RESPONSE OF TURBULENT BOUNDARY LAYER FLOWS TO ARTIFICIAL DISTURBANCES

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NOTE

RESPONSE OF TURBULENT BOUNDARY LAYER FLOWS TO ARTIFICIAL DISTURBANCES

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Different artificial disturbances were introduced into the turbulent boundary layer flows along a flat plate with a bluff front.

Peculiar disturbances are amplified and the others are damped in the wake.

1. Introduction

When surfaces of a flat plate with a bluff front are arranged parallel to the uniform flow, the flow separates from front edges and turbulent boundary layer flows are formed along the surfaces. In order to investigate the characteristics of the turbulent boundary layer flows, different artificial disturbances were introduced into the boundary layer flows. The amplification and damping of the disturbances were examined by use of hot-wire anemometers.

2. Experimental Methods

The experiments were carried out in a wind tunnel which had a closed working section of 400 cm in width, 200 cm in height and 600 cm in length. Model flat plate was 100 cm in width, 190 cm in length and 5 cm in thickness, and it had a bluff front. An artificial disturbances generator was 3.0 cm in width, 120 cm in length and 0.5 mm in thickness and it performed rotatory oscillations of $\pm$ 30° around the axis of its front tip, which was situated at the point of $x = 52$ cm and $y = 3.7$ cm, where x is the downstream distance from the front of the plate and y the transverse distance from the surface of the plate, as shown in Fig. 1. The velocity fluctuations of the flows in the boundary layer were measured at the point of $x = 170$ cm and $y = 10$ cm, and that of $x = 500$ cm and $y = 0$ cm in the wake. The uniform flow velocity was 1 m/s.

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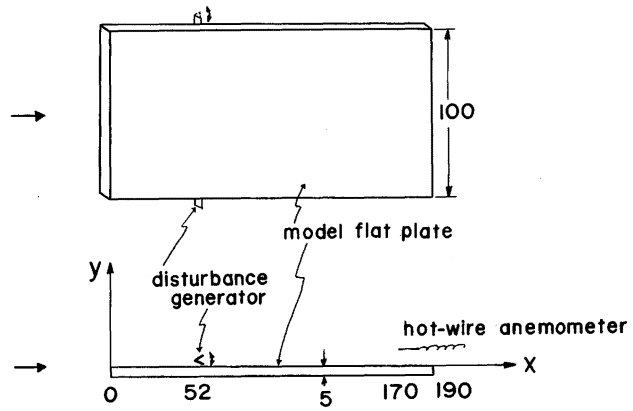

Fig. 1 Schematic diagram of the experimental apparatus

3. Experimental Results

Figures 2 and 3 show typical examples of recorded signal traces (TA) and spectra of fluctuating velocity (PA) at the points of $x = 170$ cm and $x = 500$ cm, respectively, when different values of artificial disturbances were introduced. The abscissa in each figure is graduated in 1 Hz increments.

It will be seen from Figs. 2 and 3 that (1) the flow has predominant frequency of $f = 1.0$ Hz at both points in the boundary layer and in the wake against the artificial disturbance frequency of $N = 0.5$ Hz, (2) artificial disturbances of $N = 1.0$ and 1.5 Hz remain even in the wake, (3) the disturbance of $N = 2.0$ is slightly damped in the wake and (4) the disturbance of $N = 4.5$ Hz is damped in the wake and the power spectrum is similar to that of $N = 0$ Hz.

From the results obtained, it becomes clear that a peculiar disturbance dependent upon the boundary layer thickness is amplified and others are damped in the downstream direction.

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References

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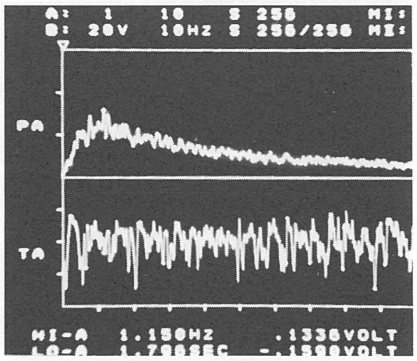
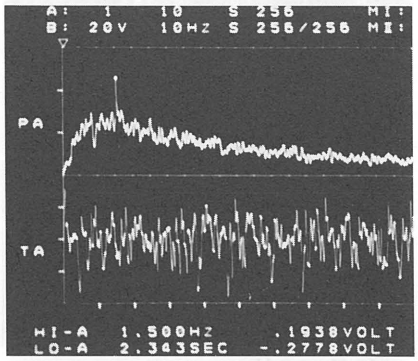
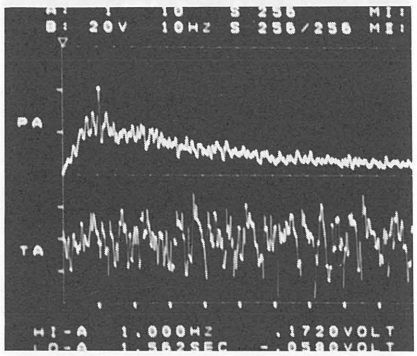


