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The US Maury collection Metadata 1796 - 1861

Hendrik Wallbrink, Frits Koek and Theo Brandsma

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PO Box 201
3730 AE De Bilt
Wilhelminalaan 10
De Bilt
The Netherlands
http://www.knmi.nl
Telephone +31(0)30-220 69 11
Telefax +31(0)30-221 04 07

Authors: H. Wallbrink, F. Koek, T. Brandsma

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THE US MAURY COLLECTION METADATA 1796-1861

Hendrik Wallbrink
Frits Koek
Theo Brandsma

TABLE OF CONTENTS

1. INTRODUCTION 5
2. KEEPING THE JOURNAL AT SEA 7
   2.1. LOG BOARD 7
   2.2. LOGBOOK 7
   2.3. JOURNAL 7
   2.4. ABSTRACT LOG 7
   2.5. WATCHES AND BELLS 8
3. DATE AND TIME 9
   3.1. SHIP'S TIME 9
   3.2. THE NAUTICAL DAY 9
   3.3. THE CIVIL DAY 10
   3.4. THE ASTRONOMICAL DAY 11
   3.5. CROSSING THE DATE LINE 13
   3.6. THE USE OF THE NAUTICAL DAY AFTER THE BRUSSELS' CONFERENCE IN 1853 13
4. GEOGRAPHICAL POSITION 15
5. CURRENT 16
6. COMPASS VARIATION 18
7. AIR PRESSURE 20
   7.1. THE COMMON MARINE BAROMETER 20
   7.2. OBSERVATION TIME OF THE BAROMETER 21
   7.3. LOCATION OF THE BAROMETER 21
   7.4. BAROMETRIC CORRECTIONS 22
      7.4.1. *Capacity or cistern correction* 23
      7.4.2. *Capillarity correction* 23
      7.4.3. *Temperature correction* 23
      7.4.4. *Index correction* 24
   7.5. FACTORS INFLUENCING THE ABSOLUTE ACCURACY OF THE BAROMETER BY THE MOVEMENTS OF THE SHIP 24
      7.5.1. *Free oscillations* 24
      7.5.2. *Forced oscillations* 24
      7.5.3. *Height of the barometer above sea level* 25
      7.5.4. *Gravity correction* 26
   7.6. TYPES OF BAROMETERS USED IN THE MC 27
   7.7. THE SYMPIESOMETER 28
   7.8. THE ANEROID BAROMETER 30
8. TEMPERATURE 34
   8.1. GENERAL COMMENTS ON THERMOMETERS 34
   8.2. DRY- AND WET-BULB TEMPERATURES 36
   8.3. SEAWATER TEMPERATURES 36
   8.4. TEMPERATURE AT DEPTH 38
9. WIND DIRECTION AND FORCE 39
   9.1. WIND DIRECTION 39
   9.2. WIND FORCE 44
   9.3. WIND FORCE CONVERSION SCALES 47
10. WEATHER ABBREVIATIONS 49

11. ABBREVIATIONS 51
12. REFERENCES 52
APPENDIX I: FOREIGN ABSTRACT LOGS 54
APPENDIX II: LEAGUES, NAUTICAL MILES, FATHOMS 58

PREFACE

This report describes the metadata found in the logbooks of the US Maury Collection (1796-1861) that was digitized in China in the period 1993-1996 (see: icoads.noaa.gov/maury.html). Much of the metadata was missed during the digitization process. Although many errors in the Maury dataset have been removed by automatic quality control procedures, some important errors, resulting from incomplete metadata, may still exist. A future reprocessing of the data, based on additional metadata or new error detection procedures, may eliminate those errors. We hope that this report may provide valuable background information for such an attempt. The report may also serve as an example for current and future efforts to digitize historical ship logbooks.

The work described in this report can be considered as an early KNMI contribution toward the RECovery of Logbooks And International Marine data project (RECLAIM) (see: icoads.noaa.gov/reclaim). The work is also part of the KNMI-program HISKLIM (Historical Climate; Brandsma et al., 2000) that aims at making historical land and sea climate data from Dutch sources physically accessible, with the highest possible time resolution and quality.

