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Corrigendum: Measurements of the fluctuating pressure at the wall beneath a thick turbulent boundary layer

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The values reported by Willmarth & Wooldridge (1962) for the root-mean-square wall pressure and the power spectra of the wall pressure are in error. G. M. Corcos and M. K. Bull pointed out to me, in April 1963, that the area beneath the power spectra of figure 4 does not agree with the values of $\sqrt{(\overline{p^2})}/q_\infty$ and $\sqrt{(\overline{p^2})}/\tau_w$ reported in table 3 and in § 4.1. The measurements for the wall pressure at high speed, $U_\infty = 206$ ft./sec, were fortunately recorded on magnetic tape. It was therefore possible to check the measurements for that case.

The tape recorder has frequency modulated electronics and accepts signals from zero to 20 kc/s. When the experiments of Willmarth & Wooldridge (1962) were made, the amplified signal from the pressure transducer was passed through a simple resistance and capacitance filter with a half power point at 40 c/s and then recorded on magnetic tape. By playing back the recorded signals through a calibrated Kron–Hite band pass filter set at 105 c/s and 20 kc/s I found that the correct root-mean-square wall pressure was

$$\sqrt{(\overline{p^2})}/\tau_w = 2{\cdot}64 \quad \text{or} \quad \sqrt{(\overline{p^2})}/q_\infty = 5{\cdot}61 \times 10^{-3}.$$

Our measured values of $\sqrt{(\overline{p^2})}/\tau_w$ and $\sqrt{(\overline{p^2})}/q_\infty$ in tables 2 and 3 and in the text of Willmarth & Wooldridge (1962) should all be increased by multiplying them by a factor of 1.21.

The error in the root-mean-square pressure was caused by my neglect of the effect of additional cable capacitance when calibrating the pressure transducer and my failure to account for a uniform attenuation over the pass band of approximately 15 % of the signal passed through the band pass filter when the root-mean-square pressure was originally measured. There were two ways to obtain the same setting of 20 kc/s on the band pass filter. I used the setting that had not been calibrated instead of the other setting that had been checked and calibrated.

The power spectrum of the pressure was also checked. An error was caused by neglect of the effect of additional cable capacitance in the calibration of the pressure transducer. The correct power spectrum will be obtained from figure 4 of Willmarth & Wooldridge (1962) by increasing the ordinate of the spectra by a factor of 1·10 or 10 % at all frequencies.

In the winter of 1963 we again measured the wall-pressure fluctuations (appendix of Willmarth & Wooldridge 1963), with the same transducer,

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$R = 0{\cdot}166\delta^*$, that was used in the previous investigation. We took great care to smooth the tunnel floor on which the turbulent boundary layer is developed. (The original smooth varnished surface of the fibreboard floor was scratched and holes had been drilled through it.) The measured root-mean-square wall pressure was $\sqrt{(\overline{p^2})}/\tau_w = 2{\cdot}31$, a decrease of 14 % from the above corrected value, $\sqrt{(\overline{p^2})}/\tau_w = 2{\cdot}64$. The amplitude of the power spectrum of the wall pressure was 28 % *lower than the above corrected value except at high frequencies*, $\omega\delta^*/U_\infty > 10$, where it was the same as before.

The 14 % reduction of the root-mean-square pressure was originally attributed to a smoother floor and better alignment between the floor and the 20 in. diameter steel plate carrying the transducer (see appendix of Willmarth & Wooldridge 1963). Based on our old data (summer and winter of 1961) there are a number of other effects that might have caused the 14 % reduction of the wall pressure.

The old measurements consist of many (largely unpublished) root-mean-square wall pressure measurements made under various conditions. Some of these measurements were made in an attempt to assess the effects of surface roughness on the magnitude of the wall-pressure fluctuations, while others were made at different times of day with different tunnel temperatures, at different longitudinal and spanwise stations, and in the summer and winter.

If one assumes that the contribution to the wall-pressure fluctuations produced by a given type of disturbance is not correlated with the pressure fluctuations produced by the boundary layer or by other types of disturbances, the contribution of any one source of small disturbances to the mean-square wall pressure will be additive. With this relatively crude assumption, one can approximately determine the magnitude of the wall-pressure fluctuations associated with a given type of disturbance. The square root of the difference in the mean-square wall pressure when the given type of disturbance was present and when it was not was divided by the root-mean-square wall pressure $\sqrt{(\overline{p^2})}/\tau_w = 2{\cdot}31$ to give the percentage contribution of a given disturbance.

The various effects we have measured are given below in terms of the above percentage contribution of a given disturbance: circular machine tool marks of the order of 2–3 sublayer thicknesses on the 20 in. diameter steel plate in which the transducer was mounted, 50 %; roughness* of the painted wooden floor everywhere beyond the steel plate, 30 %; a $\frac{1}{2}$ in. × $\frac{1}{2}$ in. boundary-layer trip 9 ft. upstream, 54 %; change in density stratification of the tunnel air during the summer caused by the sun going behind clouds, 7 %; non-uniformity of the turbulent boundary layer transverse to the stream direction, 15 %; misalignment of the leading edge of the 20 in. steel plate by $\pm\frac{1}{64}$ in., 7 % (the misalignment was certainly less than this amount); upstream propagation of sound from the diffuser, 3 %; sound produced by leaking air or rattles of the tunnel structure, 1–2 %. In some of the above cases the change in the spectrum of the pressure was also measured. The spectrum was increased uniformly across the frequency band by surface roughness but was not uniform when sound caused the disturbances. The change in the spectrum caused by transverse

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* The roughness was not measured but consisted mostly of scratches and pits in the surface of the order of 10 sublayer thicknesses deep.

non-uniformity and density stratification was not measured. The band width for all the above root-mean-square measurements was

$$105 < f < 20{,}000\,\mathrm{c/s} \quad \text{or} \quad 0{\cdot}14 < \omega\delta^*/U_\infty < 27{\cdot}2.$$

During our pressure correlation measurements (Willmarth & Wooldridge 1962), we often noticed changes of the order of 10 % in the root-mean-square wall pressure while the tunnel was running and from one run to the next after restarting the tunnel. These changes in level of the pressure fluctuations did not change the normalized pressure correlations reported in Willmarth & Wooldridge (1962). I would like to suggest that changes in the transverse structure of the turbulent boundary layer or changes in the nature of the natural transition process may be responsible for the change in the level of the pressure fluctuations and may also be responsible for the 14 % decrease in the root-mean-square pressure that we measured in the winter of 1963 (Willmarth & Wooldridge 1963).

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