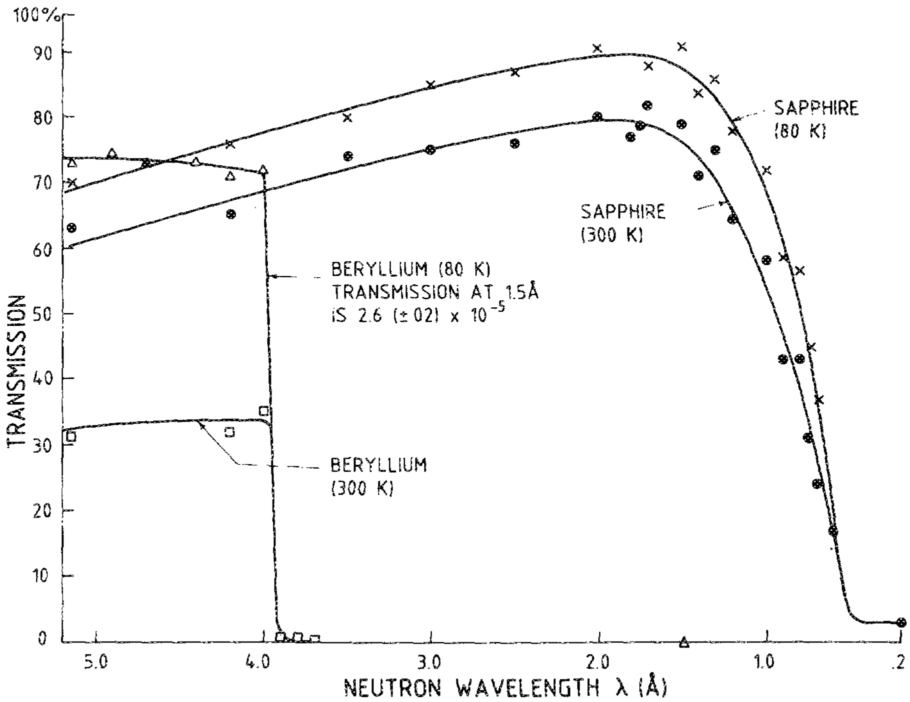

FIG. 1. The transmission of 10.16-cm sapphire and 15.24-cm beryllium filters at 300 and 80 K as a function of neutron wavelength.

sion of 4-Å neutrons is 71 ± 1%. The transmission of 80-K sapphire rises from 70% at 5 Å (3.3 meV) to 90% at 1.8 Å (25.2 meV) but it functions as an extremely effective fast neutron filter because its transmission for neutrons with wavelengths less than 0.4 Å (500 meV) is less than 3%. For this reason it is also an efficient filter for neutrons whose primary wavelength is $\leqslant 1.2$ Å. The higher orders of this wavelength ($\lambda/2, \lambda/3$) that would otherwise be available for reflection by the downstream monochromator are effectively rejected by the filter. A beam essentially free of $\lambda/2$ and $\lambda/3$ harmonics may thus be obtained from a Si(111) or Ge(111) monochromator set to reflect neutrons of wavelengths shorter than 1.2 Å ($E_0 > 55$ meV). The filter continues to provide more than four-fold rejection of $\lambda/3$ up to $\lambda = 1.86$ Å (24 meV), when used in conjunction with Si or Ge odd-index monochromator planes.

The *in situ* transmission data in the figure are published in order to help scientists in carrying out experiments requiring clean monochromatic neutron beams. The results confirm our earlier conclusions that sapphire is superior to quartz or silicon for this purpose.

[1]H. F. Nieman, D. C. Tennant, and G. Dolling, Rev. Sci. Instrum. **51**, 1299 (1980).

Frequency dependencies of precision resistors

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A variety of ac and dc resistors were examined for frequency dependence from dc to 400 Hz. It is concluded that several choices are available for use as standards in resistance thermometry.

