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THE CALIBRATION OF TWO ACOUSTIC CURRENT METERS DEVELOPED AT THE CHRISTIAN MICHELSEN INSTITUTE, NORWAY

G. Griffiths
W. Miller*
P. Taylor*

NATURAL ENVIRONMENT RESEARCH COUNCIL
INSTITUTE OF OCEANOGRAPHIC SCIENCES

INSTITUTE OF OCEANOGRAPHIC SCIENCES

Wormley, Godalming,
Surrey, GU8 5UB.
(042-879-4141)

(Director: Dr. A. S. Laughton)

Bidston Observatory,
Birkenhead,
Merseyside, L43 7RA.
(051-652-2396)
(Assistant Director: Dr. D. E. Cartwright)

Crossway,
Taunton,
Somerset, TA1 2DW.
(0823-86211)
(Assistant Director: M.J. Tucker)

INSTITUTE OF OCEANOGRAPHIC SCIENCES

Applied Physics Group

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G. Griffiths
W. Miller*
P. Taylor*

Institute of
Oceanographic Sciences,
Wormley, Godalming,
Surrey GU8 5UB.

*RVS Barry.

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1. INTRODUCTION

This document describes the results of the calibration made in the towing tank at IOS Wormley on two acoustic current meters recently purchased by RVS Barry. The design of the instrument follows that of Gytre, 1975 and a pre-production model was tested at IOS Wormley as reported in Collar and Gwilliam, 1977.

The present instrument, designated UCM-2, contains a data logger, lithium battery pack and the sensor electronics package in an extended Aanderaa type pressure case. In the instruments under tests a third (z) axis sensor was also present. When this sensor is in use, the makers recommend that an Aanderaa vane be used to orient the package such that the flow is first incident on the z axis sensor.

As we did not have a suitable digital interface to the output supplied from the deck terminal unit, all the measurements were made on the analogue output of the current sensor electronics unit. Signal leads were brought out through an adaptor screwed into the thermistor mounting socket.

Measurements were made of the linearity, azimuth and static tilt response in laminar flow, and a note was kept of the zero stability.

2. MEASUREMENT SYSTEM

The measurements were made in the towing tank at IOS Wormley, which is 50 × 2 × 2 metres, and is filled with fresh water. A speed range of 5 cm/sec to 105 cm/sec was used, the high speed limit being set by the onset of vibration in the mounting spar. The sensor outputs were filtered at 1 Hz, then digitized at 2 Hz by the onboard CAMAC based data logger/processor. The quantization interval of 5mV corresponded to ~0.5 cm/sec.

Sets of 50 samples were then used to calculate the mean and standard deviation. Carriage speed was logged digitally once a second from the pulse counting unit fed from a spring loaded wheel on the running rail. This wheel is fitted with a light source-detector path interrupted 5000 times a revolution.

RESULTS

3. LINEARITY

The instrument was mounted vertically at the end of a tubular spar clamped to the carriage and towed at constant speeds. Runs were made with the X and

Y axes aligned along the tank. Figure 1 shows the residuals from the unweighted linear regression applied to each data set. The results are very similar to those in Collar and Gwilliam, 1977. In each case the least-squares fit equations are:

UCM-2 Serial No. 1

X axis $V = 9.8215C - 4.48$ V in mV

Y axis $V = 9.8548C + 3.23$ C in cm s^{-1}

UCM-2 Serial No. 2

X axis $V = 9.2947C + 10.40$

Y axis $V = 9.2963C - 5.1$

Note that the sensitivity, especially that of Serial No. 2, is below that quoted by the manufacturer (10mV/cm s^{-1}). However, the X and Y axes of each instrument are closely matched. In use, the above calibration would need to be converted to bits/cm s^{-1}. As the analogue to digital converter has a span of -2.5 to +2.5 volts for an output count of 0 to 4095, then the above figures in mV/cm s^{-1} must be multiplied by 0.8192 to convert to bits/cm s^{-1}. However, the converter would undoubtedly affect the zero offset slightly.