1. INTRODUCTION

The U.S. Maury Collection (1796-1861), further denoted as MC, has been digitized in China during the years 1993-1996 by the China National Oceanographic Data Center (CNODC) in Tianjin. Approximately 1.4 million records of ship observations, with a vast majority after 1850, were digitized and added to the International Comprehensive Ocean-Atmosphere Data Set (ICOADS; NCDC, 1998). The MC includes 523 historical ship's weather logs stored in the National Archives and Records Administration (NARA) in Washington D.C. The logs mainly originate from the United States and the United Kingdom. However, appendix I gives a complete overview of the logs in the MC originating from other maritime countries. The original logbooks were copied onto 88 reels of microfilm to facilitate preservation of the paper logbooks (NARA, 1986). From these microfilms oversized paper copies were produced which were digitized in China. In addition, the logbooks are also available as digital images. Before being translated to the ICOADS data format (LMR6 = Long Marine Report, version 6) all digitized observations were processed through a series of quality control steps.

The MC partly covers a period where observation procedures and instruments were not standardized. The First International Marine Conference at Brussels in 1853 recommended for the first time accurate and carefully compared instruments for the use of meteorological observations on board of ships. Prior to the conference, observation procedures and instruments were not standardized, particularly between different countries.

Mariners were mainly triggered by the fluctuations of the meteorological instruments, as these indicated changes in weather. The absolute values related to the accuracy of the instruments, did not receive much attention. Scattered remarks in the logs may provide additional metadata and information on instrumental accuracy. Anecdotal evidence on how well the observers carried out their observations can sometimes be found as notes and remarks in the logs.

Historical logbooks like those of the MC are difficult to digitize, especially in a production mode where speed is a major factor for the data entry workers. Despite preliminary preparations and analysis to get the Maury logs ready for digitizing, it became clear that important metadata concerning the observation procedures and the type or scales of the instruments was not always recognized and consequently not entered in the digitized records (Elms, 1999). Bad handwriting and the inability to recognize what the observer had intended to convey, introduced gaps and errors in the metadata because it took too much time to make sense of some of the hardly readable remarks.

To complete the sparse metadata available from the MC, we tried to make sense of all the notes and remarks originally written by the logbook keepers. This work was facilitated by the availability of the digital images of the logbooks via the Internet with the aid of a NOAA application named WSSRD (Web Search Store Retrieve Display), recently replaced by a commercial product called EDADS (Environmental Document Access and Display System). Scrutinizing copies of the original logbook pages significantly enhanced the availability of undiscovered metadata.
In this report we describe the results of the search for metadata in all the logbooks used for the digitization of the MC. We present an overview of historical observing practices included in antique seaman's handbooks, together with the important logbook remarks for each ship separately. By assembling both the handbook procedures and the logbook remarks, we were able to compile a significant set of historical marine meteorological metadata. The resulting

documentation can be used for reprocessing historical marine datasets like the MC and serves as a an example for projects involving the digitization of ships' logbooks.

2. KEEPING THE JOURNAL AT SEA

Information that was of concern to the ship and that could influence the voyage was written down into logbooks, e.g. speed, distance, course, wind, weather, leeway and special events. First, the information collected on watch by the officer in charge was recorded on the log board or chalkboard at the end of the "day" (a sea day or nautical day being 12 noon to 12 noon). The first officer showed the information written down on the log board to the master for any corrections or additions, after which he transcribed the data into the logbook. The navigator used the logbook to make deductions, related to the ship's place. He did this every day at noon which operation was called a "day's work". While the ship was in a port, the remarks entered in the logbook were called "harbour work" and were noted in civil time.

2.1. *Log board*

The first column of the log board contained the 24 hours from the noon of one day to the noon of the following day. Logs from Dutch East India Company ships (VOC) show watches instead of hours. The second and third columns were for the ship's speed i.e. knots and fathoms per hour. Normally the knot was divided into eight fathoms of six feet each (see also Appendix II). The fourth column contained the courses steered by the compass. In the fifth column the wind direction (and sometimes the wind force also) was entered and in the sixth column the leeway of the ship. The seventh column contained additional remarks such as the state of the weather, the sails set, the variation of the compass and whatever was thought necessary. From the log board the officers of the ship took the information to compile their logbooks. The log board chalk was rubbed out every day at noon (Norie, 1828).

