MORE UNCOMMON DEVIATIONS

by A. HINE,
British Admiralty Compass Observatory.

In the November 1955 issue of the « International Hydrographic Review », Vol. XXXII, No. 2, there appeared a most interesting article under the title « Uncommon Deviations », written by Captain L. Winterfeldt of the Swedish Hydrographic Office. The object of the present paper is to endeavour to elaborate and to explain some of the results which Captain Winterfeldt obtained when adjusting compasses, as given in the following deviation tables:

Example 1

m.s. « Arjäng »

N	+1°
NNE	+3
NE	+4
ENE	+2
E	0
ESE	+2
SE	+4
SSE	+2
S	0
SSW	—3
SW	—5
WSW	—3
W	—1
WNW	—3
NW	—4
NNW	—2

Example 2

s.s. « Herbert »

0	—1°
15	0
30	+1.5
45	+2
60	+1
75	—1
90	—1
105	0
120	+1.5
135	+3
150	+4.5
165	+3
180	+1
195	—1
210	—3
225	—2
240	—1
255	0
270	0
285	—1.5
300	—3.5
315	—5
330	—4.5
345	—3

Captain Winterfeldt calculates the residual coefficients for Example 1 by two different methods, as follows:

Table A

A =	0.0
B =	+0.5
C =	+0.5
D =	—0.3
E =	+0.5
F =	—2.1
G =	+0.3
H =	0.0

Table B

A =	0.0
B =	+6.4
C =	+0.4
D =	—0.3
E =	+0.5
F =	—2.1
G =	+0.3
H =	0.0

In Table A the method of calculation to obtain the Approximate Coefficients is the most simple one, using the formulae:

$$A = \text{Mean of Deviations on all headings,}$$

$$B = \frac{\text{Deviation on E} - \text{Deviation on W}}{2}$$

$$C = \frac{\text{Deviation on N} - \text{Deviation on S}}{2} \text{ etc.}$$

In Table B the method of calculation of B and C is that employing the intercardinal points, i.e.:

$$B = \frac{(\text{Devn. on NE} + \text{Devn. on SE} - \text{Devn. on SW} - \text{Devn. on NW})}{4 \times 0.707}$$

This should in fact (possibly owing to a clerical error) be + 2.1.

A graphical illustration of the deviation in « Arjäng », shown by the continuous line, is given by Captain Winterfeldt (Figure 1) and he substantiates the value for B of + 6.4 in Table B by extending the curve beyond the indentations near East and West (the dotted curve).

In fact, calculation of the residual coefficients by the « least squares » method gives the following result:

Table C

$A = -0.19$
$B = +3.27$
$C = +0.44$
$D = -0.13$
$E = +0.43$
$F = +2.06$
$G = +0.13$

Figure 2 illustrates, for simplicity, the deviations due to the more accurately calculated coefficients B (+3.27) and F (+2.06), and to a combination of the two. It also shows how the erroneous value of B=6.4 arose in Captain Winterfeldt's calculations.

If, at a compass position in which the coefficients were as shown in Table C, coefficient B were corrected by normal methods, consisting of removing, by fore-and-aft magnets, all the deviation on East or West and then halving the deviation on West or East, the residual deviation curve would be as shown in Figure 1, the peaks at NE, SE, SW and NW arising from the fact that an attempt has been made to correct sin θ and sin 3 θ terms using correctors arranged to counteract semi-circular effects only. If, however, the curve is correctly analysed, coefficient F is revealed and an uncorrected coefficient B. The latter could be corrected by a re-adjustment of the fore-and-aft magnets and the residual curve would then be of an orthodox sin 3 θ type.

It may be of interest, from the theoretical aspect, to draw attention to the error in analysis which may arise if the exact coefficients are not correctly calculated. In practice, as Captain Winterfeldt points out, the corrector magnets in « Arjäng » were replaced by larger magnets further from the compass needles and the resulting residual deviations were negligible. Similarly in « Herbert » (where the same form of error occurred in calculating the coefficients) the substitution of a compass

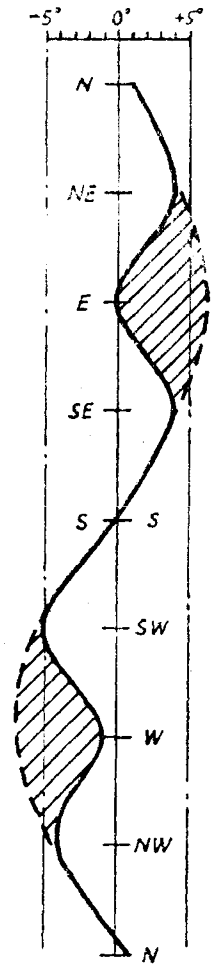

Fig. 1.

having comparatively short needles reduced the higher-order coefficients to inconsiderable proportions.

Captain Winterfeldt rightly stresses the dangers of placing corrector magnets too close to the compass, with the ensuing likelihood of producing sextantal coefficients, of which the two cases quoted are typical instances. He refers to a text-book rule that a magnet should not be placed nearer to a compass than double its length, and suggests that this is only applicable where the length of the compass needles is short in relation to their separation from the magnet. As an alternative rule he proposes that, in addition, a corrector magnet should not be placed nearer to the compass system than 1.7 times the sum of its length plus that of the longest needle.

