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PREDICTED AND HOT-FILM MEASURED TOLLMIEN-SCHLICHTING WAVE CHARACTERISTICS

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Time Traces Obtained From a Thin Film

The Tollmien-Schlichting (T-S) instability (ref. 28) is a time-dependent instability which can lead to transition of laminar boundary layers on airfoils. This paper presents a comparison of theoretical predictions and experimental observations of the T-S instability on the NLF(1)-0414F airfoil designed by Viken and Pfenninger (ref. 29). The theoretical predictions were obtained using the SALLY stability code (ref. 30). The experimental observation of the T-S instabilities was accomplished by enhancing the output obtained from the conventional hot film transition detection technique (refs. 10, 31, and 32).

The measurements were made in the Langley Low-Turbulence Pressure Tunnel (ref. 33) on a 3-foot chord model of the NASA designed NLF(1)-0414 at $M_\infty = 0.143$, $R_c = 3 \times 10^6$ and $\alpha = 3.0^o$. Pressure orifices on both surfaces were used to determine the pressure distribution, and hot-film gages were used to locate the beginning of transition.

Test results, from the same hot films that were used to detect transition, revealed that T-S waves could be detected by the hot film if the hot-film signal (fig. 1) was adequately amplified.

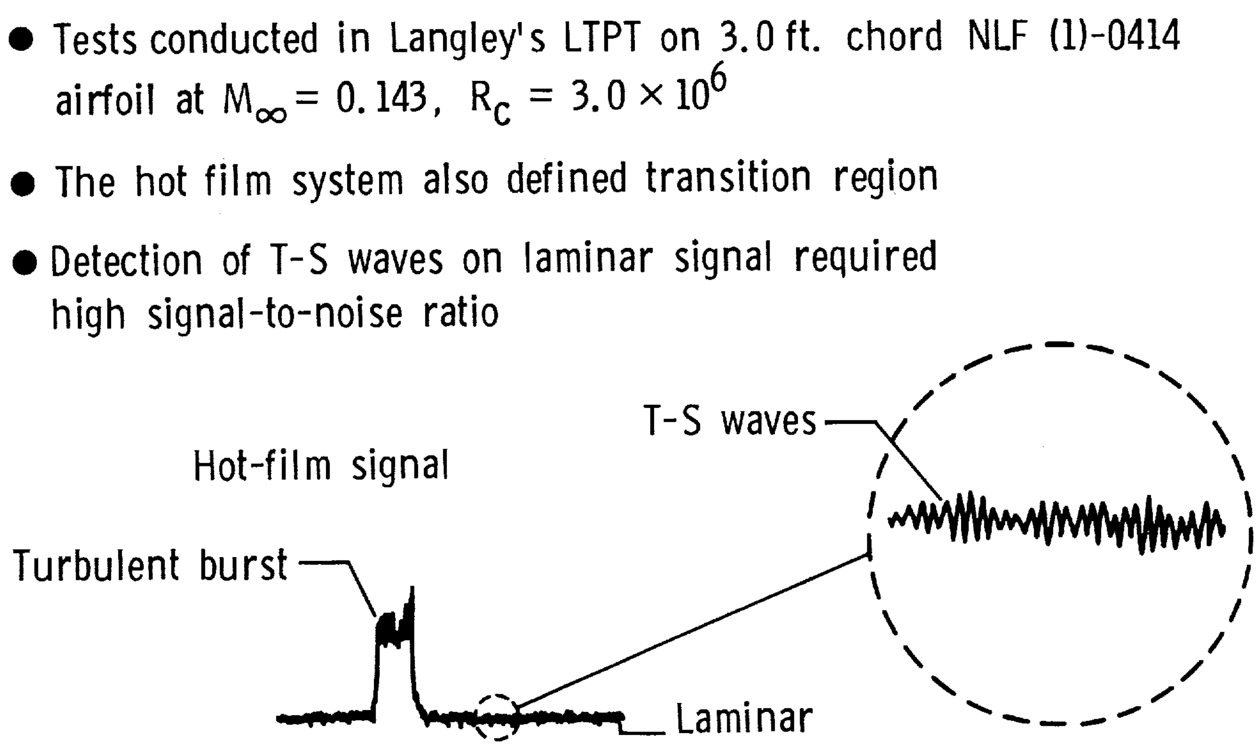

Figure 1

Wave Form and Spectra From a Thin Film

The spectral analysis from the wave form (fig. 2) clearly shows a dominant frequency at 1.4 KHz. The measurements were made at 70 percent of chord on the NLF(1)-0414 at $M_{\infty} = 0.143$ and $R_c = 3 \times 10^6$.

