iments ($\approx$4.5), the Wyngaard calculation gives an attenuation of 8%. Since our experimental results have a scatter of $\pm$8%, it is not possible to see this theoretical trend in our data. For Azad and Kassab's (1989) data, in which l_w/L_K varies from 8 to 35, Wyngaard's calculations indicate an attenuation of the order of 22% to 65%. It should also be noted that Azad and Kassab's extrapolation of their data to "zero-wire-length" does not take into account the flattening out that occurs in the Wyngaard correction curve for l_w/L_K less than about 5.

The isotropic dissipations obtained in these experiments agree very well with those obtained by Browne et al. (1987). However, they are well below the actual dissipations reported by those authors.

4 Conclusion

For the far wake of a cylinder, the zero-wire-length dissipation technique, using wire lengths no longer than about 5 times the Kolmogorov microscale, does not give correct estimates of the actual dissipation. The technique simply gives – as might be expected – the isotropic estimates of the dissipation.

The results obtained by Turan and Azad (1989) and by Azad and Kasab (1989), for a boundary layer and a fully developed pipe flow, are therefore questionable – especially since the theoretical basis for the zero-wire-lengths dissipation technique does not appear to be well founded.

Acknowledgements

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An electronic indicator for flow-separation

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Flow-separation can be made visible by wool-tufts, smoke or liquids. These methods, however, can only be applied when the area of interest can be viewed. There are many cases where this is not possible, e.g., on some parts of airplanes or in duct-flows. Here a remote indication is necessary instead. This remote indication that is described in this note consists of a small sensor fixed at the position of interest and connected with an electronic equipment by electric leads. Flow-separation is indicated by optical or acoustic signals. The signals can also be stored by a data acquisition system.

The sensor is a small NTC-resistor in a glass-bead of 1.5 mm diameter. A sensor mounted in a small plastic tube of 2.5 mm outer diameter for thermal insulation is shown on the right side of Fig. 1 (Probe 1). In the middle of the figure this sensor is mounted in the surface of an airfoil. Only the glass-bead of 1.5 mm diameter is exposed to the flow. On the left side of the figure a sensor is mounted in a flat cone, which can be fixed at any position by double-sticking tapes. The top of the glass-bead is 5 mm above the surface (Probe 2). The electric leads should be fixed in flow direction if possible. Figures 2 and 3 show the construction of the different versions.

Wool-tufts show that in separated areas the direction between forward and backward flow changes with a certain

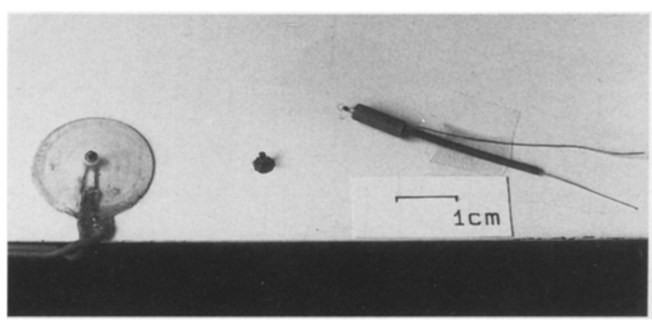

Fig. 1. Sensors in different arrangements mounted on the surface of an airfoil

frequency as a result of the dimensions of the vortices. This fact is used by an electronic circuit in order to detect flow-separation.

The NTC-resistor (Siemens M 81) is heated in a constant-temperature mode in an electric bridge whose output is filtered and amplified (Fig. 4). In this way portions with low and high frequency are discarded. Only the characteristic frequencies between 1 and 8 Hz are selected. In the next stage the signal is again amplified and rectified. By addition of a DC-voltage the threshold of the following comparator, and therefore the sensitivity of the instrument can be adjusted. A battery with 12 volts can be used as power supply. The power consumption of about 70 ma is mainly caused by heating energy. The instrument may give signals even at zero wind-velocity if suitable gusts are detected. This fact should not provoke confusion.

