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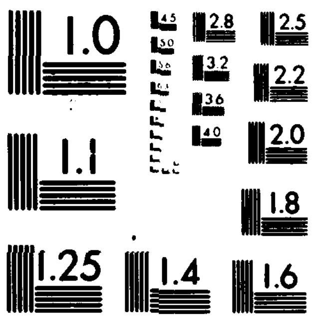

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

EXPOSURE

vol. 8 no. 2 a newsletter for ocean technologists

Aanderaa RCM Compass Errors

The Aanderaa Recording Current Meter (RCM) has been in extensive use at the Bedford Institute of Oceanography (BIO) for six years. From the beginning it was noted that large variations existed between successive compass calibrations of the same instrument. A program was initiated in 1975 to determine the causes of the compass errors and a number of them have been identified and measured.

The nickel plating on the older style pressure cases can become magnetized and cause compass errors as high as 12 degrees peak-to-peak at the ambient geomagnetic field intensity at Dartmouth, N.S. (H = 17900 gamma). As reported by Hendry and Hartling (*Exposure* III(5)), under the influence of the compass's own magnetic field and high pressure, the plating can become sufficiently magnetized to lock the compass in a fixed orientation. It is recommended that at depths of less than 1500 meters the pressure cases should be carefully degaussed just prior to mooring. If the RCM is to be moored at greater depths or in the far north where the horizontal field intensity is weak, the new epoxy-coated pressure cases having nickel only in the upper O-ring region should be used.

May 1980

The field about the energized encoder magnet will influence the compass, and the operation of this magnet during the encoding of the pressure channel can cause a compass error as high as 15 degrees peak-to-peak at the ambient field intensity at Dartmouth. In regions where the horizontal component of the geomagnetic field is 300 gamma, the error can be twice that value. The practice at BIO has been to disable the pressure channel whenever possible and wire it so that it reads 1023 (no operation of the magnet during encoding). This modification allows the compass several seconds to settle after the encoding of the conductivity channel before it is clamped, and, at the ambient field at Dartmouth, it reduces the compass error to within the manufacturer's specifications (±2°). However, if the horizontal field intensity is less than 5000 gamma, the effect of the encoder magnet on the compass during the encoding of the conductivity channel increases and renders this modification ineffective. It is suggested that instruments to be moored in the far north should have their compasses wired so as to clamp throughout the recording cycle. In fact, this is now the practice with all RCMs deployed by BIO. The modification is simple, but it places a heavier load on the instrument's battery. It has been found that the Leclanché #821 battery will power an Aanderaa RCM thus modified for about 160 percent of its tape capacity. This battery, which is now the standard power source for RCMs at BIO, is available from:

Leclanché S.A.,
48 Avenue de Grandson,
CH-1401 Yverdon,
Switzerland, 10-688

The field associated with the rotor and follower magnets will produce a compass error that is dependent on rotor speed as well as the horizontal field intensity. As can be seen in Figure 1, the combination of low rotor speed and a weak horizontal geomagnetic field can produce large errors. This error can be removed from the compass calibration by arranging to have the rotor spin at a rate of at least 50 RPM during the compass swing. In some cases, this error may be removed from field data by averaging several direction readings, but it should be noted that the combination of low currents, changing directions, and long cycle times may make it impossible to correct for this error.

The magnetic recording tape, if improperly degaussed, can cause compass errors of up to 4 degrees peak-to-peak in the ambient geomagnetic field at Dartmouth; in areas where the horizontal field intensity is weak (H = 3000 gamma) the field about the tape may be of sufficient intensity to lock the compass in a fixed orientation. The error varies from zero when all the tape is on the supply reel to maximum when all the tape is on the take-up reel, as shown in Figure 2. Much experimentation has shown that bulk tape erasers leave residual fields on reels of magnetic tape treated on them. The present practice at BIO is to degauss recording tapes on a modified reel-to-reel tape recorder. This machine has two stereo erase heads mounted in such a manner that their gaps overlap and cover the entire width of the tape. When driven by a suitable erase oscillator, this system leaves only a very small residual field about the tape.

