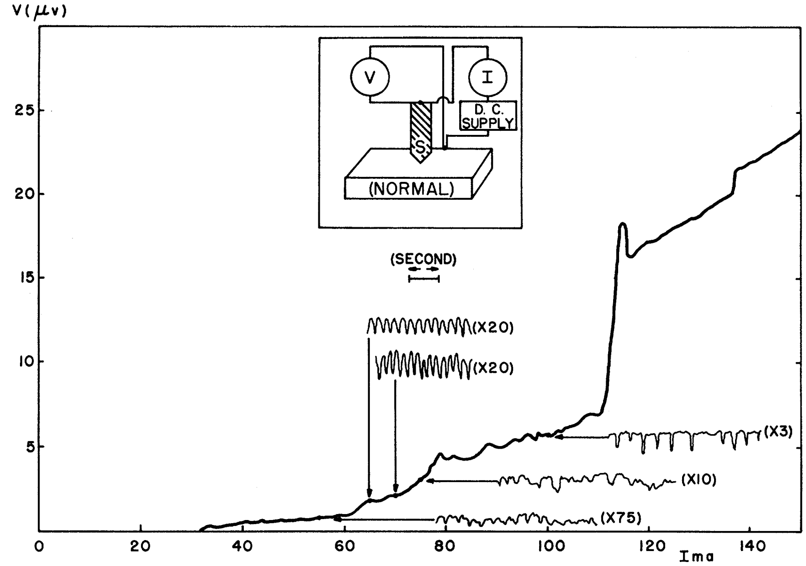

FIG. 1. Voltage-current characteristic for the point-contact configuration shown schematically in the inset (see text). Voltage fluctuations are shown with a common time scale given by the one-second marker beneath the inset and with the increased sensitivity indicated in parenthesis.

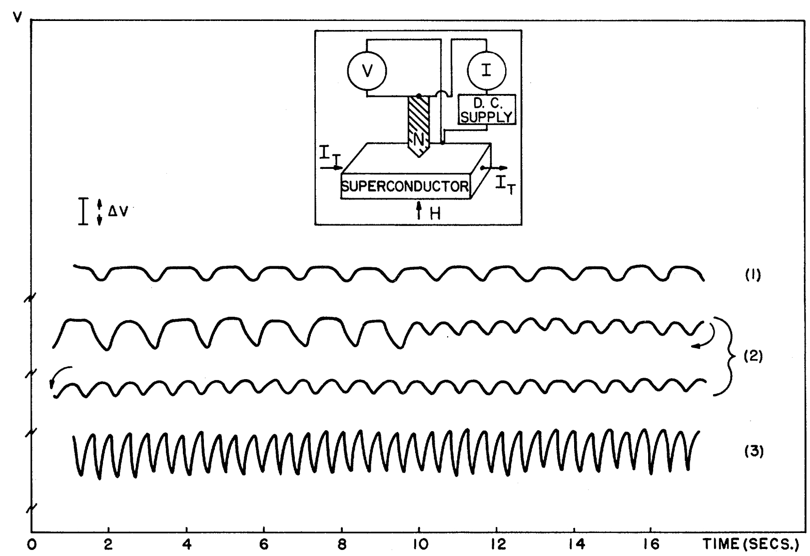

FIG. 2. Voltage fluctuations for the point-contact configuration shown schematically in the inset (see text). (1) $T = 3.5°K$, $I_T = 4A$, $I = 40$ mA, $H = 0$; $\Delta V = 10^{-8}$ V. (2) $T = 3.5°K$, $I = 40$ mA, $H = 0$; $\Delta V = 10^{-8}$ V. (The lower trace is a continuation of the upper trace.) (3) $T = 2.7°K$, $I_T = 4.9$ A, $I = 5$ mA, $H - = 100$ G; $\Delta V = 2\times 10^{-7}$ V.

change roles, we have the configuration shown in the inset of Fig. 2. The point contact N is formed from (normal) phosphor-bronze wire reduced to less than 10 μ diameter at the tip. It injects a current I into a (superconducting) rectangular tin plate (15 mm × 4 mm × 1 mm). We can apply a transverse field H to the sample and pass a transport current I_T through it. For $H = 0$ we again observe stable resistance fluctuations over certain ranges of I and I_T; an example is shown in the recorder trace (1) of Fig. 2 which displays the fluctuating portion of the observed voltage. Occasionally, as in trace (2) of this figure, an apparently stable oscillation will suddenly switch to one of a new frequency and amplitude. If we now apply a magnetic field the observations become extremely complicated. A given set of variables (H, T, I, I_T) is only sufficient to define a spectrum of possible oscillations which includes simple quasiharmonic oscillations as reported by Sharvin.[3] An example is given in trace (3) of Fig. 2. However, in general, we observe numerous different frequencies for the same (H, T, I, I_T). Occasionally spontaneous changes of frequency and amplitude occur, as remarked on for the case $H = 0$. For $H \neq 0$, however, we can obtain another oscillation of different frequency and amplitude simply by switching I_T off and then on again. Quite often no voltage fluctuations are observed at all (below the 10-cps cutoff frequency of our instrumentation) but recycling I_T in this fashion results in their appearance. These facts would seem to indicate that the instability seen in the simpler experimental situation is being modified by the chance proximity of normal domains.

In conclusion, we have observed that uniform resistance fluctuations can occur when current is injected at a point into a superconductor. The interpretation of these fluctuations in more complicated experimental conditions will be very difficult but, although domain motion may occur, it is neither a necessary nor sufficient hypothesis to explain the results. Indeed, all the observations reported in this Letter are consistent with fluctuations of a normal region in the vicinity of the point at which current is being injected.

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ISOELECTRONIC DONORS AND ACCEPTORS

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We discuss a recent classification of isoelectronic donors and acceptors by Hopfield, Thomas, and Lynch and show that a different interpretation of certain of their spectra is possible if one considers indirect transitions, with angular-momentum change accomplished by phonon emission.

Under the above title, Hopfield, Thomas, and Lynch[1] show the fluorescent spectra of ZnTe:O and GaP:Bi. The fluorescence is attributed to radiative recombination of excitons bound to the isoelectronic substituents, and certain marked differences in the spectra are used to classify these substituents as donors or acceptors. The object of the present Letter is to give an alternative explanation of the observed spectral differences, thereby introducing another factor which should be kept in mind when classifying the substituents as donors or acceptors.

Hopfield, Thomas, and Lynch do not consider the fact that the optical transitions are direct in ZnTe (at Γ) but indirect in GaP (with conduction-band minima at the three X positions). However, for weakly bound excitons in GaP much of the fluorescence should appear in lines displaced from the no-phonon line by energies characteristic of the X phonons. Such lines are said to be due to "indirect" transitions.[2] For strongly bound excitons much of the fluorescence should appear in broad lines displaced from the no-phonon line by energies which are not restricted to those of X phonons. These lines are due to "direct" transitions. In the GaP:Bi spectra of Ref. 1, it appears that both direct and indirect lines are present, and that much of the difference between the A and B spectra [Figs. 2(c) and 2(d) of Ref. 1] can be explained in terms of changes in the "indirect" part of the spectrum.

A mechanism will be outlined to explain the