From time to time, inquiries and requests for calibration are received from researchers who have purchased one of the new ac resistance thermometer bridges, and who desire to relate their new measurements to the common reference of direct current. It is well known that resistance thermometers are ratio devices, and that the parameter of interest is the ratio of the resistance at the temperature of concern to the resistance at the water triple point. When measurements are made in this way, the frequency dependence of the bridge standard is irrelevant. The frequency dependence of the thermometer itself may not be irrelevant, however, since it was found in our laboratory that the leads of one ordinary commercial 25-Ω quartz-sheathed platinum thermometer had a leakage conductance of 3 nS at 400 Hz. These leads were replaced with a pair of RG-58/U cables. In spite of the above, it is useful to periodically calibrate an ac bridge in terms of a unit that is known to be stable, and such a unit is most conveniently obtained at the present time through dc calibrations. For this purpose, it is sufficient that the transfer standard have a reasonably small frequency dependence, and that this dependence be stable.

A series of measurements was recently made at NBS which was designed to provide guidance in the selection of suitable standard resistors for use in the calibration of ac resistance thermometer bridges. Six 100-Ω resistors selected from commonly available commercial sources were investigated. They were compared with each other and with a special 100-Ω coaxial resistor that was constructed in 1969 together with a similar 1000-Ω resistor,[1] and exhaustively evaluated as part of an absolute measurement of the unit of resistance.[2] It was concluded at that time that the 100-Ω coaxial resistor increased in resistance by 0.005 parts per million (ppm) when the frequency changed from dc to 1592 Hz. In the measurements reported in this paper, the coaxial 100-Ω resistor is taken to be independent of frequency from dc to 400 Hz.

Four bridges were used to compare the six resistors with the coaxial standard. A Guildline model 9975 current comparator[3] was used for the dc measurements. A NBS-designed automatic resistance thermometer bridge with 30-Hz square-wave excitation[4] was used for the measurements reported under the heading, 30 Hz (sq). An Automatic Systems Ltd. F18 bridge[3] operated in the manual mode was used with interpolation for measurements involving 30- and 90-Hz sine waves. A NBS-designed manual resistance thermometer bridge[5] was used for measurements involving 400-Hz sine waves.

Table I summarizes the results of this study. We would conclude that the traditional dc resistors may be beyond their useful frequency range at 400 Hz, but that they could serve as transfer standards at 30 Hz, and possibly at 90 Hz. All of the other resistors tested have frequency corrections that are small enough even at 400 Hz that they should not vary over time by a significant amount.

TABLE I. Frequency dependencies of selected 100-Ω resistors. Differences from dc values, in parts per million (ppm). Estimated uncertainty: 0.05 ppm.

	30 Hz (sq)	30 Hz (sin)	90 Hz	400 Hz
E	+0.06	+0.07	+0.06	+0.11
V	+0.15	+0.20	+0.44	+0.15
T1	+0.02	+0.02	+0.07	−0.48
T2	0.00	+0.01	+0.08	−0.53
R	−0.64	−0.57	−1.42	−5.83
L	−1.71	−1.65	−2.60	−6.61

E: 10 1000-Ω Evanohm on mica card resistors in parallel; hermetically sealed in a NBS-designed enclosure.
V: Hermetically sealed thick-film resistor.
T1: Precision resistor, ac–dc type, serial number ***08; with binding posts and amalgamated contacts.
T2: Precision resistor, ac–dc type, serial number ***20; with binding posts and amalgamated contacts.
R: Precision resistor, traditional dc type, with binding posts and amalgamated contacts; manufacturer "A."
L: Precision resistor, transitional dc type, with binding posts and amalgamated contacts; manufacturer "B."

Resistors similar to "E" and "V," and "E" itself, had been compared with the coaxial standard at dc and at 400 Hz in a schedule going back to 1975. These data suggest that the frequency dependencies of hermetically sealed resistors of these types are stable over the years to at least 0.1 ppm. It appears likely that the other resistors tested will also exhibit stable frequency dependencies, but further tests over several years time would be of value.

I would like to thank Mary Odom and The Sandia National Laboratories for providing three of the resistors used in these measurements.

[1] R. J. Haddad, thesis, George Washington University, 1969.
[2] R. D. Cutkosky, IEEE Trans. Instrum. Meas. **IM-23**, 305 (1974).
[3] The particular commercial instruments named here are identified solely for completeness. This does not constitute endorsement of any commercial products.
[4] R. D. Cutkosky, IEEE Trans. Instrum. Meas. **IM-29**, 330 (1980).
[5] R. D. Cutkosky, Natl. Bur. Stand. J. Res. **74C**, 15 (1970).