After all the known sources of magnetic interference have been removed from the RCM, the compass calibrations continue to exhibit an error referred to at BIO as the "basic error." The main cause of

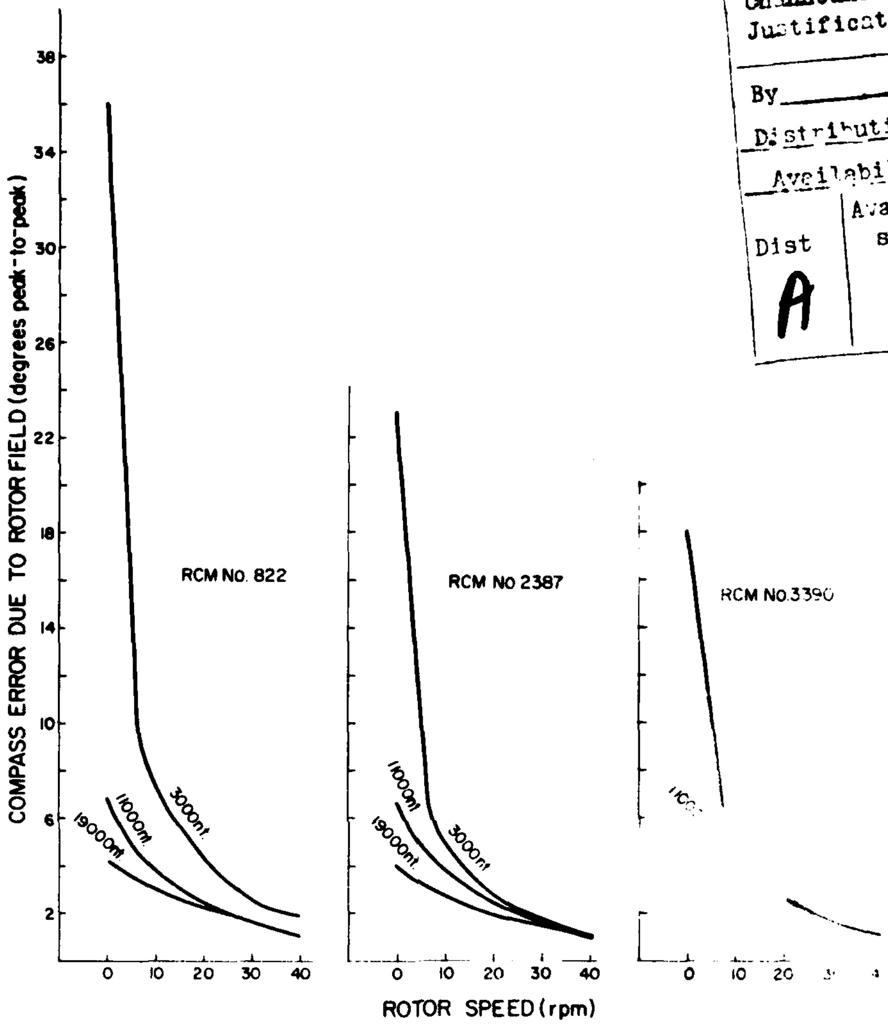

Figure 1. Compass Error Due to the Rotor Field. (1 nt - 1 [illegible])

this error is the field about the encoder drive motor, but compass non-linearity and any residual field about the nonenergized encoder magnet may also contribute to it. In any case, the basic error has proved to be stable with time and can be compensated for during data processing if the geomagnetic field intensity at both the calibration site and the mooring site are similar. However, if the instrument is moored in an area where the horizontal magnetic field is weaker than that which exists at the calibration site, then an error will result when the data is processed. This is because the effect of the motor's field on the compass reading will be greater at the mooring site than it was at the calibration site. Processing this data will result in compass errors as large as 30 degrees peak-to-peak. It is possible to

