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by

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A simple mean conductivity meter

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Abstract. This note describes a relatively inexpensive instrument for the measurement of the mean conductivity at a point in a turbulent salt water jet or plume. The complex electronic circuitry necessary to obtain a mean conductivity reading from a probe exposed directly to a turbulent salt water flow is avoided, as is the excessive time required to siphon samples from the flow in the alternative method of using a commercially available conductivity meter.

1. Introduction

Phenomena such as free turbulent jets and plumes, involving the interaction of miscible fluids of different density, are often modelled in the hydraulics laboratory by using fresh water as the lighter fluid and a solution of common salt as the denser fluid. In such investigations the mean density at a point in the flow is of interest, particularly if the entrainment function concept (Taylor *et al.* 1956) is used to take account of the shear stresses at the turbulent interface between the salt water flow and the ambient fresh water. The measurement of electrical conductivity provides a convenient means of assessing the salt concentration, and hence the liquid density, at a point in the flow.

In free turbulent jets and plumes, however, the density, and hence the conductivity, at a point in the flow is inherently very unsteady and some method of obtaining a mean conductivity measurement is necessary.

2. Review of methods of determining a mean conductivity

2.1. *Using a probe exposed directly to the flow*

Many attempts have been made to obtain a mean conductivity reading by using a probe inserted directly in a turbulent flow. Lamb *et al.* (1960) used a 'point and ring' electrode system while, more recently, Gibson and Schwarz (1963) have described a 'single electrode' probe. The cost of the associated electronic instruments for both these methods is probably prohibitive for a small research project.

2.2. *Siphoning samples from the flow*

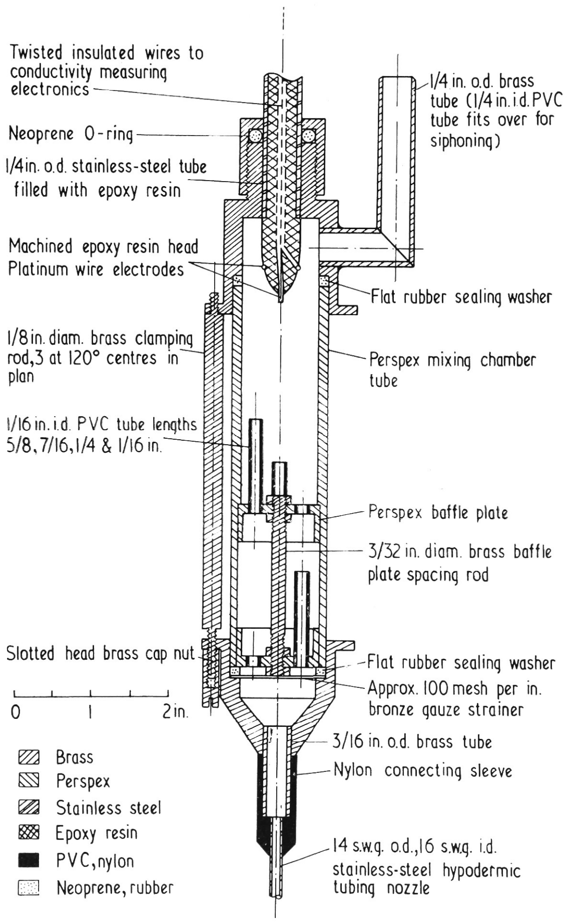
Lofquist (1960) has described a method of slow siphoning through a hypodermic needle in order to obtain a sample for use in a commercially available conductivity meter. This method is very time consuming and subject to errors due to temperature change.

2.3. *The present instrument*

A third method is to determine the conductivity in a 'mixing chamber' sited close to the point of measurement.

The essential features of such an instrument are shown in the figure. The salt water is siphoned through a hypodermic tube into a mixing chamber where conductivity fluctuations are damped out to enable a mean conductivity to be determined with the probe fitted in the top of the instrument. Mixing is achieved by dividing the chamber into two sections with baffle plates through which pass several fine bore tubes of different lengths. The 'mechanical' mixing of alternate blocks of liquid of high and low conductivity passing through the chamber is readily visualized.

The conductivity probe is a 'point and ring' electrode type after Lamb *et al.*, although two larger ring electrodes may



Mixing chamber and conductivity probe details: cross section.

yield additional damping and increased sensitivity for solutions of very low conductivity. The probe is connected in series with a 10 kc/s oscillator and a load resistance. The output from the latter is amplified, rectified and thence detected with a cathode-ray oscilloscope. The instruments used are commercially available and their cost is approximately 20% of those used by Lamb *et al.* and 10% of those used by Gibson and Schwarz.

3. Use of the instrument

The instrument is at present being used to obtain density profiles in salt water plumes of the order of 1 in. thick. The instrument is shifted from point to point in the flow and about two minutes are required to refill the chamber with liquid from a new station. The siphoning rate is adjusted to reduce entrainment at the nozzle to a tolerable amount by observing the 'pick-up' from a very thin slug flow of dyed salt water down a sloping plane. Calibration is carried out at the end of the experiment by progressive dilution of a salt water sample obtained from the source tank. This procedure could be eliminated by fitting a temperature compensating device, such as a thermistor, in the probe circuit so allowing the conductivity meter to read absolute conductivities and not relative ones as it does at present.

4. Conclusion

The instrument described above provides a relatively quick and inexpensive method of determining mean density in free turbulent salt-water flows compared with the other methods commonly used. It is easily made, not prone to mechanical damage, and the associated electronic instruments are commonly available in hydraulic laboratories.

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