

NATIONAL INSTITUTE OF OCEANOGRAPHY

WORMLEY, GODALMING, SURREY

**The Portable
Salinity/Temperature Bridge**

**(Based on the design of B. V. Hamon and built by the
National Institute of Oceanography)**

by

R. A. COX and J. MOOREY

N.I.O. INTERNAL REPORT NO. C4

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General

This instrument is designed for rapid convenient measurements of temperature or salinity, particularly for in situ applications. However it can also be used as a laboratory instrument when the highest precision is not necessary.

The bridge measures temperature by means of a thermistor. It is fitted with a moulded plastic conductivity cell incorporating platinum electrodes. This cell measures the electrolytic conductivity of the sea water. When the bridge is used for measuring salinity the thermistor is used to provide temperature compensation, so that within certain limits the bridge can be calibrated to read directly in salinity, the thermistor automatically compensating for the temperature variations.

The ranges covered are

| | |
|-------------|-------------------------|
| Temperature | -2 to 30°C |
| Salinity | 0 to 32.5‰ 32 to 38‰ |

The oscillator and amplifier circuits employ transistors, and the bridge is powered by a 9 V battery. The life of the battery should be about 200 hours operation. The battery used is Ever Ready type PP7, but suitable alternatives should be available in any country.

The in situ measuring head is mounted on 100 m of rubber-covered cable, so that working from a ship it is possible to make direct observations to about this depth.

Certain components in the bridge network have values which depend on the dimensions of the conductivity cell and the characteristics of the thermistor.

Instructions for setting-up the bridge

The following are necessary for setting up the bridge -

- 1) A sample of sea water of known salinity in the range likely to be encountered with the water to be measured. It is preferable to have one or two further samples of known salinity as checks on the working of the bridge. These can be prepared by diluting the first sample by weight.
- 2) A glass container of suitable dimensions to hold the water samples, into which the measuring head will conveniently fit. Suitable containers would be a heavy beaker (dye beaker) or a measuring cylinder.
- 3) 2 n hydrochloric acid solution. This should be analytical grade and free from heavy metals and arsenic.
- 4) Chromic acid cleaning solution. Add 100 ml of pure sulphuric acid to 100 ml of water, with the usual precautions, and dissolve in the hot acid 10 g of chromium trioxide or 12.5 g of sodium dichromate. Allow to cool to below 30°C before use, as hot acid may attack the plastic moulding.

Sequence of operations

- 1) Select the measuring head which it is desired to use and plug the 3-way plug on the cable into the socket below the on-off switch on the instrument panel.
- 2) Open the battery box at the end of the instrument case, and check that the correct board for the head to be used is plugged into the eight-way plug. See that the battery is also connected to its plug.
- 3) The conductivity cell must now be washed with hydrochloric acid. This can be done either by immersing the measuring head in acid, or alternatively a rubber bung can be fitted into the end of the measuring head and the acid poured into the internal tube in which the electrodes are mounted. Leave the acid in contact with the electrodes for two or three minutes. The acid can be returned to the bottle and used again, if necessary. Then rinse the electrodes with clean water (distilled water or clean sea water) and without allowing the electrodes to become dry immerse the head in any convenient sample of sea water. From this point until the conclusion of the series of measurements the electrodes must not be allowed to dry. The measuring head should be left immersed in each sample until the next sample is ready. When making in situ measurements from a ship keep the head in a bucket of sea water between stations.

If by accident the electrodes are allowed to dry they must be rinsed with acid again before further measurements are taken.

- 4) With the electrodes now clean and the head in a sample of sea water turn on the bridge by pulling out the switch. Turn the 3-way switch to the salinity range covering the sample in use (either 0-32‰ or 32-38‰) and rotate left-hand dial until meter reads zero (centre). Stir the sample, either with an independent stirrer or by raising and lowering the head, adjusting the salinity dial until the meter gives a steady reading. If the head has not been used for a long time it may take several minutes before a steady reading is obtained. If a steady reading cannot be obtained after a few minutes the cell will probably need cleaning or perhaps re-platinising. These procedures are described later.
- 5) Now transfer the head to a sample of water of known salinity. Set the selector switch to the correct range, and the salinity dial to read the salinity of the sample. The white figures on the scale are for 0-32‰ range and the yellow for 32-38‰. The meter should now read zero (centre). If the meter does not read zero adjust the dial until it does, stirring the sample as in the previous section. If the reading on the dial is now significantly in error (more than 0.02‰ from the true reading) the instrument must be adjusted. Open the battery box to gain access to the resistor board. Set the dial to the true reading and adjust the resistor on the board marked "salinity" until the meter reads zero.

Now take the temperature of the sample with an accurate thermometer. Turn the selector switch to "°C" and adjust the temperature dial until the meter reads zero. If the dial reading (red figures) does not correspond with the thermometer reading, set the dial to the correct value and adjust the resistor marked "T" until the meter reads zero.

Replace the battery box and fasten. The bridge is now ready for use. If further samples of known salinity are available the bridge can be further tested by transferring the head to these samples, and checking that the correct readings are obtained.