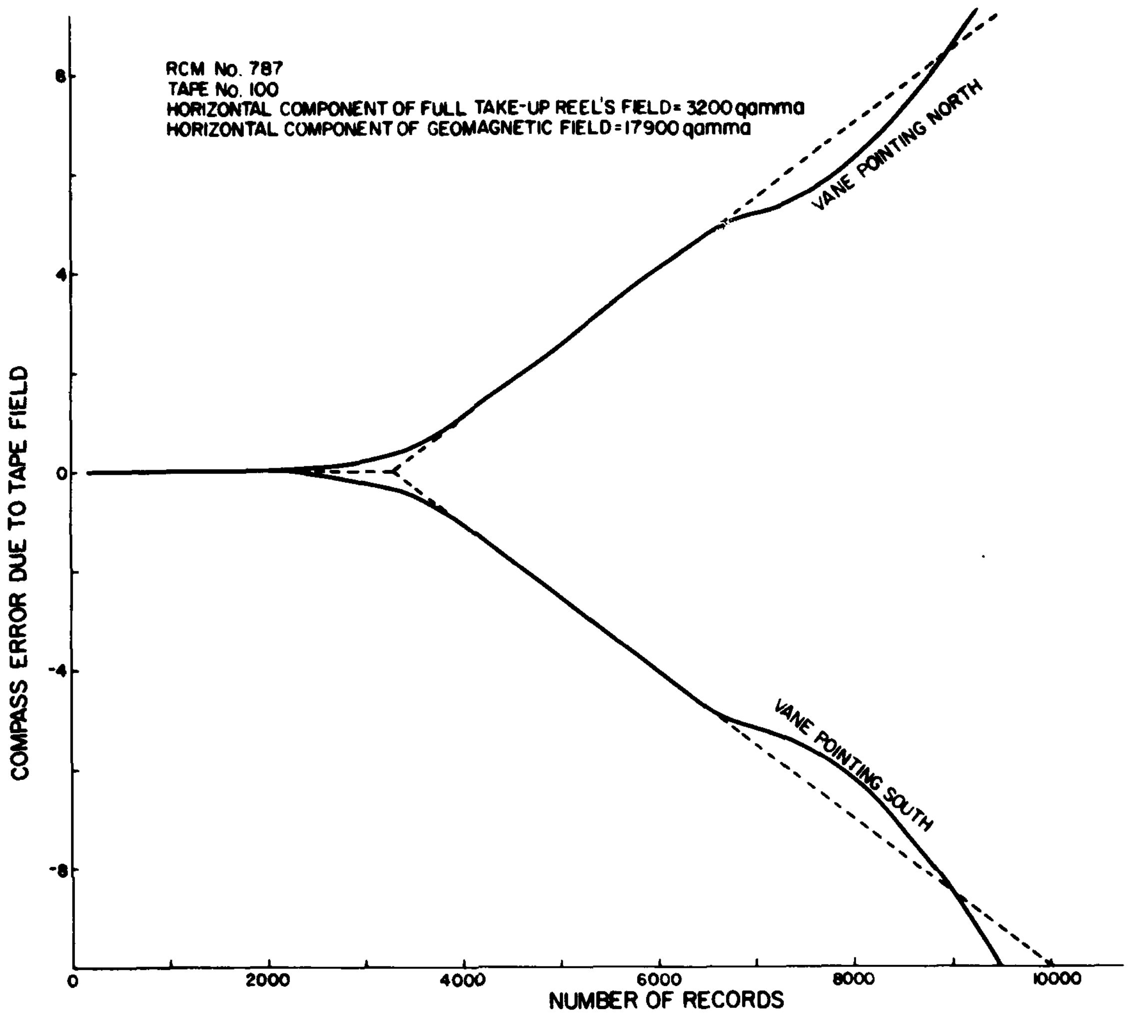

Figure 2. Compass Error Due to an Improperly Degaussed Recording Tape.

reduce this error by using the following equation:

$$\phi = \tan^{-1} \left(\frac{\operatorname{Tan} \theta \, M_1}{M_2}\right)$$

ϕ = compass error at the mooring site

θ = compass error at the calibration site

M_1 = horizontal component of the geomagnetic field at the calibration site.

M_2 = horizontal component of the geomagnetic field at the mooring site.

Along with the sources of magnetic interference already described, there exists two other sources of compass error within the RCM.

The vertical tilt specification for the Aanderaa compass, as quoted by the manufacturer, is 12 degrees. Most of the compasses tested at BIO exhibited large errors (20 degrees peak-to-peak) when tilted between 2 and 12 degrees from the vertical. As can be seen, a slightly unbalanced current meter could result in large compass errors. Also, the vertical component of the field about an improperly degaussed reel of magnetic tape on the take-up spindle of the RCM could tilt the compass and result in greater errors than would be due to the tape's field alone. It has been noted that the compasses in RCMs having serial numbers above 3500 appear to be less sensitive to tilt than those in earlier RCMs.