2.2. *Logbook*

The contents of the log board were copied daily into the logbook at noon, either at sea or in port. After correction, it was entered into the journal. On men-of-war (i.e. warships) or East-Indiamen the commanding officer usually signed the watches of the logbook (Falconer, 1780). In contrast to the journal, the logbook was the official record of a voyage. While the journal could be kept by any crew member, the logbook was most often kept by the first officer. It was the official record of the ship's voyage. However, despite the legal implications of keeping the logbooks, they were rarely systematically and meticulously kept during the 18th and first half of the 19th century (Norie, 1828).

2.3. *Journal*

The navigation journal is a kind of diary or daily register of the ship's course and distance sailed, winds and weather, together with a general account of whatever seemed important to be remarked during the voyage. In sea journals the day - or twenty-four hours - generally terminated at noon because then the errors of the dead reckoning could be corrected with the latest solar observation.

There were various methods of keeping a sea journal. Some preferred a journal including the logbook, each day's work at some length and important events. Others preferred a short abstract of this long journal containing little more than the course and distance run, the latitude and longitude and the wind for each day.

2.4. *Abstract log*

Meteorological abstract logs came into use after 1842 when Maury asked the captains to record meteorological information for the benefit of his "Wind and Current Charts". Meteorological observations were then copied from ship logs or journals into abstract logs of different layout. Prior to 1842, hardly any information is available about keeping the log on board of US ships. However, some logbooks contain procedures of the British Navy and merchant service (East India Company). British logbooks represent a significant part of the MC. Fortunately there were no differences in reporting procedures based on the country of registry.

After the Brussels' Conference, the form of the abstract log changed drastically. The logs were maintained during the voyage and then returned to the National Observatory in Washington, D.C., in exchange for free "Wind and Current Charts". In the United States the secretary of the Navy (the Hon. J.C. Dobbin) ordered that the abstract log, as recommended by the Conference at Brussels, had to be used on board of every man-of-war. He recommended the same to be done by merchantmen.

2.5. *Watches and bells*

Sailors normally divide the 24-hour day into six watches or six periods of 4 hours. During a watch one division of the ship's crew remained on deck, working, while the rest were relieved from duty, either when the vessel is under sail or at anchor. It was common practice to give these watches names. The purpose of dividing the dog watch (see Table 1) into two dog watches of 2 hours each - the 1st and last dog watch - is to provide an odd number of watches in the 24 hour day so that the starboard and larboard (or port) watches would keep a different watch each day. Strikes of the ship's bell were used to mark each half hour during the watch and were based on turning a half-hour sandglass. On each watch the bell would be struck once after the first half-hour glass was turned. On the second turn the bell was struck twice and so on every half hour until 8 bells at the end of the watch (after 4 hours).

<table>
<tr><th>Time</th><th>USA/UK</th><th>NETHERLANDS</th><th>GERMANY</th><th>FRANCE</th></tr>
<tr><td>Noon - 4 pm</td><td>Afternoon watch</td><td>Achtermiddagwacht</td><td>Nachmittagswache</td><td>Le quart de midi à quatre</td></tr>
<tr><td>4 pm - 6 pm</td><td>First dog watch</td><td rowspan="2">Platvoetwacht</td><td rowspan="2">Plattfusswache</td><td rowspan="2">Le quart de quatre à huit</td></tr>
<tr><td>6 pm - 8 pm</td><td>Last dog watch</td></tr>
<tr><td>8 pm - midnight</td><td>First watch</td><td>Eerste wacht</td><td>Abendwache</td><td>Le quart de huit à minuit</td></tr>
<tr><td>midnight - 4 am</td><td>Middle watch</td><td>Hondenwacht</td><td>Hundewache</td><td>Le quart de minuit à quatre</td></tr>
<tr><td>4 am - 8 am</td><td>Morning watch</td><td>Dagwacht</td><td>Morgenwache</td><td>Le quart de quatre à huit</td></tr>
<tr><td>8 am - noon</td><td>Forenoon watch</td><td>Voormiddagwacht</td><td>Vormittagswache</td><td>Le quart de huit à midi</td></tr>
</table>

