Errors in "A History of Nautical Astronomy" by Charles H Cotter

compiled by George Huxtable and Jan Kalivoda. Last updated 8 August 04.

That update includes comments on Merrifield's method (pages 227 - 231) and on notation (in pages 244-246)

Back in 1968, Hollis and Carter published Charles H Cotter's thorough survey, "A History of Nautical Astronomy", which is properly regarded as a goldmine of information on that topic, not approached by any other publication. It is frequently referred to, in papers relating to early navigation. It's now long out-of-print, and hard to find secondhand.

Unfortunately, an extraordinary number of errors have recently been detected in Cotter's text, which detract significantly from its usefulness. Partly, it may have been due to sloppy proofreading, but in addition it appears that Cotter may have transcribed old publications without perceiving all the technical details.

This list of known or suspected errors below has been assembled as a joint effort by-
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(In the list of errors below, originators of contributions are identified by the initials shown above.)

Although we rather doubt it, it may be that a few of the items listed below are not errors at all, but perhaps misunderstandings on our part. Wherever we have pointed to an "error", you should view Cotter's text with, at least, some suspicion and make up your own mind. A few of the entries in the list are not errors at all, but where we think Cotter has omitted to provide important relevant information.

Entries have been put into page-order, and in many cases the line-number on that page is hinted at by "12 down" (from top of page) or "5 up" (from the bottom) though this may have been guessed-at rather than precise. We have used the compound symbol -> to imply "should be instead".

The paging corresponds to the Hollis & Carter 1968 edition, the last page of its index being 387. There was also a US edition with identical paging, and there were no later editions that we know of.

Some of the formulae have had to be transcribed into a rather different form from Cotter's original, compatible with the limitations of ASCII text, but these should explain themselves..

We don't consider the list, below, to be at all exhaustive. The entries are not the result of a thorough search, just what we have stumbled across in our own reading of the book. An owner of a copy of Cotter may find it useful to print off a copy ans insert it into his book.

We would like to hear from anyone who finds or suspects further errors, or who finds errors in our own list. Please email GH or JK.

Although it's regrettable that so many errors exist, Cotter's book remains unrivalled as an account of how astro-navigation evolved.

LIST OF KNOWN OR SUSPECTED ERRORS, AND OMISSIONS.

49: The third paragraph starts- "The civil day at sea commenced at midnight", which is correct. In the next paragraph Cotter states "The civil day commenced when the Mean Sun culminated at noon." which is contradictory, and wrong. (GH)

83,10 down: Alae sui -> Alae sive (JK)

84,15 up: the longest side -> the lower shorter side ??? (JK)

97: Much vital information has been omitted from chapter IV, (The Altitude Corrections). There's no mention of sextant **index error**, determined by aligning the same distant object in the two mirrors. The resulting reading has to be subtracted from sextant readings to correct for index error. "If it's on (the arc) take it off: if it's off, add it on". Nor any mention of scale error, the correction for which was determined by the maker and usually pasted into the sextant box. (GH)

97: **Refraction.** Cotter doesn't mention which way to apply refraction. It should be subtracted from the observed sextant angle to make a correction. (GH)

101,1 up: the true zenith distance theta_1 -> the apparent zenith distance theta_1 at the point O_1 (i.e. "O with the index 1") (JK)

107,5 up: To the formula at this line a remark would be useful: "(mi - 1) = U". Otherwise the deduction from the formulas at the page 105 is not clear. (JK)

108,3 down: Here I am not certain. But the deduction of this formula from the formulas III and IV on the page 105 seems to be wrong. Cotter proceeds, as "2 PZ" on page 105 would equal "lambda" (geographical latitude !) in the picture 2, page 104. But this is not the case! Can anybody help with this derivation? (JK)

110,11 down: the first edition (of Maskelyne's "Requisite Tables") -> the second edition (JK)

111: Cotter doesn't explain which way to apply the **dip**. It should be **subtracted** from the observed sextant angle. (GH)

113,6 up: One would add to this line: "And h much less than R" (otherwise R/(R+H) would not equal to (R-h)/R) (JK).