The formula supplied by Aanderaa Instruments for converting the binary number to degrees assumes a 3-degree-wide dead band. The dead bands of the compasses of 70 RCMs owned by BIO, as interpolated from compass calibrations conducted on them over a period of 2 years, varied from 4 to 11 degrees wide with a mean width of 6 degrees. If the manufacturer's formula is used to process direction data, an error will result which increases from 0 degrees when the RCM's vane points south to as high as 8 degrees peak-to-peak near the dead band region (north). The formula used at BIO is:

$$\text{DIRECTION} = \frac{360 - \text{dead band}}{1023} + \frac{\text{dead band}}{2}$$

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A TEXT PREPARATION STYLE SHEET FOR THE EXPOSURE NEWSLETTER IS AVAILABLE FROM THE EDITOR--SUBMITTING AN ARTICLE IS QUITE PAINLESS!

An Underway Towed Sampling System

An underway towed sampling system designed for trace metal studies is being developed by the National Ocean Survey's Engineering Development Laboratory. The system consists of a passive towed body, a faired umbilical assembly containing a Teflon tube and electrical cable, a towing wire, and a control console.

The towed body (Figure 1) houses a Teflon pump and a submersible motor which delivers seawater to the towing vessel at 6 liters per minute. The body also contains a temperature sensor, pressure sensor, multiplexing electronics, and 450 kilograms of lead ballast.

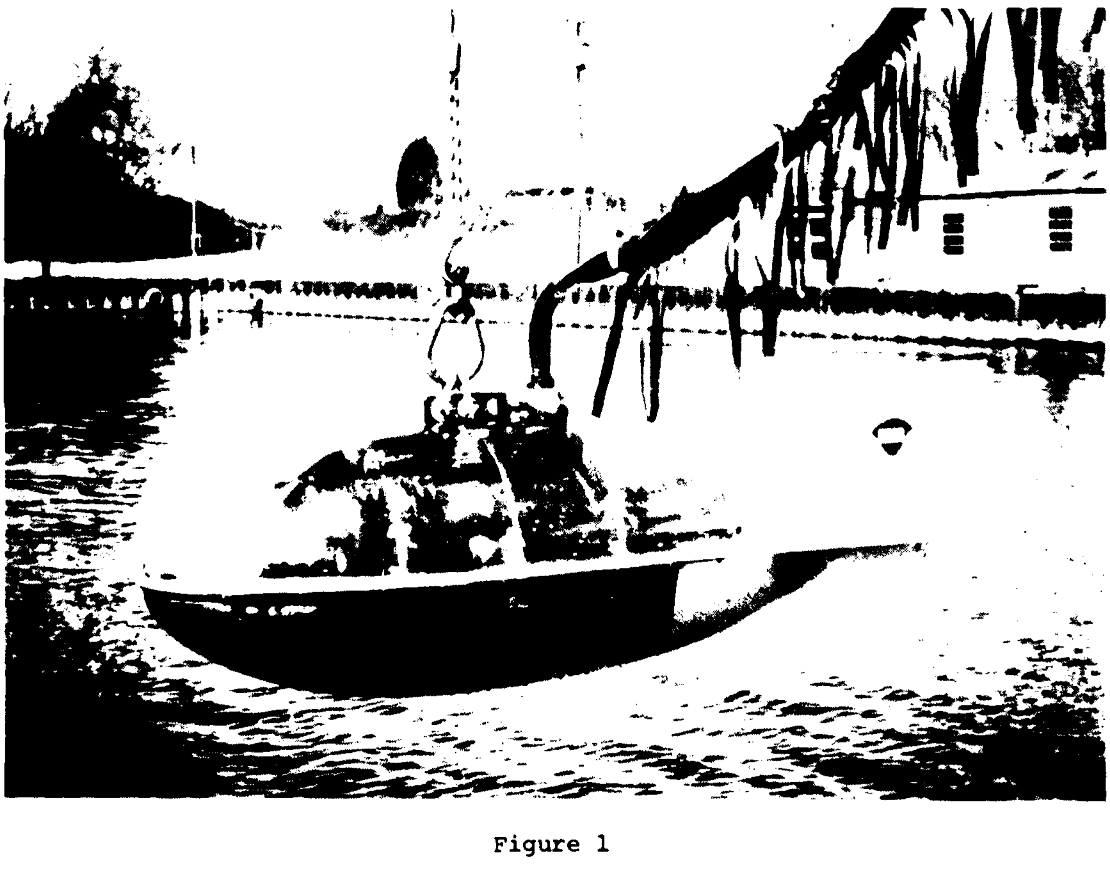

Figure 1

The umbilical assembly contains a Teflon water delivery tube and electrical cables to power the pump motor and two sensors. The assembly is overbraided with a nylon jacket which contains strain relief breakouts at 1-meter intervals. Snap shackles secured to the breakouts are attached to the towing wire rope during deployment of the system. Ribbon-type fairing is currently being used on the umbilical assembly.