Table 1: Sea watch names

The length of the sea watch is not equal in the shipping of different nations. The longest of the watches, in the American and British marine, is four hours. In France, the duration of the watch was rather different, being in some places 6, 7 or 8 hours (Falconer, 1780). This depended mainly on the origin of the ship.

During the 17th and 18th century Dutch sailors sometimes divided the 24 hours in 8 parts of 3 hours each named after the position of the sun.

Noon:	Zuiderzon,
3 pm:	Zuidwesterzon,
6 pm:	Westerzon,
9 pm:	Noordwesterzon,
Midnight:	Noorderzon,
3 am:	Noordoosterzon,
6 am:	Oosterzon,
9 am:	Zuidoosterzon.

3. DATE AND TIME

3.1. *Ship's time*

Abstract logs were kept in ship's time i.e. the local apparent time adjusted at intervals to the change of longitude. Apparent time, at any place, is the time deduced from the sun's culmination at noon (Nautical Almanac and Astronomical Ephemeris, 1804). By an old practice time adjustments on board were made at noon when the officer taking a sun sighting to determine their latitude called: "Twelve o'clock, sir", and the captain said: "Make it so". Once the sun crossed the ship's meridian, it was a new day.

At least up to 1806, the practice was to carry on at sea until a whole day had been gained (or lost) and then to make the change. While a ship was in port she might find her reckoning different from the port reckoning. But this was not altered, except perhaps temporarily (Hinks, 1935).

3.2. *The nautical day*

Logbooks were normally kept according to the nautical day i.e. they were copied from the log board at noon. The nautical day (or sea day) starts at noon or 12 hours before the civil day and ends at noon of the civil day. This way of reckoning stemmed from the custom of seamen dating their day's work for the preceding 24 hours the same as the civil day. Occurrences, that happened e.g. on Monday 21st afternoon, were entered in the log marked Tuesday 22nd (Norie, 1828).

The British Royal Navy shifted the beginning of a nautical day from noon to midnight in 1805 by an order of the British Admiralty (Circular of 11 October 1805), aiming to correspond with the civil reckoning. The merchant ships of the British East India Company ended the use of the nautical day in the 1820's. However, the logs of the MC show a much longer use of the nautical day, often until far after the Brussels' Conference of 1853.

Logs in the MC showing the nautical day

All logbooks have been checked for the type of day used. The logs of the following ships indicate that the nautical day was used. Note that there are several ways to express this:

Name	Year	Reel	Volume	Sequence	Remarks
Bark George And Henry	1847	74	289	223	Ship time
Ship Favourite	1847	29	106	188	Log kept in Nautical Time
Ship Milan	1849	32	121	880	Sea act
Ship Yorkshire	1849	43	162	145	Sea account
Bark Mollie Metcalf	1850	56	198	88	Sea time
Ship Plantagenet	1853	16	51	27	This log is kept in nautical time and therefore ends at noon each day
Bark Gleaner	1854	15	50	876	This journal is kept by sea account
Ship Henry Ware	1854	33	124	790	The time inserted in this abstract is sea time
Ship Nightingale	1854	48	180	58	This log is kept by sea account
Ship Torrent	1854	55	197	356	This abstract is kept sea time
Bark Petrea	1855	63	214	416	N.B. This log is kept in sea time

