THE SPECTRUM OF TURBULENCE

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NOTE

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Electric signals which are similar in power-spectrum to the velocity fluctuations in turbulence can be produced from a few sinusoidal-wave signals using a simple non-linear circuit.

Key words : Sinusoidal waves, Non-linear circuit, Power-spectrum, Turbulence

Figure 1 shows the non-linear electric circuit used in the present experiment. The circuit is a simple rectifier. The signal applied to the input is rectified by a diode. The output signal is analyzed with a fast Fourier transform analyzer (FFT analyzer), and the waveform and power-spectrum are graphed on a plotter.

Figure 2 shows the output waveform and its power-spectrum in the case when two square-waves are applied to the input of the circuit. The two square-waves are close in frequency and the same in amplitude.

Figure 3 shows the case when three square-waves are applied to the input. The three square-waves are close in frequency and the same in amplitude.

It is seen from figures 2 and 3 that an electric signal whose power-spectrum is continuous can be produced from a few square-wave signals using a simple non-linear circuit. As is well known, a sinusoidal-wave can be easily transformed into a square-wave using an amplifier. When a sinusoidal-wave is applied to the input of an amplifier, if the amplitude is increased beyond the limit of the amplifier, the output signal approaches a square-wave. This shows that a wave whose power-spectrum is continuous can be produced from a few sinusoidal-waves through amplification, saturation, mixing and rectification.

Figures 4 and 5 show the waveforms and power-spectra of the velocity fluctuations in a turbulent boundary layer on a flat plate parallel to the flow. What is very interesting is that the power-spectra shown in figures 2 and 3 are very similar to those shown in figures 4 and 5.

In view of the above results it can be suggested that the spectrum of turbulence is ascribed to a few instability waves which are close in frequency.

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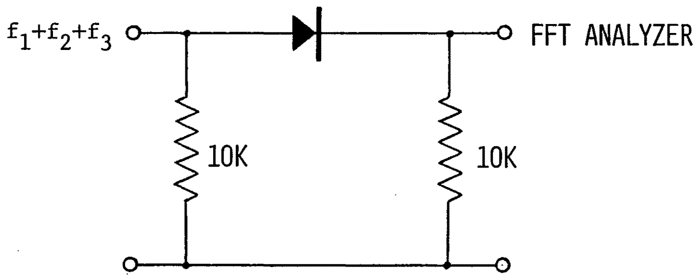

Fig. 1 Electric circuit used in the experiment.

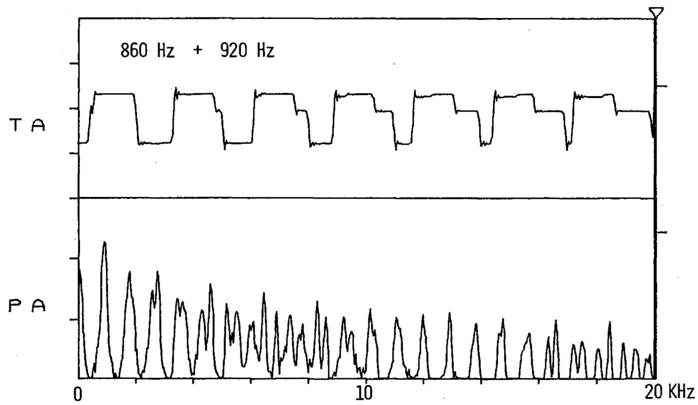

Fig. 2 Output signal waveform (TA) and its power-spectrum (PA) in the case when two square-waves 860 Hz and 920 Hz in frequency are applied to the input of the circuit.

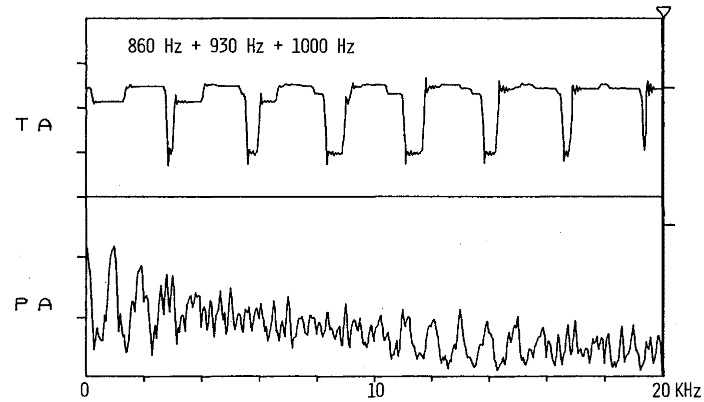

Fig. 3 Output signal waveform (TA) and its power-spectrum (PA) in the case when three square-waves 860 Hz, 930 Hz and 1000 Hz in frequency are applied to the input of the circuit.

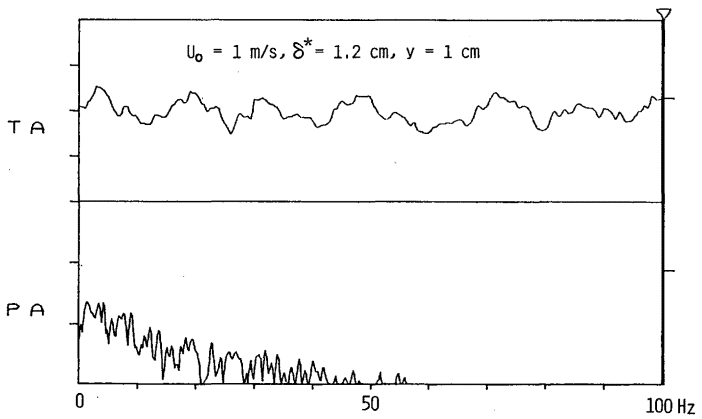

Fig. 4 Velocity fluctuation (TA) in a turbulent boundary layer on a flat plate and its power-spectrum (PA).
Air speed $U_0 = 1$ m/s, displacement thickness $\delta^* = 1.2$cm and distance of hot-wire from wall y = 1 cm.

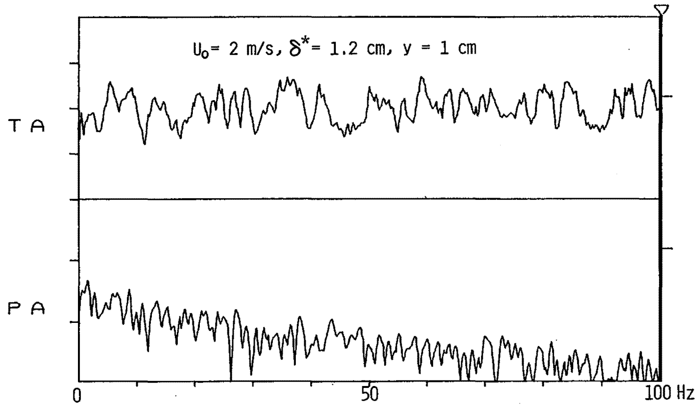

Fig. 5 Velocity fluctuation (TA) in a turbulent boundary layer on a flat plate and its power-spectrum (PA).
$U_0 = 2$ m/s, $\delta^* = 1.2$ cm and $y = 1$ cm.