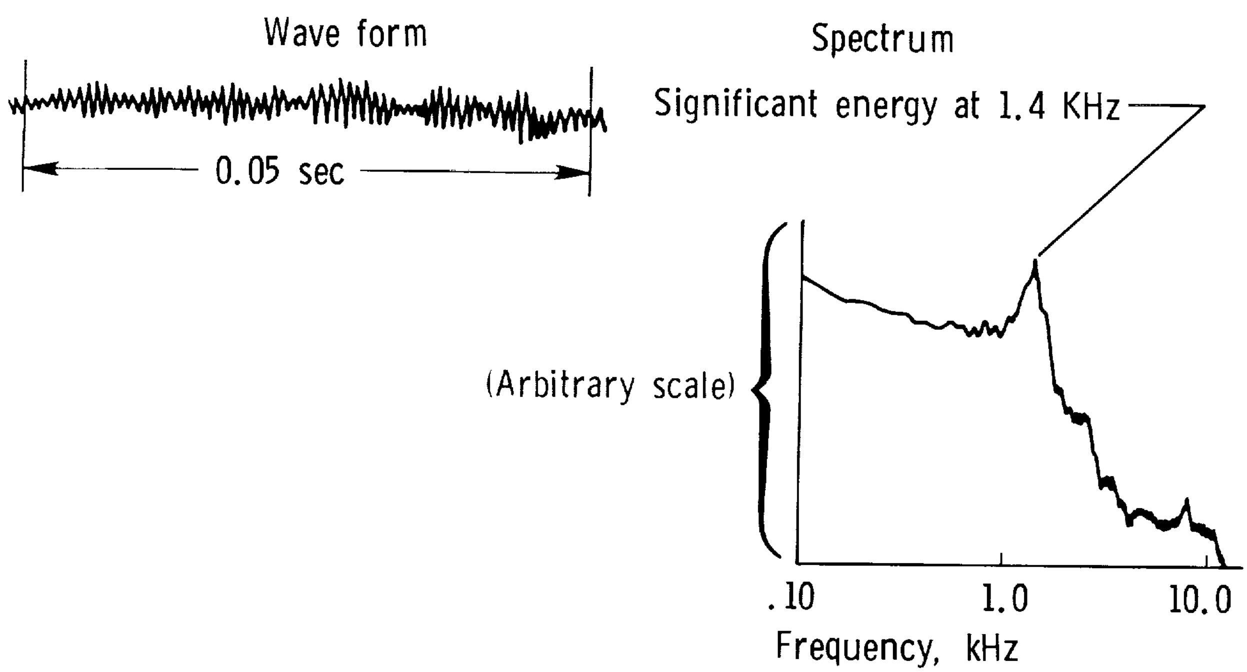

Figure 2

Predicted Tollmien-Schlichting Wave Characteristics

The dominant frequency, shown in figure 2, can be seen to fall within the theoretically predicted incompressible T-S amplification range for $M_{\infty} = 0.143$, and $R_c \doteq 3 \times 10^6$ at 70 percent of chord on the for the NLF(1)-0414 airfoil (fig. 3). This comparison of the predicted and experimental measurement of the T-S instability on an NLF airfoil demonstrates that conventional hot films, generally used for the detection of boundary-layer transition, can be extended for use to measure the T-S most amplified frequency.

Amplified T-S frequencies at x/c = 0.7 and values of n

T-S freq., Hz	n
□ 1250	11.1
◇ 1500	12.2 *
△ 1750	10.7

*Most amplified frequency is 1500 Hz at transition location, with n = 12.2

Measured freq. is 1400 Hz

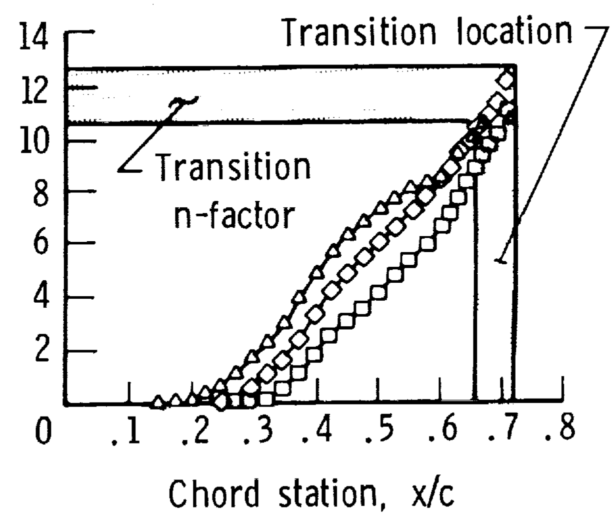

Figure 3