Name	Year	Reel	Volume	Sequence	Remarks
Brig Balclutha	1855	74	288	45, 46	This log is dated from noon
Ship Antelope	1855	61	209	344	Friday the 7th civil or Saturday the 8th sea account; Sea account used
Ship Corinne	1855	51	188		Sea acct has been kept
Ship Ringleader	1855	33	124	628	Time noted herein is sea account
Bark John Carver	1856	59	205	366	The time used in the following abstract is Sea Time
Schooner Conquest	1856	51	188	352	NB. This Abstract is kept after Nautical time account
Screw steam ship Royal Charter	1856	11	297	296	Nautical time
Ship S. H. Talbot	1856	53	193	493	This journal is kept in sea time
Bark Sarah H. Snow	1857	62	212	748	The time used in this abstract will be Nautical
Schooner Lewis Perry	1857	55	197	483	Sea time
Ship Sabine	1857	55	197	605	This log commences sea a/c on this 13th June 1857
Ship Eagle Wing	1859	65	218	361	Sea days to correspond with my private journal
Ship Tropic	1859	48	181	430	My journal is dated & ends with the sea time
Ship Escort	1860	49	183	72	This log will be kept by nautical or sea time

3.3. *The civil day*

The civil day begins at midnight and ends at the following midnight. The day is divided into two equal parts of twelve hours each. The first part (from midnight till noon) marked A.M., signifying *Ante Meridiem* or before noon, and the latter 12 hours (from noon till midnight) are marked P.M., signifying *Post Meridiem* or afternoon. At the Brussels' Conference the civil day was adopted to be used on all sorts of ships (Navy and merchant) or if not, the type of day should be given in the logbook.

Logs in the MC showing the civil day

The logs of the following ships indicate that the civil day was used. Ships not indicating the type of time used (nautical, civil or astronomical) probably used the civil day:

Name	Year	Reel	Volume	Sequence	Remarks
Ship Nebraska	1848	77	388	243	Civil Time Mid to Mid *[edtr.: midnight to midnight]*
Ship Vandalia	1849	15	47	34	Civil time
Bark J. E. Donnell	1851	39	147	42	This log is reckoned for civil time
Ship North Carolina	1853	37	140	622	Ship for San Francisco of which the following is the abstract in civil time
Bark Le Cocq	1854	47	178	67	Civil time throughout
Ship John Adams	1854	67	222	96	This log is kept according to the directioned civil time being used

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Bark Garland	1855	48	180	177	Civil time
Frigate Constitution	1855	55	196	255	Civil time is kept throughout this abstract
Ship Flying Dutchman	1856	59	204	13	Civil Time
Bark Etha	1859	65	218	275	The dates and days are civil time and begin at midnight
Ship Ilion	1859	49	183	230	The time is civil time, counted from 12 at night to 12 at night

3.4. *The astronomical day*

The astronomical day begins 12 hours after the civil day according to the time used in the Nautical Almanac, first published in 1767, and was used for navigation. It is generally reckoned through the 24 hours from noon to noon and what are by the civil way of reckoning called morning hours are by astronomers reckoned in succession from 12 or midnight to 24 hours (Norie, 1828). The astronomical day was shifted from noon, twelve hours after midnight, to midnight per 1 January 1925 (Resolution 6 of the International Meridian Conference, Washington D.C., 1884).

Logs in the MC showing the astronomical day

The logs of the following ships indicate that the astronomical day was used:

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Ship London	1832	84	494	334	Astronomical time
Ship Admiral	1848	88	534	78	Astronomical account
Bark Cordelia	1849	21	70	123	Astronomic time having this journal
Brig Mozambique	1853	73	333	328	Astronomical time (Portuguese: *O Tempo he Astronomico*)
Ship Golden Gate	1854	61	209	491	Astronomical time
Ship Petrel	1854	66	221	720	This log is kept by sea time. The 1st of January commencing on the 31st December at Noon Astronomical time
Bark Amazon	1855	47	179	362	Astronomical account
Ship Starlight	1858	51	189	676	Astronomical time
Ship Wild Pigeon	1858	57	200	64	This log is astronomical time

The astronomical day begins at noon of the civil day, which is the end of the nautical day. Hence, it appears that the noon of the civil day, the beginning of the astronomical day, and the end of the nautical day, take place at the same time and date (Table 2). However, sometimes there may be some confusion, as for the following ships.

