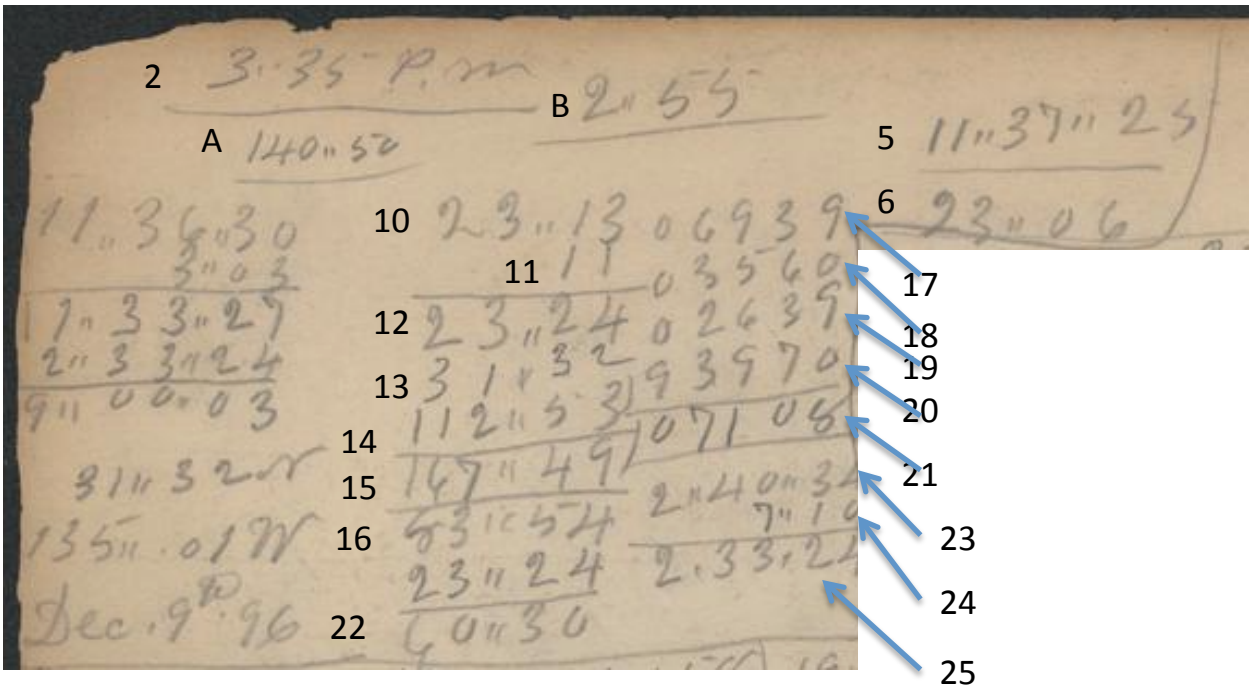
Here is my attempt to decipher a "time sight" entry from the Navigation Logbook of the Charles W. Morgan. Online I thumbed through a few pages of the Navigation Log kept at Mystic Seaport and on page 4 of 61 found an entry dated December 9th, 1896 at 3:35 PM that looked like a good candidate. Here is the link to the page: (http://library.mysticseaport.org/initiative/PageImage.cfm?PageNum=4&BibID=38512) Adding 3 angles and dividing by 2 and adding 4 logs to the side seemed good indicators. Below is the actual entry. I have numbered each entry.



Initial assessment: Entry 1 would be the date and entry 2 would appear to be about the Time (local) that the sight was taken. The final position would appear to be entries 3 and 4.

My guess is that entries 5 and 6 were the watch time and sextant height (hs) that were copied down from the data obtained on deck. But why 11:36:25 for time? Why not 03:36:25 PM corresponding to entry 2, 3:35 PM.?

Time: entries 5, 7, 8 and 9, appear to be dealing with time. I was a little confused by the times all appearing to be around 11 in the morning. I would have expected to see 23:37:25 given the local time of (3:35 PM) 15:35, then I surmised that entry 5 must have been the time synched with the Chronometer that was set to Greenwich Civil Time (G.C.T.). Since the Chronometer hands go from 1 to 12, not 24, 11:37:25 must be Greenwich time in the PM or the equivalent of 23:37:25 (G.C.T.)