Figure 2 shows the standard deviation of the sample sets as a function of carriage speed. The level is higher than that attributable to carriage speed fluctuations and sampling noise except at the lowest speeds. In magnitude, the aligned and transverse axes are similar, this differs from the results of Collar and Gwilliam (1977) in that they reported significantly higher noise levels on the transverse axis. Our results for the aligned axis agree well with their work.

4. AZIMUTH RESPONSE

Measurements were made at 15° intervals from -90° to $+90^\circ$, at 10 cm s^{-1} and 50 cm s^{-1} (nominal speeds). The results, in the form of percentage deviation from the vector magnitude response at 0° are shown in Figure 3. The scatter in the results at 10 cm s^{-1} is most likely due to the residual currents in the towing tank, which can be up to 1 cm s^{-1} for several minutes before decaying to $\sim$2 mm s^{-1}.

At 50 cm s^{-1} the residual currents are less important, and the response is similar for the two instruments. Minima are found at $\pm 45^\circ$, corresponding to the acoustic path intersecting the largest portion of the wake of the inner, and to a lesser extent, the outer support cage. Collar and Gwilliam (1977) show that this is the most likely cause of the under sensitivity, and our results agree with their findings at 50 cm s^{-1}. The noise level remains substantially constant over ±90°.

5. STATIC TILT RESPONSE

A series of measurements were made with instrument serial no. 1 inclined from the vertical, at 30 cm s^{-1} (nominal), at angles from +30° to -30°. In this set, the X and Z axes were logged. The tilt was measured with a hand held inclinometer and the error was ~±2°. The X axis results shown in figure 4, indicate a deviation from the ideal cosine response; especially for ϕ negative. The asymmetry between positive and negative tilt is clear, and our results are similar to those of Collar and Gwilliam, 1977, taken at 24 cm s^{-1}.

The deviation from the ideal sin ϕ curve for the Z axis sensor is less than 12% of the horizontal flow, and is greater for ϕ positive.

6. ZERO STABILITY

During the experiments which lasted 4 days, the zero stability of each current meter was within ±2 mm s^{-1}. No long term test was made.

7. CONCLUSIONS

This document described the initial set of measurements made on the production ultrasonic current meter from CMI. The limitations in azimuth and tilt response can be ascribed to the transducer mounting stubs and the wakes of the support cages. Since the tests of Collar and Gwilliam, the reduction in size of the reflector and reflector support struts have decreased the noise level on the transverse axis, but the azimuth and tilt response has not improved. The linearity and response speed of the instrument are good, but the use of an Aanderaa compass reduces the suitability of the instrument for work in the near surface zone, or in turbulence.

REFERENCES

COLLAR, P.G. and T.J.P. GWILLIAM. Some laboratory measurements on an acoustic current meter developed at Christian Michelsen Institute, Norway. IOS Report No. 47, 1977 (unpublished manuscript).

GYTRE, T. The use of a high sensitivity ultrasonic current meter in an oceanographic data acquisition system. The Radio and Electronic Engineer, Vol. 46, No. 12, pp. 617-623, 1976.