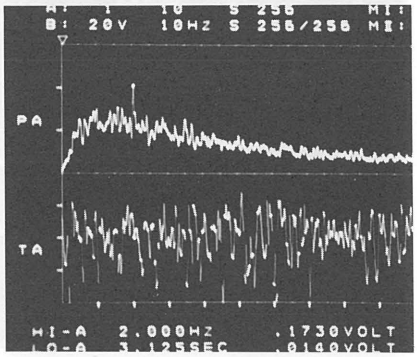
(1) N = 0 Hz



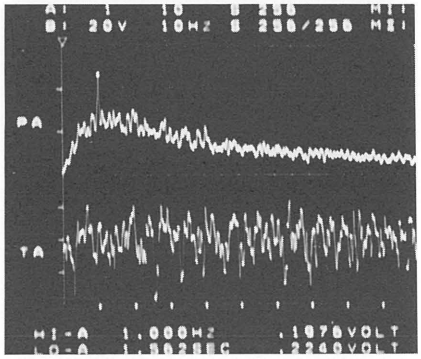
(4) N = 1.5Hg



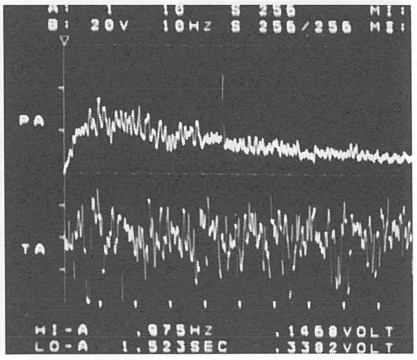
(2) N = 0.5Hg



(5) N = 2.0 Hz



(3) N = 1.0 Hz



(6) N = 4.5Hg

Fig. 2 Signal traces(TA) and spectra of fluctuating velocity (PA) at the point of x = 170 cm and y =10 cm.
N indicates the artificial disturbance frequency.

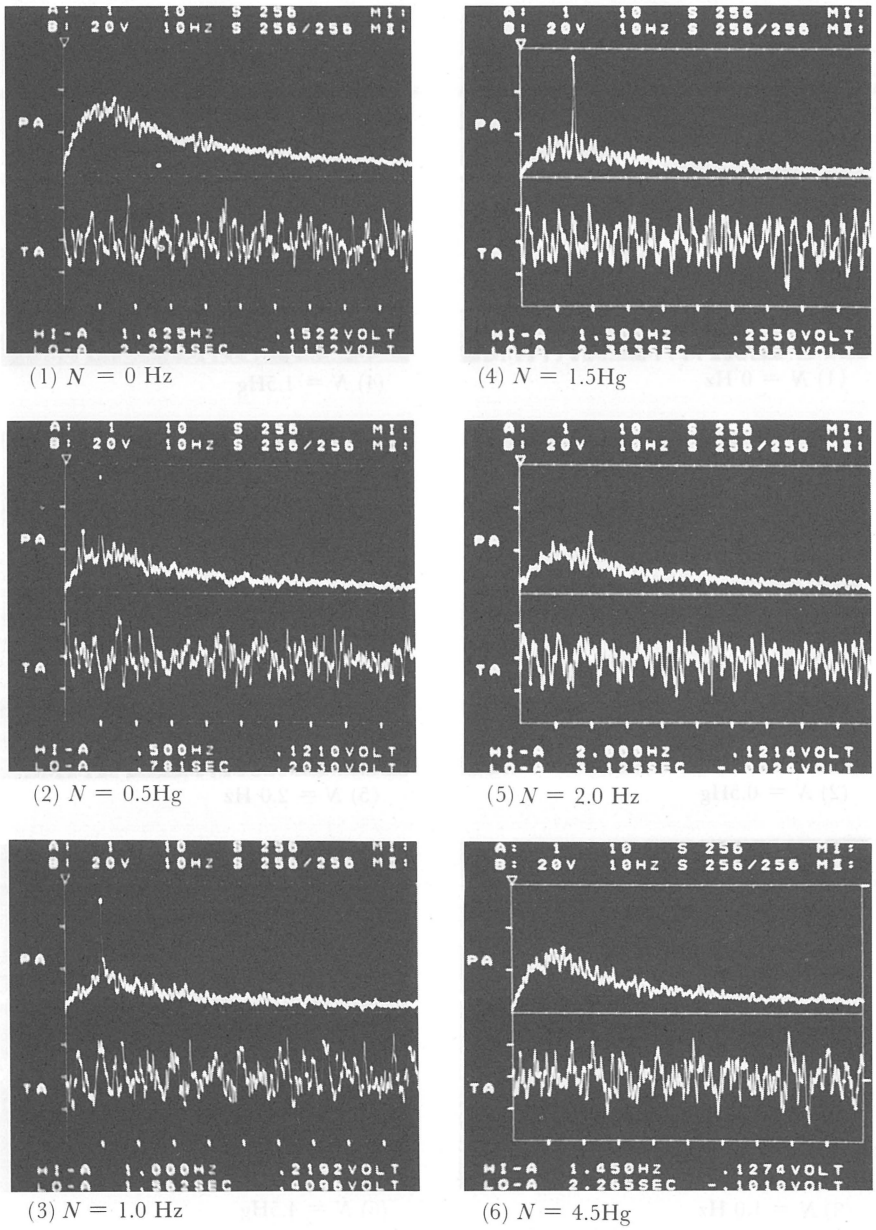


Fig. 3 Signal traces (TA) and spectra of fluctuating velocity (PA) at the point of $x = 500$ cm and $y = 0$ cm.
N indicates the artificial disturbance frequency.