The Zone description for 135 W through me off. It is -9. So adding 9 to 15:35 to get back to G.C.T. would put the chronometer time at 00:35 the next day?

My guess is that they had not bothered to change whatever time device was measuring 15:35 PM (entry 2, 3:55 PM) when they crossed from Zone -8 into zone -9.

OK, so now how do we get from entry 5 to entry 7? I would conclude that the difference of 45 seconds would be the watch error. Whatever watch/stopwatch they used on deck was 45 seconds fast, the navigator did the correction in his head for entry 7.

Alright, now for entry 8. I am assuming that entry 8 represents the chronometer's error; the chronometer being 3 minutes and 3 seconds fast. Thus entry 9 represents the corrected Greenwich Civil Time (G.C.T.) But wait, what about the Equation of Time correction that my 1938 edition of Bowditch talks about to get to Greenwich Apparent Time (G.A.T.)? We will come to that later.

Now that I have a position and time, let's go to the USNO website and see what the Calculated information for that date, time and location looks like.

Celestial Navigation Data for 1896 Dec 9 at 23:33:27 UT

For Assumed Position: Latitude N 31 32.0
Longitude W 135 01.0

	Almanac Data				Altitude Corrections			
Object	GHA	Dec	Hc	Zn	Refr	SD	PA	Sum
	o '	o '	o '	o	'	'	'	'
SUN	175 06.0	S22 57.2	+23 21.7	220.2	-2.3	16.2	0.1	14.1

I appear to be in the ballpark given Hc, is only 2.3' different from entry 12, the Corrected Altitude (Ho).

Altitude: assuming that entry 6 represents the altitude taken on deck(Hs) how do I account for entries 10, 11 and 12? My assumption is that the difference between entry 6 and entry 10 is index correction (+7 off the arc) . The navigator did this calculation in his head, not bothering to write it down on paper. Makes sense? Now, what does the 11 represent? Knowing that the altitude correction given by the USNO site above is 14.1, I conclude that the 11 (entry 11) must be made up of +14 (the altitude correction for a lower limb site) and -3 for dip representing a height of eye of about 10 ft. Having never stood on the deck of the Charles W. Morgan, not sure if this makes sense or not but I will go with it. So entry 12, 23° 24' minutes is the Height Observed (Ho).

<u>Calculating (*t*)</u>, the Local Hour Angle of the sun: my 1938 edition Bowditch lists the following equation to be used:

hav *t* = sec L cosec *p* cos *s* sin (*s*-*h*)*

s=1/2 (*h* + L + *p*)

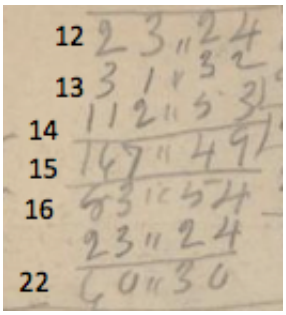
p= 90°+/-*d* (the Polar Distance)

where:

L= the assumed Latitude
h= Ho
d= declination

Now, back to the example:

It appears that 12-16 are the calculations to determine *s*



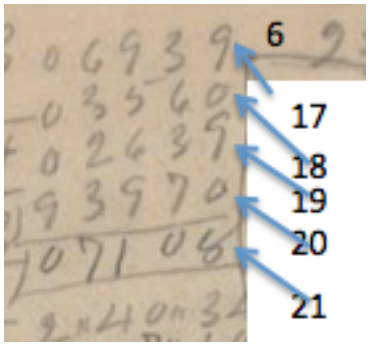
Entry 12=*h*
Entry 13=L
Entry 14=*p*
Entry 15 being the sum of 12-14

And entry 16 dividing the sum by 2. Easy going here.
The one twist, no spot on the worksheet where *d* is written down. *d* must be 22° 53' S, the navigator just added this to 90 ° in his head to get entry 14, *p*. I am surprised that *d* is so different from the USNO calculation of 22° 57.2' S. Not sure why? I calculated the Dec. for this date and time using an online copy of the Nautical Almanac from 1896, and got the same answer as the USNO. See Appendix (1). Dare I suggest that this was an error by the Navigator, am I missing something?