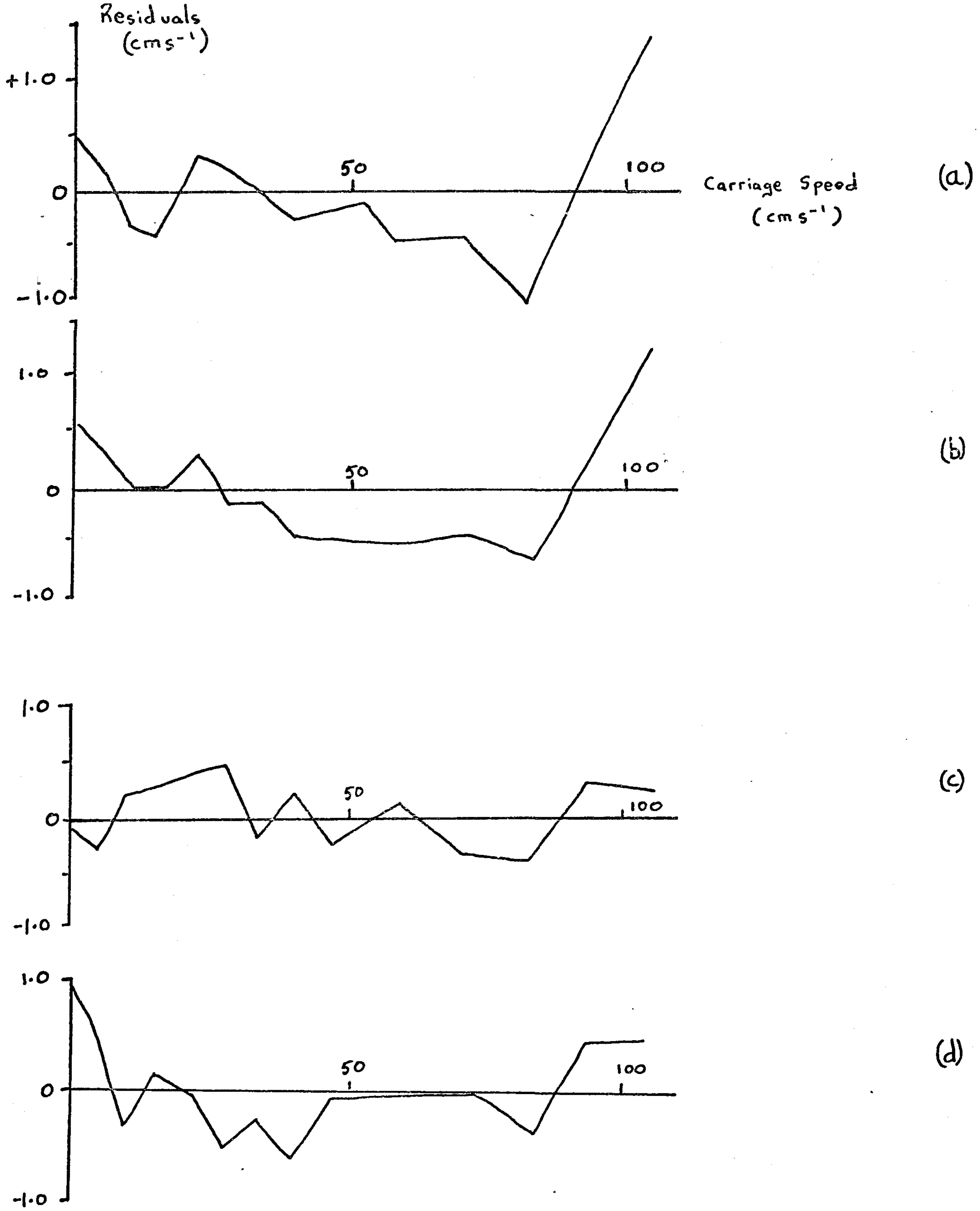

Fig. 1. Residuals in cm s^{-1} from the best fit linear regression.
(a) Serial No. 1 X axis, (b) Y axis, (c) Serial No. 2 X axis,
(d) Y axis.