The function of the electric indicator was tested in the Laminar-Windtunnel of the Institute. In separated tests each of the two NTC-sensor probes was fixed on the suction side of a two-dimensional airfoil section with a chord of 0.7 m. Here flow separation can easily be demonstrated by changing the angle of attack. On each side of the probe several wool-tufts were fixed downstream and somewhat upstream from the sensor in such a way that the flow on the sensor was not influenced. By increase of the angle of attack, flow-separation was produced at the trailing edge. With growing angle of attack the upstream migration of the flow-separation could be observed by the wool-tufts. As soon as the separation had reached the sensor, the acoustic signal was triggered and it sounded as long as the separation migrated downstream from the sensor. By reduction of the angle of attack the wool-tufts beside and behind the sensor showed again attached flow, and at the same time the signal stopped sounding. This experiment was carried out at several velocities and recorded by a video camera (sound included). When testing it on a sailplane, the sensor and the wool-tufts were fixed on a part of the wing, which could be observed from the cockpit. Again, the indication of the wool-tufts and the acoustic signal corresponded to each other.

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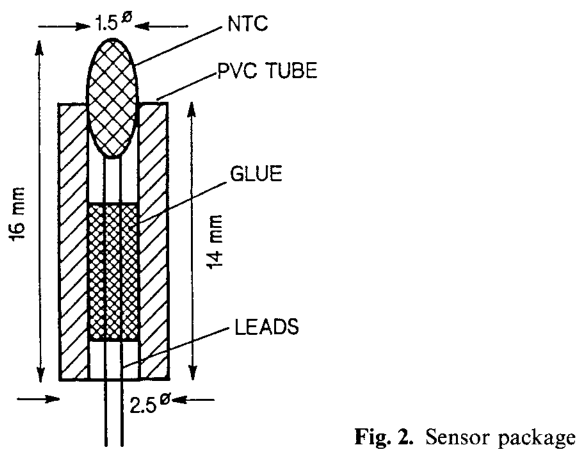

Fig. 2. Sensor package probe 1

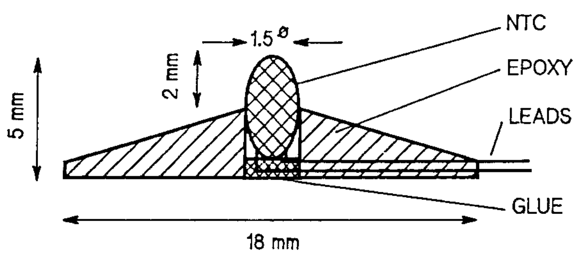

Fig. 3. Sensor package probe 2

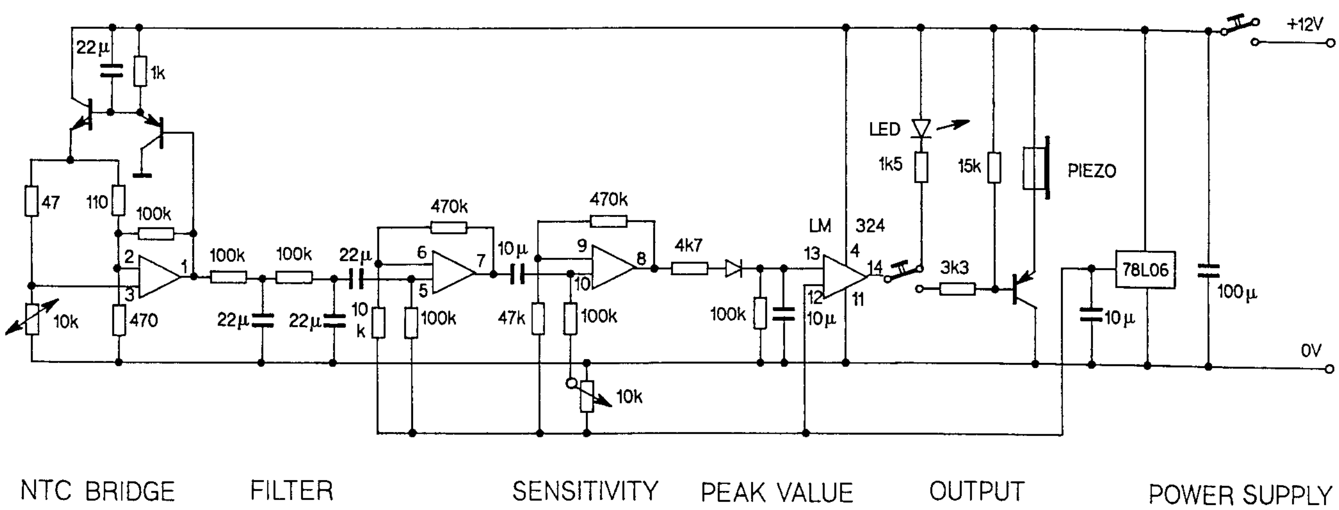

Fig. 4. Electronic circuit