Entry 22 is *s*-*h.*

*This equation(4 multiplications) allows the navigator to make four convenient additions with the Logarithms of the Trigonometric Functions, Table 33 of Bowditch on the right side, and one lookup of the sum on the left side in Table 34 of Bowditch for example to determine *t.*

Logarithms of Trigonometric Functions and the Haversine



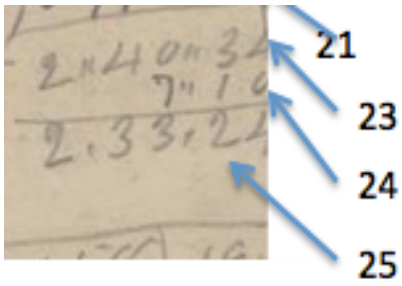
Recall hav *t* = sec L cosec *p* cos *s* sin (*s*-*h*)*

Entries 17-21 seem fairly straightforward

17 being the secant of L	10.06939*
18 being the cosecant of *p*	10.03560
19 being the cos of *s*	9.02639-10
20 being the sin (*s*-*h*)	9.93970-10
21 being the sum of 17-20	9.07108-10

It is interesting to note that the navigator leaves off the whole number portion of the logarithm. He does this calculation in his head. I guess if you were doing this routine on average a couple times a day over a 2 to 3 year voyage, you could do a lot of it in your head.

Now we come to entries 23-24.



Entry 23 is the inverse haversine of 21 which can be Found in Table 34 of Bowditch. I normally compute *t* in arc form versus time. This example is worked In time. Perhaps this is why they called it a "time sight", this being the normal procedure?
My 1991 copy of Norie's does not list haversines in terms of time, but the 1938 Bowditch, Table 34 gives both. See Appendix (2).

*All entries taken from Table 33 of my 1938 copy of Bowditch

So *t*=2 h 40 m 34 s. After scrutinizing Appendix (1), the 1896 Almanac
It can be seen that entry 23 is the Equation of Time which is to be subtracted or added to Mean Time. I had thought that this correction would have been subtracted From line 9 [the Greenwich Civil Time (G.C.T.) to obtain Greenwich Apparent Time (G.A.T.)] I guess it does not matter whether you subtract it from *t* or G.C.T. Maybe Someone can shed light on this for me. It's clear that the math ends up being the same.

Since the sun is west of our position, we subtract the meridian angle *(t*), entry 26 from the sun's Greenwich Hour Angle (both measured in time) to get our Longitude measured in time. The time diagram below helps identify the relationships.

By inspection in Table 34 of Bowditch, 9 h 00 m 03 s is 135 ° 01' which we label West.

I have no idea what entries A or B represent. Maybe someone could shed light on them?

Any constructive feedback would be greatly appreciated.

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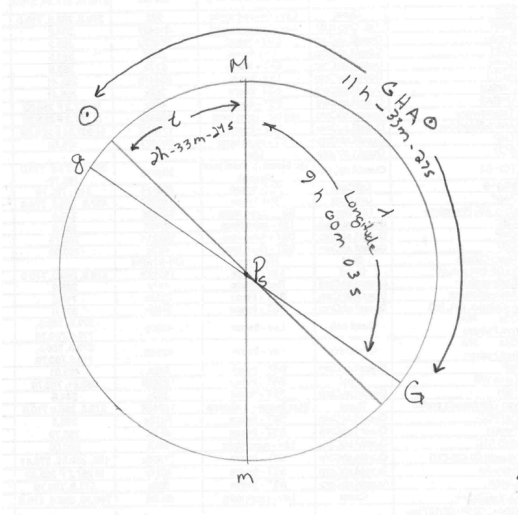

Appendix (1) 1896 Nautical Almanac

AT GREENWICH MEAN NOON.

Day of the Week.	Day of the Month.	THE SUN'S Apparent Right Ascension.	Diff. for 1 Hour.	THE SUN'S Apparent Declination.	Diff. for 1 Hour.	Equation of Time, to be Added to / Subtracted from Mean Time.	Diff. for 1 Hour.
		h m s	s	° ′ ″	″	m s	s
Tues.	1	16 32 48.26	10.820	S.21 56 30.7	−22.50	10 33.41	0.963
Wed.	2	16 37 8.25	10.846	22 5 18.0	21.44	10 9.98	0.989
Thur.	3	16 41 28.87	10.871	22 13 39.6	20.37	9 45.92	1.015
Frid.	4	16 45 50.07	10.895	22 21 35.4	−19.28	9 21.28	1.038
Sat.	5	16 50 11.83	10.918	22 29 5.1	18.18	8 56.07	1.061
SUN.	6	16 54 34.11	10.939	22 36 8.3	17.08	8 30.35	1.082
Mon.	7	16 58 56.90	10.959	22 42 45.0	−15.97	8 4.13	1.102
Tues.	8	17 3 20.14	10.978	22 48 54.9	14.85	7 37.44	1.121
Wed.	9	17 7 43.82	10.995	22 54 37.8	13.72	7 10.32	1.138
Thur.	10	17 12 7.90	11.011	22 59 53.4	−12.58	6 42.80	1.154