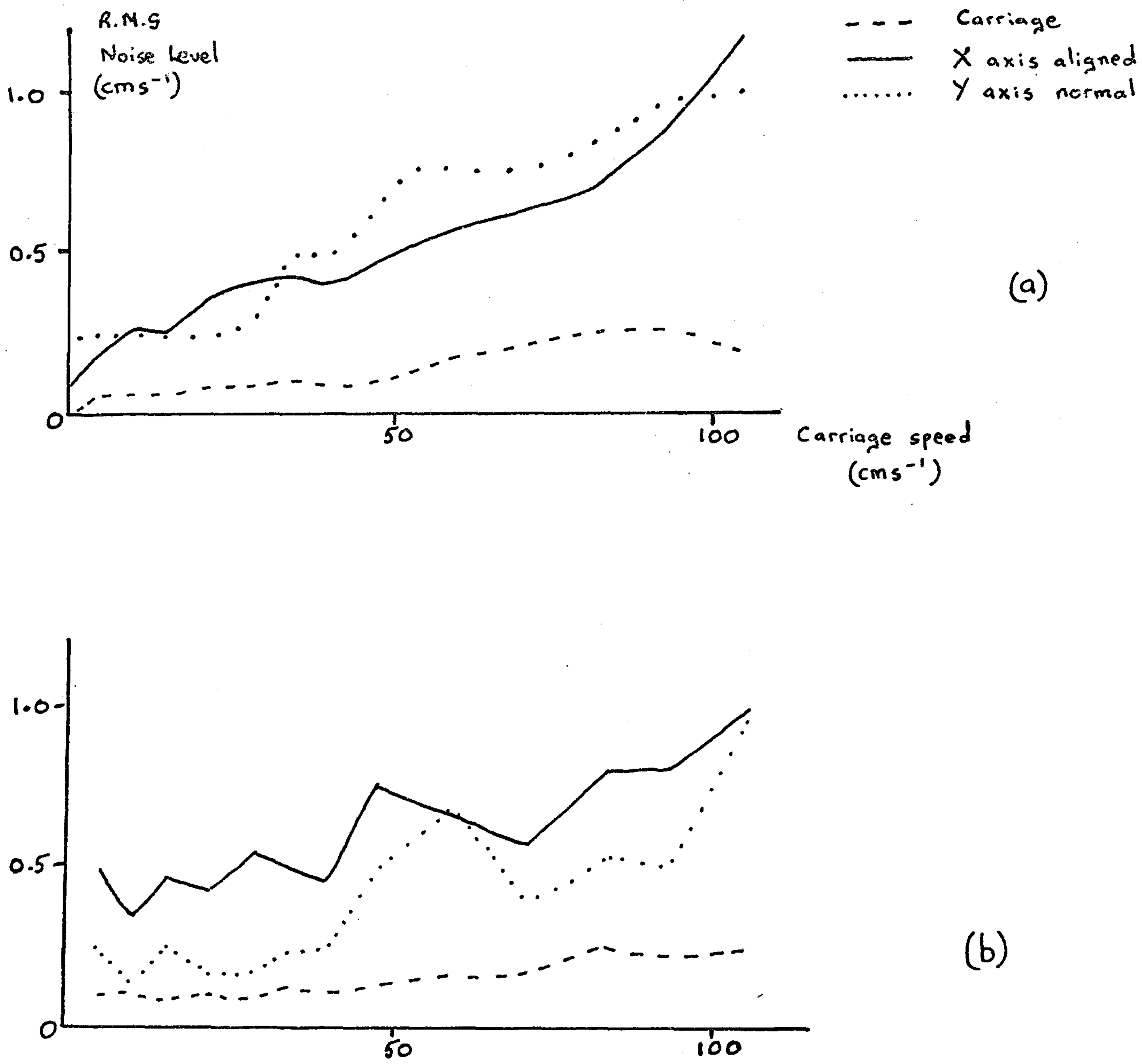

Fig. 2. Variation of standard deviation of sensor output with mean carriage speed. (a) Serial No. 1, (b) Serial No. 2.