Logs in the MC showing mixed astronomical and nautical day

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Ship Golden Rule	1855	59	205	504	Astronomical time or nautical
Ship Bremen	1856	45	175	737	The time inserted in this abstract log is astronomical (or sea) time
Ship Alice Thorndike	1857	68	226	572	This log will be kept with astronomical or sea account throughout this voyage

For the above ships it would be best to assume nautical time, as the use of astronomical time required skilled personal on board, which was not always available.

Traditionally, ships left port or the roads at civil time (shore time) and changed to nautical time or astronomical time at sea:

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Ship Arcole	1848	88	534	237	Discharged our pilot at 3 P.M. Monday civil account or Tuesday 7 Nov. sea account
Ship Liverpool	1849	23	80	322	Remarks 21st April 1849: At 1.30 p.m. the steamer Ajax came alongside and we got under weigh in tow of the steamer and proceeded down the Bay. At 4.50 p.m. crossed the bar and at 5 p.m. the steamer let go of us and we made all sail. Now we commenced sea account 22nd April 1849
Bark Home	1850	74	289	230	This day contains 36 Hours to regulate Sea account
Ship Masconomo	1850	16	52	541	After discharging the pilot off the Hook: “Here ends civil, commences sea account”
Ship Great Britain	1852	43	164	419	At 11 a.m. Civil account cast off from wharf & proceeded to sea in tow of steam tug ... At 3 p.m. Sea account steamer left us outside the bar
Ship Panther	1854	55	196	137	The American ship Panther ... has passed Boston Lighthouse on Saturday March 4th civil time and March 5th Sea time, which latter will continue to be used in this Abstract until farther notice
Ship Swan	1854	16	51	82	In port and at anchorage: Civil time; At sea: Sea account
Bark Evangeline	1856	62	211	256	At noon passed the Boston Light house, here ends civil Time
Bark Powhattan	1857	60	207	353	First 3 days of the log in Chesapeake Bay at Civil Time, then Sea Time

Name	Year	Reel	Volume	Sequence	Remarks
Schooner Lightning	1857	57	200	169	At 4 A.M. civil time sailed from Hanton Roads at noon leave Cape Henry bearing - NW dist 10 miles and ends this day of civil time with 12 hours and commences Sea time
Ship Nabob	1857	62	210	11	In port: civil time; at sea, behind the bar and during voyage: Sea time
Ship Archer	1858	51	189	543	Day of departure: Civil time; during the passage: Sea time

3.5. ***Crossing the date line***

On crossing the 180th meridian from Greenwich the navigator normally adds or subtracts a day to or from the vessel's reckoning. Prior to 1840 the navigator did not change the date in the ship's log until he had circumnavigated the globe, thereby making the nautical day, the civil day, and the astronomical day subject to an error (Bartky, 2002). If this is not taken into account in the quality control of the data, it may lead to serious errors.
Logs in the MC showing remarks on crossing the date line

The following logs show remarks on the date line crossing, which were not always noted in the digitization process:

Name	Year	Reel	Volume	Sequence	Remarks
Ship India	1849	33	122	141	Omitted writing the 27th as we have come into East Longitude
Ship Thomas B. Wales	1852	31	114	244	Changing time. September 26th was skipped
Ship Malay	1853	86	524	669	Passing into East longitude we drop this day
Brig Juliet	1854	3	4	314	After crossing the date line, written into the log as "changed the day for crossing 180", the longitude in the log changed from east to west but remained east in MC in the ICOADS database (causing the ship to "bounce" at the date line)

3.6. ***The use of the nautical day after the Brussels' Conference in 1853***

After the Brussels' Conference nautical time was abolished as being inconvenient. The only advantage it possessed was finishing the day's work and the date together at the same time. Noon of the astronomical day is at the instant that it begins and noon of the nautical day is at the instant when it ends. As both take place on the noon of the civil day of the same date it is plain that the same noon answers for any given day in the three methods of reckoning time (Thomson, 1857).

Around 1900 the opinion was that "the barbarism of reckoning by a nautical day 12 hours in advance of the astronomical day cannot be too much deprecate and must have frequently led to errors in the computation of the astronomical data. Besides, two modes of reckoning must surely be enough, without the complication of a third, and wholly useless, date" (Norie, 1900).