12/9/1896
USNO dec = 22° 57.2′ S

1896 ALMANAC
GREENWICH MEAN NOON
12/9/1896

22° 54′ 37.8″ = 22° 54.6′

correction 13.72″/hr = .23′/hr

Difference in time from noon = 23 hr 33 min 27 sec
− 12 hr
11 hr 33 min 27 sec
= 11.56 hrs

Total correction 123′/hr × 11.56 hrs = 2.7′

so 22° 54.6′
+ 2.7′
22° − 57.3

time and arc

t

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TABLE 34.

Haversines.

s	2h 40m 40° 0′		2h 41m 40° 15′		2h 42m 40° 30′		2h 43m 40° 45′		2h 44m 41° 0′		s
	Log. Hav.	Nat. Hav.	Log. Hav.	Nat. Hav.	Log. Hav.	Nat. Hav.	Log. Hav.	Nat. Hav.	Log. Hav.	Nat. Hav.	
0	9.06810	.11698	9.07329	.11838	9.07845	.11980	9.08357	.12122	9.08865	.12265	60
1	.06819	.11700	.07338	.11841	.07853	.11982	.08365	.12124	.08874	.12267	59
2	.06828	.11702	.07346	.11843	.07862	.11984	.08374	.12127	.08882	.12269	58
3	.06836	.11705	.07355	.11845	.07870	.11987	.08382	.12129	.08890	.12272	57
+ 1′	9.06845	.11707	9.07364	.11848	9.07879	.11989	9.08391	.12131	9.08899	.12274	56
5	.06854	.11709	.07372	.11850	.07887	.11992	.08399	.12134	.08907	.12276	55
6	.06862	.11712	.07381	.11852	.07896	.11994	.08408	.12136	.08916	.12279	54
7	.06871	.11714	.07390	.11855	.07905	.11996	.08416	.12138	.08924	.12281	53
+ 2′	9.06880	.11716	9.07398	.11857	9.07913	.11999	9.08425	.12141	9.08933	.12284	52
9	.06888	.11719	.07407	.11860	.07922	.12001	.08433	.12143	.08941	.12286	51
10	.06897	.11721	.07415	.11862	.07930	.12003	.08442	.12146	.08949	.12288	50
11	.06906	.11724	.07424	.11864	.07939	.12006	.08450	.12148	.08958	.12291	49
+ 3′	9.06914	.11726	9.07433	.11867	9.07947	.12008	9.08459	.12150	9.08966	.12293	48
13	.06923	.11728	.07441	.11869	.07956	.12010	.08467	.12153	.08975	.12296	47
14	.06932	.11731	.07450	.11871	.07964	.12013	.08475	.12155	.08983	.12298	46
15	.06940	.11733	.07458	.11874	.07973	.12015	.08484	.12157	.08992	.12300	45
+ 4′	9.06949	.11735	9.07467	.11876	9.07981	.12018	9.08492	.12160	9.09000	.12303	44
17	.06958	.11738	.07476	.11878	.07990	.12020	.08501	.12162	.09009	.12305	43
18	.06966	.11740	.07484	.11881	.07999	.12022	.08509	.12165	.09017	.12307	42
19	.06975	.11742	.07493	.11883	.08007	.12025	.08518	.12167	.09025	.12310	41
+ 5′	9.06984	.11745	9.07501	.11885	9.08016	.12027	9.08526	.12169	9.09034	.12312	40
21	.06992	.11747	.07510	.11888	.08024	.12029	.08535	.12172	.09042	.12315	39
22	.07001	.11749	.07519	.11890	.08033	.12032	.08543	.12174	.09051	.12317	38
23	.07010	.11752	.07527	.11892	.08041	.12034	.08552	.12176	.09059	.12319	37
+ 6′	9.07018	.11754	9.07536	.11895	9.08050	.12036	9.08560	.12179	9.09068	.12322	36
25	.07027	.11756	.07544	.11897	.08058	.12039	.08569	.12181	.09076	.12324	35
26	.07036	.11759	.07553	.11900	.08067	.12041	.08577	.12184	.09084	.12327	34
