In Situ Temperature and Salinity Meter

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Development of a portable self contained electronic meter for on the spot determination of temperature and salinity is described. Instant and remote measurements of temperature and salinity of sea and estuarine waters in the range of 25–30°C and 30–35°C for temperature with an accuracy ±0.05°C and 0–37‰ and 31–37‰ for salinity with an accuracy of ±0.2‰ and ±0.05‰ respectively are possible with the instrument. The temperature compensations of the salinity measurements are done manually with the help of temperature charts. The temperature and salinity measurements can be fed to continuous recorders.

Salinometers of various types are available in foreign market. Salinity is estimated either by chemical analysis or by electronic methods. There are electronic instruments for determining the salinity of the given sample in the laboratory or directly under water by sending the sensing probe to the required depth. Electronic methods are very simple and quick as it eliminates the time required for collection and estimation by chemical methods. All the existing electronic methods of salinity measurements are based on the conductivity of the water. Conductivity is proportional to the salinity under constant termperature conditions.

Other constituents of the sea water cause further conduction introducing errors in the measurements which are negligible for ordinary requirements. Conductivity of sea water is dependent on the ambient temperature also, while salinity is not. Hence, salinity is estimated from conductivity, either from the conductivity vs salinity charts prepared for different temperatures of the samples, or by compensating such variations automatically by means of temperature sensing devices attached to the conductivity probes.

Basically conductivity probes belong to two types, namely (1) electrode type and (2) induction type. In the former, current is passed through the water for measuring the conductivity, while in the latter magnetic flux is passed. Both types require AC sources to energize the probes. The signals from the probes are amplified and displayed either in a microammeter directly or in a calibrated dial. The former method of display has got the advantage of feeding the signals to continuous recorders for permanent recordings and detailed observation. Automatic compensation is achieved by means of a thermistor properly shunted and used in the opposite arm of the bridge to oppose the extra conductivity of the probe due to increase in temperature. Since automatic compensation can be done effectively, as both conductivity cell and the thermistor, changes their electrical resistances inversely with the temperature. However, the amounts of compensation required are not uniform throughout the range and there are inadequacies in this method. The maximum efficiency in compensation is obtained by subdividing the ranges into several parts and adjusting the rate of compensation accordingly. Even though there are various methods for remote sensing of temperature, thermistors are widely used because of their simplicity and high sensitivity.

The possibilities of using conductivity of sea water for estimating the salinity has been worked first by Thomas *et al.* (1934) and the problems associated with dissolved gases are discussed by Parks *et al.* (1964). Conductivity type salinometers have been reported by Wenner *et al.* (1930) & Bradshaw & Schleicher (1956). Induction type salinometers are reported by Brown and Hamon (1961), Gupta and Hills (1956) and Brown (1966).

In this paper the author describes an electronic instrument for remote measurement of temperature and salinity using platinum electrode sensing probe and a simple and noval electronic circuit.

This has the following advantages, (1) the probe is connected through a 3-core ordinary cable instead of conventional 4-core cable (2) the cable length can be altered to reasonable lengths (say 500 m) without any adjustments or recalibration (3) the reliability and accuracy can be checked easily as it requires much smaller quantity of sample.

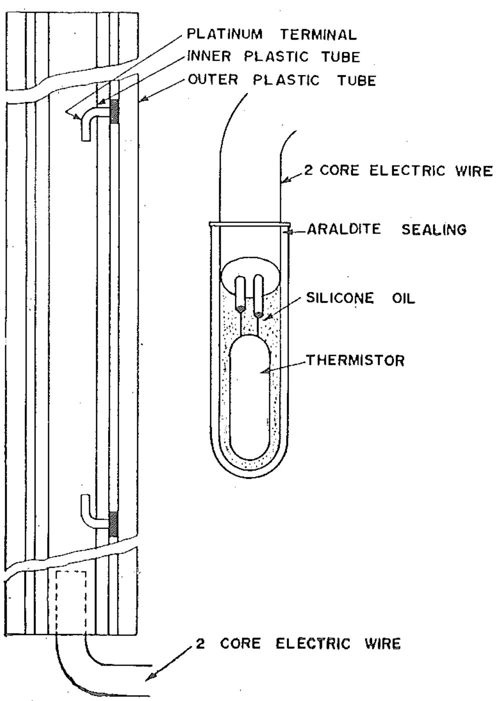

Fig. 1. *Cross section of conductivity cell and the thermistor*

The Instrument

The sensing probe of the *in situ* temperature and salinity meter (Fig. 1) consists of a thermistor and a platinum conductivity cell both designed for the purpose. The thermistor is enclosed in a strong stainless steel chamber to withstand even high hydrostatic pressure. The chamber is filled with silicone oil leaving about 10% air space. The silicone oil conducts the temperature to the thermistor while the air gap controls the possible increase in pressure caused by the volume expansion of the silicone oil due to temperature changes. The conductivity cell consists of a long plastic tube of 30 cm with platinum electrodes kept in the middle, 10 cm apart. This tube is encased in another tube and the gap filled with Araldite. Both the sensors are connected to a 3-core PVC insulated and sheathed strong cable keeping one wire common.

