Kleiman *et al.* Reply: In our technique[1] the sample is affixed to a high-Q mechanical oscillator. The oscillator is vibrated in its resonant mode, but as opposed to previous measurements[2] with our technique the sample itself is *not* stressed. The increased stiffness and dissipation are due only to the tilting of the sample with respect to the magnetic field, which is easily understood and calculable. In the strong pinning limit the increased stiffness in a magnetic field is due to an effective magnetization of the sample resulting from flux pinning on the time scale of the measurement. Dissipation arises from the motion of the flux lines relative to the crystal via the Stephen-Bardeen[3] mechanism, as the flux lines depin. Because of the small samples and low residual damping of the oscillator it is possible to maintain very low amplitudes and dissipation levels, which we have demonstrated are essential for studying intrinsic properties of the samples such as flux-lattice melting.

Brandt, Esquinazi, and Weiss[4] correctly point out that Fig. 1 of our Letter is misleading. While the bulk of the motion associated with the cantilever mode which we employ is a translation with respect to the field which does not couple to the flux lattice, it also includes a contribution from rotation with respect to the field, which does give a coupling to the flux lattice. This coupling is intentionally kept small to reduce the damping of the oscillator by keeping the axis of rotation parallel to the field to within $\sim 1°$. Nonetheless, it is the relative orientation of $\mathbf{H}$ and the $\hat{\mathbf{c}}$ axis of the *sample* that will determine the properties of the sample if they are anisotropic. This is independent of the geometry of the *oscillator* with respect to the field.

Brandt, Esquinazi, and Weiss have suggested that the dissipation we observe is due to hysteretic damping as was seen in previous experiments on superconducting vibrating reeds. This would suggest a strongly amplitude-dependent damping. In our measurements the linearity of the response has been verified, and good agreement with Stephen-Bardeen-type viscosities is found. They also suggest that our effect is similar to the flux-pinning peak previously seen near H_{c2} in weak-pinning materials. We point out that in our measurements on $Bi_{2.2}Sr_2Ca_{0.8}Cu_2O_8$ (BSCCO) the observed transition occurs at roughly 0.2% of H_{c2}.

As we stated in our paper we feel that our results can be interpreted as indirect evidence for flux-lattice melting via the following mechanism. The torque from rotation of the sample in a magnetic field is $\mathbf{M}\times\mathbf{H}$. If the flux lattice is a solid, the relaxation time of the magnetization is much longer than the period of the oscillator and the torque due to the sample magnetization is added to the restoring force of the oscillator. However, as the lattice melts, the relaxation time becomes much shorter than the oscillator period and the response softens. The dissipation peak occurs at $\omega\tau = 1$, which we identify as the melting temperature. While the interesting question of the frequency dependence is not addressed by this measurement, it was on the basis of this model and our observations that we conjectured that the flux lattice was melting well below T_c.

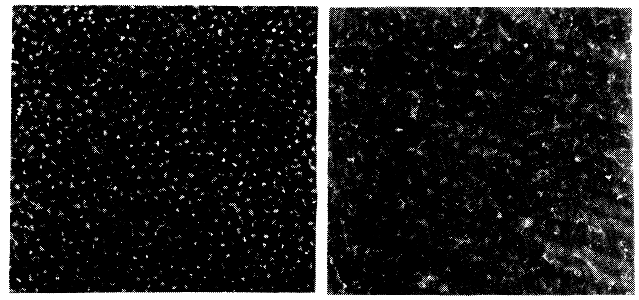

FIG. 1. Simultaneous flux-lattice decorations of YBCO (left) and BSCCO (right) at 15 K in a field of 20 G. In contradistinction to YBCO, the flux lines in BSCCO move significantly during the decoration time ($\sim$1 sec) providing convincing visual evidence that the flux lattice in BSCCO is melted into a liquid significantly below T_c.

To verify this interpretation of our mechanical measurements we have carried out a series of flux-lattice decorations[5] at different temperatures. Shown in Fig. 1 are decorations at 15 K for both $YBa_2Cu_3O_7$ (YBCO) and BSCCO in an applied field of 20 G. The decoration takes place over approximately 1 sec as the magnetic particles strike the surface. The YBCO which, at 15 K, is well below the melting temperature shows stable, discrete flux lines as do both YBCO and BSCCO at 4.2 K. However, at 15 K the flux lines for the BSCCO are blurred and show evidence of motion during the decoration. As 15 K is approaching the melting temperature, we feel that this is convincing visual evidence that the flux lattice is indeed melting well below T_c in BSCCO as we had concluded from our mechanical measurements.

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[1] P. L. Gammel *et al.*, Phys. Rev. Lett. **61**, 1666 (1988).
[2] P. Esquinazi, H. Neckel, G. Weiss, and E. H. Brandt, J. Low Temp. Phys. **64**, 1 (1986).
[3] M. J. Stephen and J. Bardeen, Phys. Rev. Lett. **14**, 112 (1965).
[4] E. H. Brandt, P. Esquinazi, and G. Weiss, preceding Comment, Phys. Rev. Lett. **62**, 2330 (1989).
[5] P. L. Gammel *et al.*, Phys. Rev. Lett. **59**, 2592 (1987).

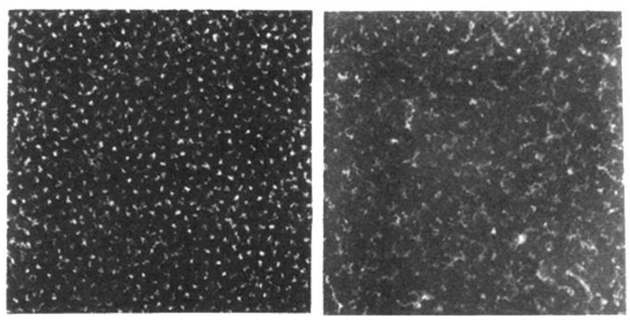

FIG. 1. Simultaneous flux-lattice decorations of YBCO (left) and BSCCO (right) at 15 K in a field of 20 G. In contradistinction to YBCO, the flux lines in BSCCO move significantly during the decoration time (~1 sec) providing convincing visual evidence that the flux lattice in BSCCO is melted into a liquid significantly below T_c.