CALIBRATION
4. CALIBRATION

The instrument has been calibrated taking every factor independently. The facilities needed for calibrating all parameters except current, can be produced in the laboratory.

4.1 CALIBRATION OF CURRENT

The following are the factors to be found out during calibration of water current.

1. Threshold current value.

2. Plotting a curve between the actual speed of water current and the r.p.s. of the rotor.

3. If the curve is found to be sufficiently linear, find out the constant time during which the water speed in cms/sec coincides with the number of rotations of the rotor.

1. Threshold value of current.

The factors that decide the threshold value are inertia of the rotor and friction. Low inertia gives low threshold value. The rotor has been designed for extremely low inertia by making it small in size, least in weight and extremely low friction on the supports. Extremely low friction is achieved using pin and socket assembly at the rotating points.
Fig 52  
SPEED vs RPS. OF ROTOR 
(CALIBRATION CURVE OF WATER) 
(PREPARED AT CWPRS, PUNE)
The threshold value was found to be 3 cms/sec.
The calibration chart was prepared by subjecting the underwater probe to water flow using a towing tank and a trolley over it. The instrument was calibrated in the towing tank of Central Water & Power Research Station, Pune.

The tank has got 228 m length, 2.13 m depth and 3.66 width with a maximum towing speed of 4.5 m/sec. The trolley which moves over the tank has got precise machineries for smooth movements and its measurements.

The probe was suspended from the trolley at a water depth of 1 metre. The trolley was given different speeds between 2 cms/sec and 350 cms/sec. The rotor rotations were noted for 10 seconds in each case. The graph drawn between r.p.s. of rotor and speed of trolley (relative speed of sensor in water) is given Fig.32. The exact time needed for the counts in e.m. counter to coincide with the speed of trolley in cms/sec is found out to be 30 seconds, for large rotor. That means, if the current meter is operated for 30 seconds, the number of rotations of rotor will coincide with the speed in cms/sec.

4.2 CALIBRATION OF CURRENT DIRECTION

A precision magnetic compass was used to make a thick line on the floor referring to the north-south direction. The underwater probe was kept over the line so that its vertical fin is parallel to the line. Now the tail portion
Fig 33: Variation of current direction with direction of vertical fin.
is directed Northwards. The direction sensor at this condition should correspond to maximum electrical resistance i.e. 2000 ohm. The outer cover of the unit was removed and the remaining portions kept in the original condition. The direction sensor was mounted such that when energised, it gave out a signal corresponding to the maximum, i.e. 2000 ohm. The sensor was fixed in this condition. Now this should correspond to 360° in the LCD meter. The 22 turn 10 k. preset (Fig. 26) and the resistance R were adjusted so that the LCD readings indicated 360° when directed to North and 000° when turned slightly to the clockwise direction to correspond to 0 ohm of the sensor. Now the extreme ends are decided. The points in between should indicate proportionally if the electronic circuit used is working normally. This has been confirmed as shown in Fig. 33.

Extreme care was taken during the whole course to see that no magnetic materials are present in the vicinity of the sensor.

4.3 CALIBRATION OF TEMPERATURE

Temperature baths were prepared from 10°C to 40°C. The temperature sensor was immersed in the bath for sufficiently long time and the meter readings noted. The 100 ohm and 100 k. ohm 22 turn presets connected to the thermistor sensor and at the output of opamp respectively were adjusted such that the LCD meter was fed with 100 mV to
OUTPUT OF OPAMP IN VOLTS

mV OUTPUT FOR FEEDING TO LCD METER AFTER CONVERSION THROUGH POTENTIAL DIVIDER NETWORK.

RESPONSE CURVE TEMPERATURE VS OUTPUT OF OPAMP

TEMPERATURE °C

FIG. 34 TEMPERATURE CALIBRATION
400 mV corresponding to 10°C to 40°C. The third digit represented the first decimal point. Fig. 34 shows the calibration of temperature.