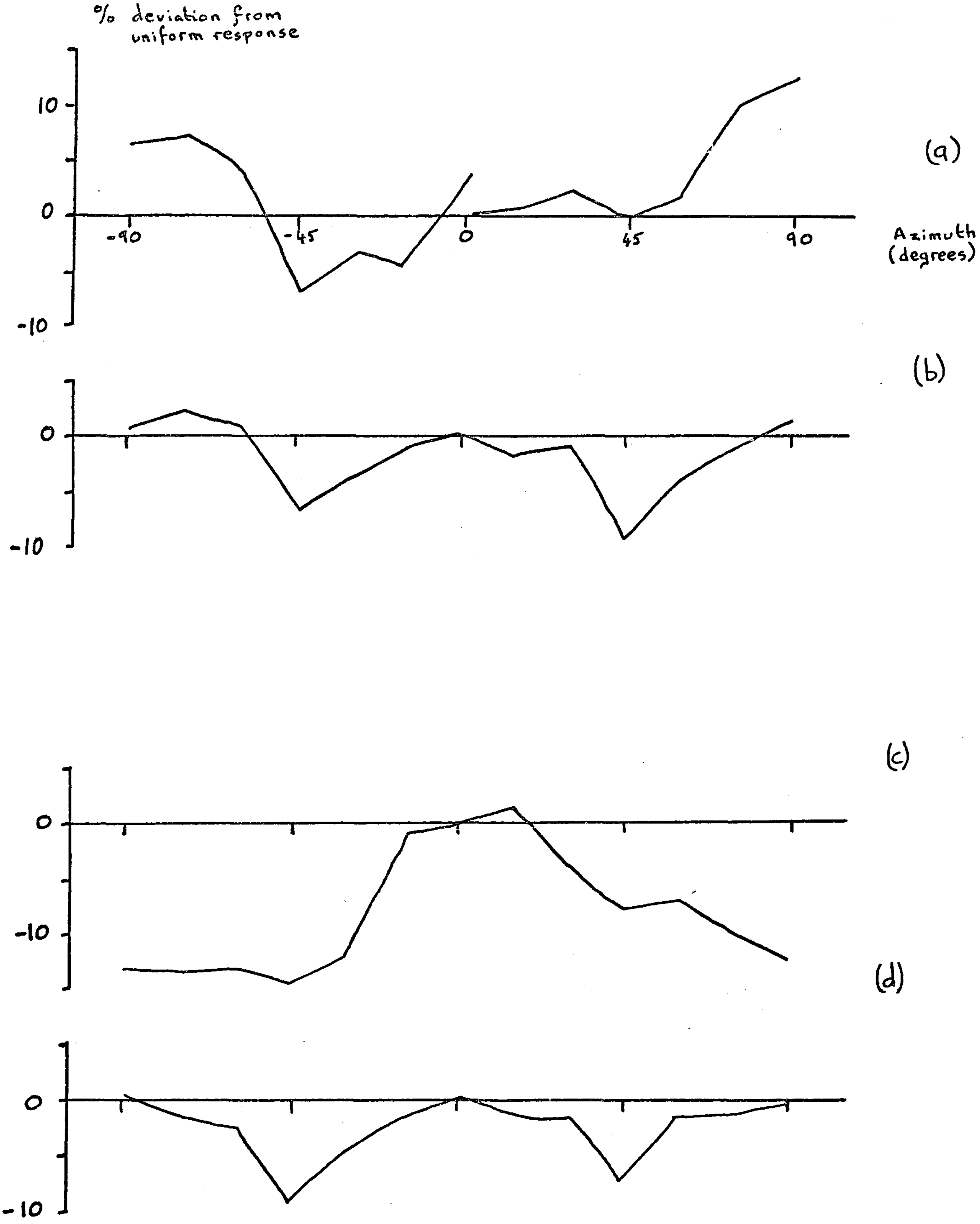

Fig. 3. Azimuth response in horizontal plane; deviation of vector magnitude from that at 0°. (a) Serial No. 1 at 10 cm s^{-1}, (b) at 50 cm s^{-1}, (c) Serial No. 2 at 10 cm s^{-1}, (d) at 50 cm s^{-1}.

Fig. 4. Static tilt response. (a) X axis output compared with cos ϕ, (b) Z axis compared to sin ϕ.