118, foot of: Cotter states- "Augmentation = Moon's semidiameter x sine apparent altitude". This is wrong.
It would be roughly true to state instead- Augmentation (in minutes) = Moon's semidiam. (in degrees) x sine apparent altitude, but more accurate to say-
Augmentation (in minutes) = Moon''s semidiam. (in minutes) x sine apparent altitude / 55. (GH)

119 Parallax.: Cotter doesn't explain which way to apply the parallax correction. It is to be **added** to the apparent altitude. (GH).

120, 2 down: Cotter says- "... body Y, which has the same **apparent** place as body X", but fig 5 shows body Y at the same **true** place as body X. (GH)

121,11 up: 1/4 (approx.) -> 4/1 (approx.) (JK)

135,9: 15th century -> 16th century (JK)

151, 5-7 down: The words from "Moreover, ..." to the end of paragraph seem to be wrong to me. When reducing the measured altitude of the Sun to the time of the first observation by the run and azimuth of the Sun, the observer should not make any other reductions acording to the run between observations? (JK)

158,16 down: ZY is the great circle -> XY is the great circle (JK)

163,12 up: after the meridian altitude -> before the meridian altitude ??? (JK)

210-212: Borda's method. Here I think Cotter has got into a real mess with his trig. The equation that

precedes equation (Y) is given as
$(\sin D/2)^2 = \sin\{(M+S)/2 + \theta\} \sin \{(M+S)/2 - \theta\}$
Here, he has got the last term the wrong way round and it should be
$(\sin D/2)^2 = \sin\{(M+S)/2 + \theta\} \sin \{\theta - (M+S)/2\}$
so in consequence, in equation (Y), the second sine term in the product of two sines is also reversed.

Similarly in the last equation on page 210, for log sin D/2, the last term in the sum should end up as log sin (theta- (M+S)/2), not log sin ((M+S)/2- theta), as Cotter gives it. If you slavishly follow Cotter's steps, you will end up taking the log of a negative quantity, which is an impossibility.

I think Cotter has realised there's something wrong, without being sure what it is, because on page 211 he states the rules in words for clearing the distance, and in rule 5 he says- "Find the sum of and difference between theta and phi". Because he hasn't defined here which way round to take that difference, the navigator will presume that he should subtract in such a direction as to give a positive answer. So that bit of "fudging" has got Cotter out of his problem. In fact the subtraction should **always** be theta - phi, and **never** as stated at the foot of 210, phi - theta.

On line 3 of page 212, that's what he has written down in the calculation, theta - phi, just as it should be. (GH)

211, end of the point 5: "The result is the sine of the half ..." -> "The result is the log sine of the half ..." (JK)

213, lower half: In the log computation, the log entries in the right column are mis-ordered. The entry "log 2 0.3010300" should be moved down to allow the entry "A Comp cos 0.1783835" to be shifted down two rows, alongside "s = 48 27 32", where it should be. (GH)

217,16-18 from below: This was true only if the navigator used the table of "logarithmic differences", giving the value of the equation X from the page 216 by inspection. Such tables were in use, but introduced an error of 3-6 arc-seconds into the result. This was tolerable in the times when lunar positions themselves (hence the true lunar distances, too) were tabulated with the error of 15-30 arc-seconds in almanacs, owing to deficiences of the used theories of lunar motion. (JK)

225 below, 231 passim: Cotter explains the fundamentals of the lunar distances clearly and sufficiently. But his historical sketch of their evolution is very unsatisfactory. With late 19th century and neglects the most esteemed methods from the first half of 19th century when the importance of lunars was the greatest. Elford, Bowditch, Turner, Thomson, Cambridge Tables - all are missing.

