A Simple Torsion Pendulum for Measuring Internal Friction

by M. E. Fine

IN the apparatus for measuring internal friction shown in fig. 1, a modification of that described by Kê,^{1,2} the parasitic energy loss or background is equivalent to a Q^{-1} of approximately 4×10^{-5} . This low value of background was obtained by using a jeweler's collet of appropriate size for the upper support, eliminating lateral motion without immersing the bob in oil, and designing the bob to reduce air resistance. The pendulum is supported on the frame through a snug fitting, sliding rotary joint (fig. 1-B). A slight twist of the top imparts essentially pure torsional motion to the pendulum. No evidence of energy loss in the sliding joint has been observed. In the bob (E) steel balls are used in the torsion arm, and the bottom is filled with lead giving a total weight of 94 g. A lighter bob may be used for small diameter specimens. Another bob was a solid disc with provision for adding discs to change the frequency. The oscillating image of the filament is recorded on a revolving drum camera (fig. 1-J) driven by a synchronous motor. This allows use of frequencies higher than can be measured visually on a glass scale.

Samples varying in diameter from 0.020 to 0.075 in. have been measured, the frequencies have ranged from 1 to 12 cps, and the maximum strain varied from 0.5 to 10×10^{-3} . With appropriate modification the sample may be placed in a thermostat.

M. E. FINE, Member Technical Staff, Bell Telephone Laboratories, Murray Hill, N. J.

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Table I. Internal Friction of Metal Wires

Material	Diam In.	Freq. cps.	Max. Strain	Internal Friction Q^{-1}
Beryllium-copper solution treated	0.058	6.4	1.2×10^{-5}	6×10^{-5}
Same, age hardened	0.058	6.6	1.2	5
Nickel brass, hard drawn	0.065	7.9	1.7	10
Same, 1.5 mil, lead coating	0.068	8.1	1.2	49
Permendur (50Fe,50Co,0.5Mn) slowly cooled from 1000°C	0.063	10.9	3.5	350
Same	0.063	10.9	1.3	99
Same	0.063	1.1	3.5	290
Permendur quenched from 1000°C	0.063	12.4	2.1	17
82Mn, 18Cu, quenched from 925°C, aged 1 hr at 400°C	0.061	5.1	1.0	1,750
46.8Ni, 0.5Mn, Bal.Fe, cold worked	0.074	11.4	1.7	20
Same, annealed at 900°C	0.074	11.9	1.3	59

The apparatus may also be used to measure the shear modulus.

In the examples of measurement given in table I the internal friction of Permendur and the 46.8 Ni-Fe alloy are due, for the most part, to magneto-mechanical hysteresis³ (elastic hysteresis accompanying stress-induced magnetostriction) which depends on strain amplitude and increases with annealing. The internal friction of most materials decreases with annealing.

References

1. T. S. Kê: *Physics Review* (1947) **71**, 533.
2. T. S. Kê: *Transactions AIME* (1948) **176**, 448; *Metals Technology* (June 1948) TP 2370E.
3. R. Becker and W. Döring: *Ferromagnetismus*. 365 (1939). J. Springer.

Fig. 1—Torsional pendulum for measuring internal friction.

- A Frame
- B Slip joint
- C Jeweler's collet holder with replaceable collet
- D Specimen
- E Bob with torsion arm
- F Light source
- G Lens
- H Mirror
- I Cylindrical lens
- J Rotating drum camera