In this connection it seems doubtful whether the length of the corrector magnet is itself critical, except in respect of its field being uniform over the space occupied by the compass system, and this may be borne out by the fact that in the case of « Herbert » (quoted above) the substitution of the compass system having shorter needles eliminated the sextantal deviations. In fact, a rule given in Smith and Evans (Philosophical Transactions of the Royal Society, 1861), which is normally followed in British Admiralty designs, calls for the following separations between corrector magnets and compass needles :

— When in the same horizontal plane: six times the length of the compass needle;

— When in a parallel horizontal plane above or below the compass: three times the length of the compass needle.

On the other hand, modern British commercial binnacle design normally requires a minimum separation of twice the length of the corrector magnet between it and the compass needles (the text-book rule quoted by Captain Winterfeldt) and, although in both « Arjäng » and « Herbert » this rule had been kept (with undesirable results), the fact remains that appreciable higher-order coefficients are fortunately only very rarely encountered in modern compass equipment.

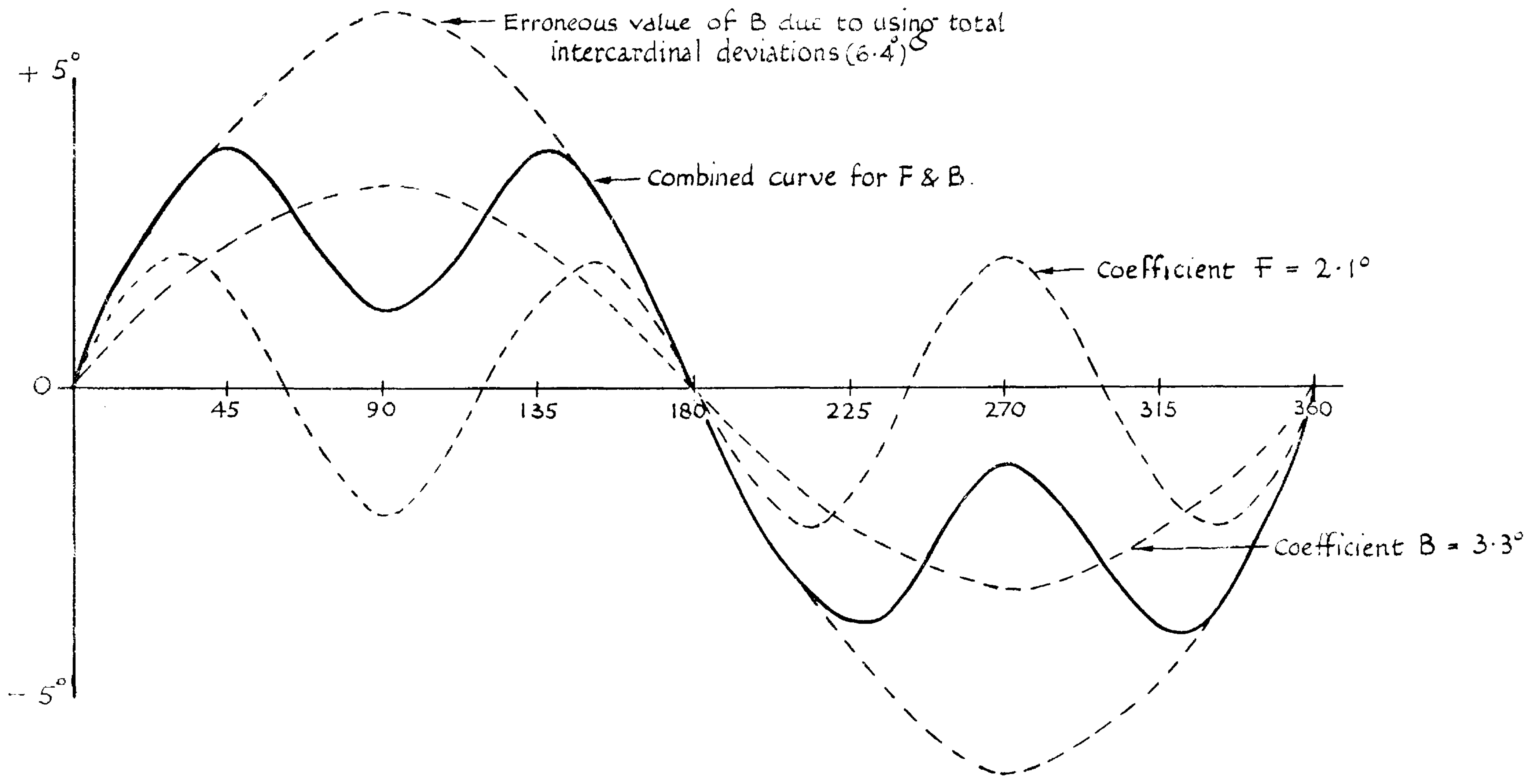
Erroneous value of B due to using total intercardinal deviations (6·4°)
Combined curve for F & B.
Coefficient F = 2·1°
Coefficient B = 3·3°
+ 5°
O
- 5°
45
90
135
180
225
270
315
360

Fig 2