In particular, Dunthorne's method mentioned on these pages was not a indirect method, but the first and the most succesful direct method, preceding Borda's in time and a simpler one. It was the most common method of lunars in continental Europe, apart from France. (JK)

227-231. Cotter describes Merrifield's method in some detail, describing it as "a method for clearing lunar distances which he had invented", and quoting-"the method is direct in its application, requires no special tables, and is claimed to be a very close approximation well adapted for sea use."
However, closer examination of Merrifields method, as described by Cotter, shows it to be (with an important exception, discussed further below) different in only trivial ways from Mendoza's method. Mendoza's method is not discussed by Cotter, but is included (as Norie's 4th method) in the 1848 (and presumably earlier) edition of Norie's, and in a pamphlet issued by Norie in 1816 which included printed blank forms for clearing a lunar by that method. Both Merrifield and Mendoza treat the two right-angled correction triangles (in Cotter's fig.3 on page 228, Sqs and Mpm) as simple plane triangles, because they are both small. Making that assumption, their corrections to apply to the lunar distance are precisely the same.
Now we come to the exception referred to above. Having made those corrections, Merrifield treats that result as his final answer. Mendoza, however, goes on to make a further small correction, for the initial approximate assumption of plane triangles, which was based on a special Table XXXV in Norie's. That

correction is unlikely to exceed 30 arc-seconds, but even so, is often worth allowing for in a lunar calculation.
So Merrifield's "invention" appears to be no more than the discarding of Mendoza's fine-correction term, which he had specified three-quarters of a century earlier. This degradation seems to me to be a backward form of progress, indeed. Cotter would have done better to include Mendoza in his "approximate" methods, and exclude Merrifield. (GH)

232-236: The description of the Hall's method abounds with typographical errors and had been written very carelessly from the logical point of view, too. It's better for a reader to omit it. The method itself isn't very interesting, it was devised only to be the last method of lunars invented, when lunars were being left out from the Nautical Almanac in 1906. (JK)

237: For a navigator, it may be useful to know that alpha Aquilae is more familiar as Altair, alpha Arietis as Hamal, and alpha Pegasi as Markab. (GH)

239,6 up: prop. log **small** delta being given in the almanac -> prop.log. **great** delta being given in the almanac !!! (JK)

241,8 down: the value 50' of error when neglecting the second differences is grossly exaggerated (JK)

244, 6 down and also 245, expression at foot, 246, expression at head. Arc ZX (zenith distance of X) should also be labelled z, as that abbreviation is used for arc ZX in the expressions at the foot of page 245 and at the head of page 246. (GH)

247, near foot: In the expression for hav P, the square-root sign should be omitted (GH)

248,5 down: vers (PX ± PX) -> vers (PZ ± PX) (in the numerator on the right side of the equation) (JK)

250: The four equations shown on this page all use the quantity s, but I cannot find any definition of s. I presume that s is half the perimeter of the PZX triangle, so s = 1/2 (ZX + PZ + PX)

In the third expression, for cos P/2, a quantity s with a subscript 2 appears. That little 2 appears to be a misprint and should be erased.

mid-page: Cotter says : "it can be demonstrated that the first is suitable for cases in which P is near 90 deg", but really suitable -> **un**suitable. (GH)

264. Cotter says, about finding the moment of noon by equal Sun altitudes-

"By taking the equal-altitude sights shortly before and after noon the necessity for applying a correction for the change in the Sun's declination in the interval is obviated, since any such change will be trifling."

I disagree with Cotter's analysis here. It seems to me that the correction necessary for a changing declination does **not** reduce as the interval chosen gets closer to noon. (GH)

265,7 up: delta d -> delta h (JK)

265,3 up: tan l cos h -> tan l csc h (JK)

266,2 down: cos h -> csc h (JK)

266,9-13 up: This text seems completely confused - either by Cotter or by the author of original. One could try to correct it, but it would be better to verify it in the Nautical Magazine for 1848, which I don't have at my disposal. (JK)

272,19 up: if the two hour angles -> if the difference of two hour angles (JK)

275, midpage: In the quotation from Sumner, defect -> difficulty, and observation -> projection. (HP)

308,3 up: Now the least important -> Not the least important (JK)

311: The manual of Martin Cortes appeared in 1551 (JK)

354: Napier's rule. The second expression, shown as cos x = cos y cos z is wrong, and should be- cos y = cos x cos z (GH)

366 Nos 238 and 240 of bibliography seem uncomplete to me. The first (1766) and fourth (1811?) editions of Maskelyne's "Requisite Tables" are not mentioned. (JK)

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