DYNAMIC THEORY OF A SHORT HOT WIRE
NORMAL TO AN INCOMPRESSIBLE AIRFLOW,
CONSTANT RESISTANCE OPERATION

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Abstract
The aim of the investigation was primarily the computation of the dynamical
corrections on the static calibration curve. A brief account is given of the
available analytical expressions for the heat transfer of a hot wire to the
ambient airflow. The appropriate form is inserted in the small perturbation
energy equation giving, with constant values of the characteristic para-

Nomenclature

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>A, B, B'</td>
<td>coefficients of heat transfer; ( B' = 0.4BU^{0.4} )</td>
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<tr>
<td>b</td>
<td>temperature coefficient of electric resistance</td>
</tr>
<tr>
<td>C</td>
<td>( \frac{4bR_0}{\pi d^2 \rho_w} )</td>
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<tr>
<td>c</td>
<td>velocity of sound; specific heat</td>
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<tr>
<td>d</td>
<td>diameter</td>
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<tr>
<td>G</td>
<td>overall transconductance</td>
</tr>
<tr>
<td>Gr</td>
<td>Grashof number</td>
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<tr>
<td>h</td>
<td>heat transfer coefficient</td>
</tr>
<tr>
<td>I</td>
<td>heating current, ( I + i = I + i e^{j\omega t} )</td>
</tr>
<tr>
<td>I_0</td>
<td>&quot;cold length&quot;, ( [C(V - I_0)]^{-\frac{1}{4}} )</td>
</tr>
<tr>
<td>Kn</td>
<td>Knudsen number</td>
</tr>
<tr>
<td>M</td>
<td>Mach number</td>
</tr>
<tr>
<td>Nu, Nu'</td>
<td>Nusselt numbers</td>
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</table>
\(N_T\) Temperature number
\(Pe\) Péclet number
\(Pr\) Prandtl number
\(\rho\) \(1 + j\omega/\omega^*\)
\(q\) specific heat flow
\(R_{w1}, R_{g1}, R_{f1}\) electric resistances of hot wire per unit length,
\(R_{w1} = \frac{\bar{U}d}{\nu} = R_{w1} + f_{w1} e^{j\omega t} = F(x) + \tilde{f}(x) e^{j\omega t}\)
\(Re = \frac{\bar{U}d}{\nu}\) Reynolds number
\(Str = \frac{\omega d}{\bar{U}}\) Strouhal number
\(T_w, T_f, T_g, T_0\) temperature
\(\dot{t}\) time
\(U = \bar{U} + \eta = \bar{U} + \hat{a} e^{j\omega t}\) velocity of main air flow
\(V\) \(A + B\bar{U}^{0.4}\)
\(x\) coordinate along hot wire
\(e = \frac{l}{2l_0}\)
\(\kappa = \frac{c_p}{c_v}\) ratio of specific heats at constant pressure and constant volume
\(\lambda_g, \lambda_f, \lambda_w\) heat conductivity of air; \(\lambda_w'\) ditto of hot wire
\(\lambda\) molecular mean free path
\(\mu\) dynamic viscosity
\(\nu\) kinematic viscosity
\(\rho\) density
\(\omega\) angular frequency
\(\omega^*\) \(\frac{1}{\rho_w c_w} \frac{\rho^2}{R_w}\)
\(H\) \(\frac{\lambda_w}{R_g}\)
\(\xi\) \(\frac{x}{l_0} = \frac{2x}{l} = \frac{2x}{2l_0} = \frac{l}{l}\)
\(\zeta\) amplification factor of acoustic resonance
\(\tau\) \(f_{w1}/R_{g1} = \tilde{f}(x)/R_{g1}\)
\(\Re\) \(R_{w1}/R_{g1}\)

**superscripts**
\(\wedge\) amplitude
\(\bar{\text{---}}\) mean value with respect to time
\(<\text{ >}\) mean value with respect to position

**subscripts**
\(\ast\) characteristic quantity
\(f\) film
\(g\) mean gas flow
\(w\) hot wire