The electronic indicating meter (Fig. 2) consists of an oscillator for producing sinusoidal oscillations at 1 kHz. The output of the oscillator is buffer amplified and fed to a bridge net work with the sensor as one of its arms. The AC output signals from the bridge are amplified separately and equally. The amplified signals across the collector resistors are smoothed and made steady by means of the condensers connected parallel to them. The voltage at the collector of Q4 represents the signal to be measured along with unwanted deviation of the oscillator output, while that at the collector of

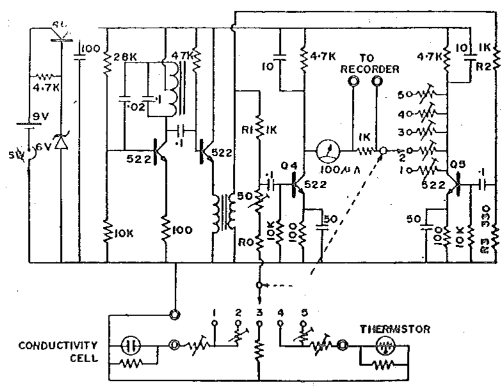

Fig. 2. *The electronic circuit of the instrument*

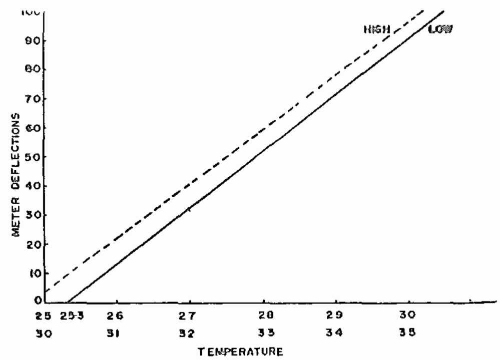

Fig. 3. *The calibration curves of temperature low and high*

Q5 represents the signal caused by the unwanted deviation only. Thus the circuit acts as a differential amplifier eliminating unwanted drifts and provides smooth DC output, free from the usual problems of DC amplifiers.

Two ranges for temperature (25 to 30°C & 30 to 35°C) and salinity (0-37‰ & 31-37‰) are provided in the instrument. In all these ranges the resistances in series to the respective sensors are adjusted so that they came to a fixed uniform value at the beginning of each measurement when their respective meter readings coincide. A variable resistance is provided in series with each sensor for precise adjustment of the meter deflections to the respective parameters. A reference check is provided by a fixed value resistor by checking the zero adjustment prior to measurement.

Results and Discussion

The instrument was subjected to environmental tests in the laboratory and in the field and consistency in readings without any drift was noticed. The noval but simple electronic circuit had nullified the possible deviations or drifts due to small variation of oscillator output or the supply voltage, as they are automatically compensated. However, it showed some deviation when the ambient temperature changd to extremes and the battery voltage varied from 9V to 6V. This variation was fully eliminated by the 'calibration adjustment' made before taking measurements. As high accuracy of measurements is expected, it is found convenient and more dependable to get the final measurements of salinity corrected for temperature variations of the sea water, from the calibration charts prepared for different temperatures in the range 25 to 35°C.

There is already enough resistance 'Ro' connected in series to the sensors and it is seen that cable lengths can be altered conveniently up to a limit equivalent to the resistance Ro, without recalibration of the instrument. Cable lengths up to a few hundreds of metres can be added or dropped without any adjustments as this can be accommodated in the 'CAL ADJ' control and the resistance Ro.

The non-linear response of both temperature and salinity is reduced to the minimum by shunting them with low value resistors. In the case of thermistor the output signals came linearly proportional to temperature because of their very short ranges as in figure 3. The higher salinity range (31-37‰) has almost reached linearity (Fig. 4)

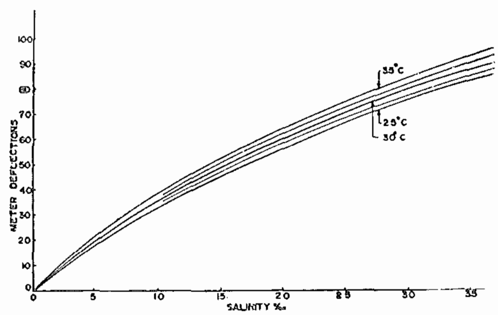

Fig. 4. *The calibration curves of salinity 'low' for different temperatures*

while the wide salinity range remained very much non-linear because of its wide range from 0 to 37‰. The instrument was operated from self contained 9V dry cell source stabilized at 6V with a current consumption of 27 mA.

The temperature range can be altered or extended with recalibration as the thermistor can operate safely in the range of -20°C to + 150°C. Unlike the field operated inductive salinometers, the accuracy of the readings

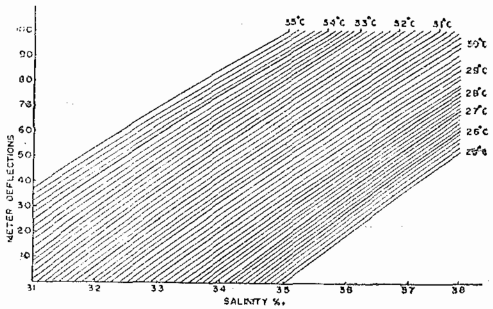

Fig. 5. *The calibration curve of salinity 'high' for different temperatures*

can be checked or the calibration can be done easily by using sea water samples of different salinity values at different temperatures as it requires only much less quantities of the samples (Fig. 5).

The author is grateful to Shri G. K. Kuriyan, Director, Central Institute of Fisheries Technology, for his encouragement in developing the instrument and permission to publish the paper.

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