Measurement of unknown samples

For bench measurements, if the samples are contained in bottles with wide necks it is possible to insert the measuring head directly into the sample. Stir the sample vigorously by moving the head up and down or by shaking the bottle. Switch to the appropriate salinity range, adjust the dial until the meter is steady at zero, and read the salinity from the dial. Switch to temperature and adjust the temperature dial in the same way. If the water bottles are not large enough to take the head, the water must be poured into a suitable beaker or other container.

It is essential that the temperature of the water inside the conductivity cell is the same as that surrounding the thermistor. When making measurements in a small bottle or other container this is difficult to ensure unless the temperature of the water sample is very nearly the same as the atmospheric temperature. If it is necessary to measure samples very much colder than room temperature it is advisable to use a silvered vacuum flask as a container to reduce temperature gradients.

For in situ measurements from a ship

there will usually be enough motion to keep the head moving slightly relative to the water, and so keep the conductivity tube flushed with clean water. In very calm conditions, or when working from bridges etc., it may be necessary to move the cable up and down a few centimetres to keep the cell flushed.

cable can be run over a measuring sheave, or the head tied to a heavy sinker on a hydrological wire. When working from a ship at anchor in a considerable current a heavy sinker should first be lowered to the bottom on a taut wire, and the head tied to a smaller weight sliding down the wire.

When making a long series of measurements it is desirable to check the bridge occasionally against a known sample of water. For field use it is convenient to carry a large thick-walled polythene bottle of such water, with a wide neck so that the head can be lowered into it. The volume of such a sample (perhaps 2 litres) is enough to make insignificant the errors caused by the dilution from the water wetting the head. The frequency with which the bridge should be checked depends largely on the cleanness of the water, and the operator will learn by experience.

After a series of measurements is finished, in the laboratory it may be convenient to leave the head immersed in the last sample to be measured until next required. If this is not possible, wash the head with fresh (preferably distilled) water before allowing it to dry. After drying out the head will probably need cleaning with hydrochloric acid before it will give consistent readings, as described above.

Cleaning and re-platinising

At intervals, particularly when used in water contaminated with sewage or where there are dense plankton populations, the electrodes will become fouled with grease which is not easily removed with dilute acid. This state of affairs is shown by relatively large differences between dial readings and the true value of the standards, and a tendency for the meter to drift. Immerse the head in the chromic acid solution (see above) taking care that the acid does not come into prolonged contact with the flexible cable. Leave in the acid for an hour or two, wash thoroughly with water and check the calibration.

If after this cleaning process the meter still drifts, the cell may need re-platinising. First clean off the old platinum black with aqua regia (four parts concentrated hydrochloric acid to one part concentrated nitric acid). Do not leave this in the cell longer than necessary, as it attacks the plastic. Wash and without allowing the cell to dry immerse in platinising solution (3 g platinum chloride, 0.03 g lead acetate, 100 ml water). Apply a potential of about 6 V

across the electrodes for ten minutes, reversing every minute. Wash, fill with dilute hydrochloric acid and again apply 6 V, reversing every minute for ten minutes to remove any occluded solution. It is imperative that the 6 V is applied across the cell pins A and B of the socket and NOT the thermistor or the thermistor will be ruined. Wash and re-calibrate.

Accuracy

(1) Systematic errors

It is possible to achieve reasonably good temperature compensation at a given salinity, and an accurate salinity scale at a given temperature. However, the temperature coefficient of conductivity varies with salinity, and the proportional change in conductivity with salinity varies with temperature. Thus, if both temperature and salinity are near the limits of the working ranges, appreciable systematic errors can be introduced. A correction curve is supplied with each instrument.

(2) Non-systematic errors

There is a wide variety of possible causes of non-systematic errors. The two most likely to cause trouble are -

- (a) Dirty or poisoned electrodes. This has been discussed above.
- (b) Lack of temperature equilibrium. The temperature compensation is critical: a difference of 0.01°C between the thermistor and the water in the cell produces an error of about 0.01% in the salinity reading for water with a salinity of 35% .

Other errors are due to such causes as the finite steps in the measuring potentiometers, due to the individual turns of wire, non-linearities in the potentiometers, setting and reading errors in the dials, and so on.

With care in the use of the instrument, these non-systematic errors can be kept within the following limits.

| | |
|-------------|--------------------------------------|
| Temperature | $\pm 0.1^{\circ}\text{C}$ |
| Salinity | 0 to 32% range, $\pm 0.1\%$ |
| | 32% to 38% range, $\pm 0.03\%$ |

Pressure correction

The effect of pressure on the readings is not a large one, and with an instrument of this nature is probably not significant. The pressure coefficient was determined by Hamon (J. Marine Research, 16, 2, 1958, 83-89) for sea water of chlorinity 19. If a similar proportional coefficient exists for lower chlorinities the error will be about $+0.02\%$ per 100 m depth at salinity 35% and temperature 15°C , so that unless the water is unusually uniform in both temperature and chlorinity with depth this effect is unlikely to be considerable.



Photo. 1 - Front panel of instrument showing measuring head