4.4 CALIBRATION OF SALINITY

Sea water samples were prepared covering the entire range with values 8.50, 16.4, 27.2, 28.5 and 35. These samples were maintained at temperatures of 20°C, 25°C, 30°C and 35°C using hot water baths. The 100 ohm and 100 k. ohm preset pots in series to the salinity cell and the output of opamp (Fig. 29) were adjusted so that the readings in the LCD came to 000 and 35.0 when the salinity cell was immersed to the corresponding solutions of 000 and 35.0 both at 30°C. '000' salinity solutions means either distilled water or air. The feedback resistance \( R_4 \) of the circuit was adjusted such that the meter indicated linear response with the sample values at 30°C, as shown in Fig. 35. The meter readings for the solutions for all other values were noted and the graph prepared. The reliability of the sea samples were compared with the Copenhagen sample. The dotted lines in Fig. 35 are the actual lines passing through the points. The continuous lines are the straight lines passing through maximum points. The mathematical relation represents the continuous lines. This causes an error of maximum of \( \pm 0.2 \) salinity at certain points. This error can be eliminated if the salinity values are directly taken from the graph.
m.V. OUTPUT FOR FEEDING TO L.C.D METER AFTER CONVERSION THROUGH POTENTIAL DIVISION NETWORK.

OUTPUT VOLTAGE OF OPAMP.

-35°C
-30°C
-25°C
-20°C

ERROR CAUSED BY THE WANT OF EXACT LINEARITY

BALANCING VOLTAGE TO SHIFT THE ZERO LINE.

FIG. 35 RESPONSE CURVE OF SALINITY VS OUTPUT VOLT OF OPAMP FOR DIFFERENT TEMPERATURES AFTER LINEARISATION
FIG. 3.6
RESPONSE CURVE OF SALINITY vs OUTPUT VOLTAGE OF OPAMP FOR DIFFERENT TEMPERATURES (without linearisation)
Now the meter directly gives the salinity when the temperature of the sample is 30°C, while all other data gave straight lines making symmetrical lines on either sides of the 30°C line. This symmetrical nature of the curves has resulted in the formation of a linear relation between the meter readings and the actual salinity, given by

\[ S = R \tan (45 \pm KD) \]

where \( S \) = salinity in PPT
\( R \) = meter reading
\( D \) = difference in temperature of the water sample from 30°C.

\( K \) = a constant

Positive (+) is used when temperature is below 30°C and negative (-) when it is above 30°C. It is found that the value of \( K \) varies between 0.55 to 0.65. But this can be made to be fixed if the cells are made alike during commercial manufacture of the equipment. This relation can be used up to an accuracy of ±0.2 salinity. Better accuracy of ±0.05 can be achieved directly from the graph in Fig.36. Where the curves are not linearised. The accuracy in the linearised graph (Fig.35) reduced, because the process of linearisation is not obtained to the required extend.

4.5 CALIBRATION OF DEPTH

A pressure chamber was used for the primary setting and calibration. The pressure developed in the chamber was
mV OUTPUT FOR FEEDING TO LCD METER AFTER CONVERSION THROUGH POTENTIAL DIVISION NETWORK.

OUTPUT VOLTAGE OF OPAMP.

FIG. 37 DEPTH CALIBRATION
applied to the inlet tube of the sensor. The required pressure was estimated as below:

\[ P = \rho gh \]

where \( p \) = pressure in kg/cm\(^2\)
\( h \) = height of water say 100 m
\( \rho \) = density of water, say 1
\( g \) = acceleration due to gravity, 980 cm/sec\(^2\).

Here pressure needed for 100 m water column is 9.8 kg/cm\(^2\).

The 100 ohm and 100 K ohm 22 turn presets in series to the depth sensor (Fig.29) and at the output of opamp respectively were adjusted such that the LCD readings are 000 and 98.0 when the pressure applied are 0 and 10 kg/cm\(^2\). The sensor was later subjected to precise setting in deep water tank. The probe was immersed to different depths up to 100 m and the LCD readings precisely set. The meter readings were found to be quite linear as given in the graph in Fig.37.

In all the cases above, except in current\& current direction, the 'zero set' of the instrument was adjusted '000' invariably before taking measurements.
Fig 38 DETAILS OF BELLOWS