

On the Hot-Wire Length Correction

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TWO of the conclusions reached by F. N. Frenkiel¹ concerning the effect of finite length of a hot-wire anemometer upon measurement of turbulence intensity appear to be in error:

(1) Although $1/I_b^2 (\equiv \langle e^2 \rangle_{AV} / \langle e_0^2 \rangle_{AV})$, the ratio of mean square measured voltage to ideal mean square voltage (for $R_y(s) = 1$) approaches zero as $1/l$ when the wire length l approaches infinity, still the longitudinal turbulent energy measured by this hot-wire does not approach zero. The measured energy is proportional to $\langle e^2 \rangle_{AV} = \langle e_0^2 \rangle_{AV} / I_b^2$, and since $\langle e_0^2 \rangle_{AV} \sim l^2$, $\langle e^2 \rangle_{AV}$ increases proportionally to l as $l \rightarrow \infty$.

(2) A Gaussian longitudinal correlation function does not lead to $I_b = 1$ when the turbulence is isotropic. If we substitute $R_x = \exp\{-\pi x^2 / 4L_x^2\}$ into the special form for isotropic turbulence, i.e.

$$1/I_b^2 = \frac{1}{l} \int_0^l R_x(s) ds$$

we find

$$\frac{1}{I_b^2} = \frac{L_x}{l} \operatorname{erf}\left\{\frac{(\pi)^{1/2} l}{2 L_x}\right\}$$

which is less than unity when $l > 0$. In fact, it is physically obvious that for any turbulent flow $1/I_b^2 < 1$ whenever the fluctuations are not perfectly correlated all along the hot-wire. This can also be seen immediately from a sketch of the general length-correction integrand, $[(l-s)R_y(s)]$.

It should furthermore be noted that in the two expressions for measured correlation as a function of true correlation (either the general relation for R_b, y or the additional relation for isotropic turbulence), there is zero error due to finite wire length when the true correlation function is Gaussian.

¹F. N. Frenkiel, Phys. Rev. **75**, 1263 (1949).

Elastic Constants and Internal Loss of Single Nickel Crystals

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SINCE the elastic constants of single nickel crystals have never been measured and are of some interest in magnetic studies, the velocities and approximate attenuations have been measured for two single nickel crystals. In preparing the crystals, 750 grams of electrolytic nickel of high purity (0.04 percent Co, 0.002 percent Fe) were melted in an alumina crucible (dextron bond, Norton ATM409) in a molybdenum wound resistance furnace in pure dry hydrogen. The bottom of the crucible was placed in the hottest part of the furnace and the charge melted. The furnace was cooled at the rate of 8°C/hour until the metal was well below the melting point.

Several single crystals of 50 to 75 grams each were obtained and were carefully cut from the ingot with a thin carborundum wheel. The surfaces were etched, and the orientation determined approximately by reflection of light from the etch pits, which were of the (111) form. Surfaces were cut parallel to the (100) and (110) planes as nearly as possible, and were tested by x-rays using back reflection, then corrected by careful grinding and etching to within a few minutes of arc of the desired plane.

The crystal upon which most of the measurements were made was cut in the form of a disk about 2.5 cm in diameter and 0.472 cm thick, the circular surfaces being parallel to the (110) planes. The other crystal used for check purposes had its two major surfaces parallel to the (110) plane and 3.13 cm apart, and two other surfaces parallel to (001) and 1.35 cm apart. Other surfaces were irregular.

The velocities and attenuations were measured by pulsing methods. The most satisfactory arrangement, shown by Fig. 1,

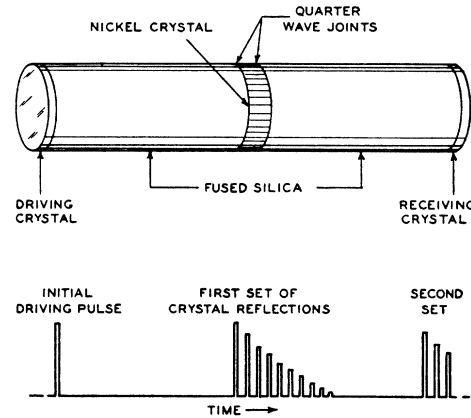


FIG. 1.

consisted in soldering longitudinal or shear wave crystals to the ends of two one-inch fused silica rods and connecting the nickel crystal to the polished ends of the rods by an approximate quarter wave-length of a poly- α -methyl styrene liquid and film of polystyrene. This provided a low mechanical impedance on either side of the nickel crystal, and a longitudinal or shear wave in the crystal was reflected back and forth giving a series of pulses in time and amplitude, from which the velocity and attenuation could be measured. The silica rods were long enough so that reflections from the ends did not arrive in time to interfere with the multiple pulses in the crystal. The most satisfactory way to determine the velocity was by making the pulses considerably longer than the time between reflections and adjusting the frequency until all the pulses added in phase. A number of such frequencies were determined, using the wide frequency range possible with the soldered crystals, and the number of wave-lengths corresponding to each frequency determined. By this method a velocity determination good to better than one percent was possible with a crystal thickness of 0.5 cm.

TABLE I. Orientations and elastic constants.

Direction of propagation	Direction of particle motion	Type of mode	Equation for velocity	Measured velocity	Elastic constants (dynes/cm ²)
110	110	Long.	$v = [(c_{11} + c_{12} + 2c_{44}) / 2\rho]^{1/2}$	6.06×10^5 cm/sec.	$c_{11} + c_{12} + 2c_{44} = 6.53 \times 10^{12}$
110	110	Shear	$v = [(c_{11} - c_{12}) / 2\rho]^{1/2}$	2.26×10^5	$c_{11} - c_{12} = 0.90 \times 10^{12}$
110	001	Shear	$v = [c_{44} / \rho]^{1/2}$	3.65×10^5	$c_{44} = 1.185 \times 10^{12}$
100	100	Long.	$v = [c_{11} / \rho]^{1/2}$	5.30×10^5	$c_{11} = 2.50 \times 10^{12}$
100	010	Shear	$v = [c_{44} / \rho]^{1/2}$	3.65×10^5	$c_{44} = 1.185 \times 10^{12}$