27	.07044	.11761	.07562	.11902	.08075	.12044	.08586	.12186	.09093	.12329	33
+ 7′	9.07053	.11763	9.07570	.11904	9.08084	.12046	9.08594	.12188	9.09101	.12331	32
29	.07062	.11766	.07579	.11907	.08092	.12048	.08603	.12191	.09110	.12334	31
30	.07070	.11768	.07587	.11909	.08101	.12051	.08611	.12193	.09118	.12336	30
31	.07079	.11770	.07596	.11911	.08110	.12053	.08620	.12195	.09126	.12339	29
+ 8′	9.07088	.11773	9.07605	.11914	9.08118	.12055	9.08628	.12198	9.09135	.12341	28
		.11775	.07613	.11916	.08127	.12058	.08637	.12200	.09143	.12343	27
34	.07105	.11777	.07622	.11918	.08135	.12060	.08645	.12203	.09152	.12346	26
		.11780	.07630	.11921	.08144	.12062	.08654	.12205	.09160	.12348	25
+ 9′	9.07122	.11782	9.07639	.11923	9.08152	.12065	9.08662	.12207	9.09169	.12351	24
37	.07131	.11784	.07647	.11925	.08161	.12067	.08671	.12210	.09177	.12353	23
38	.07139	.11787	.07656	.11928	.08169	.12070	.08679	.12212	.09185	.12355	22
39	.07148	.11789	.07665	.11930	.08178	.12072	.08687	.12214	.09194	.12358	21
+ 10′	9.07157	.11791	9.07673	.11933	9.08186	.12074	9.08696	.12217	9.09202	.12360	20
41	.07165	.11794	.07682	.11935	.08195	.12077	.08704	.12219	.09211	.12363	19
42	.07174	.11796	.07690	.11937	.08203	.12079	.08713	.12222	.09219	.12365	18
43	.07183	.11798	.07699	.11940	.08212	.12081	.08721	.12224	.09227	.12367	17
+ 11′	9.07191	.11801	9.07708	.11942	9.08220	.12084	9.08730	.12226	9.09236	.12370	16
45	.07200	.11803	.07716	.11944	.08229	.12086	.08738	.12229	.09244	.12372	15
46	.07208	.11806	.07725	.11947	.08237	.12089	.08747	.12231	.09253	.12374	14
47	.07217	.11808	.07733	.11949	.08246	.12091	.08755	.12233	.09261	.12377	13
+ 12′	9.07226	.11810	9.07742	.11951	9.08254	.12093	9.08764	.12236	9.09269	.12379	12
49	.07234	.11813	.07750	.11954	.08263	.12096	.08772	.12238	.09278	.12382	11
50	.07243	.11815	.07759	.11956	.08271	.12098	.08781	.12241	.09286	.12384	10
51	.07252	.11817	.07768	.11958	.08280	.12100	.08789	.12243	.09295	.12386	9
+ 13′	9.07260	.11820	9.07776	.11961	9.08288	.12103	9.08797	.12245	9.09303	.12389	8
53	.07269	.11822	.07785	.11963	.08297	.12105	.08806	.12248	.09311	.12391	7
54	.07277	.11824	.07793	.11966	.08306	.12108	.08814	.12250	.09320	.12394	6
55	.07286	.11827	.07802	.11968	.08314	.12110	.08823	.12253	.09328	.12396	5
+ 14′	9.07295	.11829	9.07810	.11970	9.08323	.12112	9.08831	.12255	9.09337	.12398	4
57	.07303	.11831	.07819	.11973	.08331	.12115	.08840	.12257	.09345	.12401	3
58	.07312	.11834	.07827	.11975	.08340	.12117	.08848	.12260	.09353	.12403	2
59	.07321	.11836	.07836	.11977	.08348	.12119	.08857	.12262	.09362	.12406	1
+ 15′	9.07329	.11838	9.07845	.11980	9.08357	.12122	9.08865	.12265	9.09370	.12408	0
	21h 19m		21h 18m		21h 17m		21h 16m		21h 15m		