The control console and water delivery manifold for the system are normally located inside the ship's chemistry laboratory. The console (Figure 2) has digital readouts for temperature, depth, flow rate, time, and pump motor parameters. Temperature and pressure data are recorded on a strip chart.

The present configuration allows for sampling to depths up to 50 meters and ship speeds up to 4 knots. Future developmental work will be directed towards increasing the system's depth capability to 100 meters and providing a shipboard data management/display system and a data acquisition system compatible with existing chemical analysis equipment. Although the system is designed primarily for trace metal analysis, it appears that with slight modification it may have applications

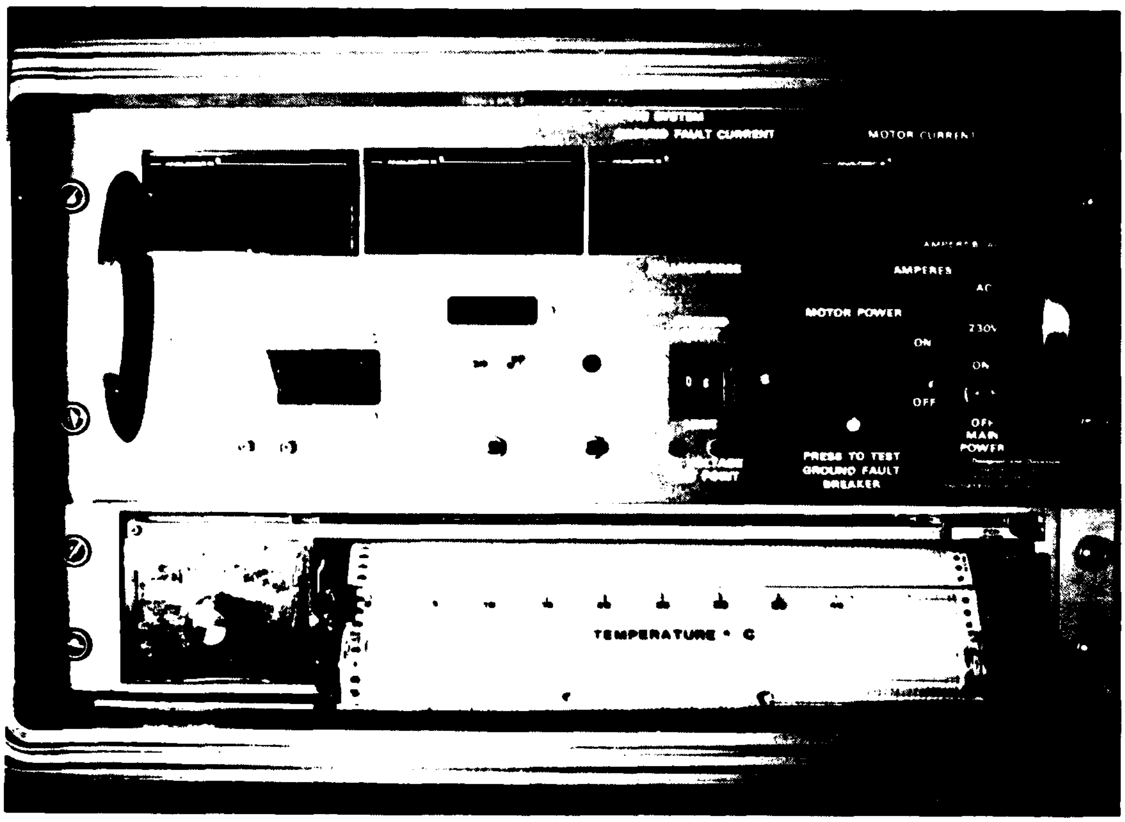

Figure 2

in the areas of organic sampling and living resource surveys. Arrangements are currently being made to make the system available for use by groups outside of NOAA.

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