We cannot say that after the Brussels' Conference all records in the logs used civil time. Many ships continued to report their observations according to nautical time, the normal time that seamen were used to. The time reckoning that was used often is given in the "Remarks section" of the log.

Watch	Part of the day	Civil day; commences at midnight		Nautical day; ends at noon		Astronomical day; commences at noon	
Middle watch	Middle	**Midnight**	**Monday May 10**	**Midnight**	**Monday May 10**	**Midnight**	**Sunday May 9**
"	"	01 AM	Monday May 10	01 AM	Monday May 10	13	Sunday May 9
"	"	02 AM	Monday May 10	02 AM	Monday May 10	14	Sunday May 9
"	"	03 AM	Monday May 10	03 AM	Monday May 10	15	Sunday May 9
Morning watch	Latter	04 AM	Monday May 10	04 AM	Monday May 10	16	Sunday May 9
"	"	05 AM	Monday May 10	05 AM	Monday May 10	17	Sunday May 9
"	"	06 AM	Monday May 10	06 AM	Monday May 10	18	Sunday May 9
"	"	07 AM	Monday May 10	07 AM	Monday May 10	19	Sunday May 9
Forenoon watch	"	08 AM	Monday May 10	08 AM	Monday May 10	20	Sunday May 9
"	"	09 AM	Monday May 10	09 AM	Monday May 10	21	Sunday May 9
"	"	10 AM	Monday May 10	10 AM	Monday May 10	22	Sunday May 9
"	"	11 AM	Monday May 10	11 AM	Monday May 10	23	Sunday May 9
Afternoon watch	First	**Noon**	**Monday May 10**	**Noon**	**Monday May 10**	**Noon**	**Monday May 10**
"	"	01 PM	Monday May 10	01 PM	Tuesday May 11	01	Monday May 10
"	"	02 PM	Monday May 10	02 PM	Tuesday May 11	02	Monday May 10
"	"	03 PM	Monday May 10	03 PM	Tuesday May 11	03	Monday May 10
(1st) Dog watch	"	04 PM	Monday May 10	04 PM	Tuesday May 11	04	Monday May 10
"	"	05 PM	Monday May 10	05 PM	Tuesday May 11	05	Monday May 10
(Last) Dog watch	"	06 PM	Monday May 10	06 PM	Tuesday May 11	06	Monday May 10
"	"	07 PM	Monday May 10	07 PM	Tuesday May 11	07	Monday May 10
First watch	Middle	08 PM	Monday May 10	08 PM	Tuesday May 11	08	Monday May 10
"	"	09 PM	Monday May 10	09 AM	Tuesday May 11	09	Monday May 10
"	"	10 PM	Monday May 10	10 AM	Tuesday May 11	10	Monday May 10
"	"	11 PM	Monday May 10	11 AM	Tuesday May 11	11	Monday May 10
Middle watch	"	**Midnight**	**Tuesday May 11**	**Midnight**	**Tuesday May 11**	**Midnight**	**Monday May 10**
"	"	01 AM	Tuesday May 11	01 AM	Tuesday May 11	13	Monday May 10
"	"	02 AM	Tuesday May 11	02 AM	Tuesday May 11	14	Monday May 10
"	"	03 AM	Tuesday May 11	03 AM	Tuesday May 11	15	Monday May 10
Morning watch	Latter	04 AM	Tuesday May 11	04 AM	Tuesday May 11	16	Monday May 10
	"	05 AM	Tuesday May 11	05 AM	Tuesday May 11	17	Monday May 10
	"	06 AM	Tuesday May 11	06 AM	Tuesday May 11	18	Monday May 10
	"	07 AM	Tuesday May 11	07 AM	Tuesday May 11	19	Monday May 10
Forenoon watch	"	08 AM	Tuesday May 11	08 AM	Tuesday May 11	20	Monday May 10
	"	09 AM	Tuesday May 11	09 AM	Tuesday May 11	21	Monday May 10
	"	10 AM	Tuesday May 11	10 AM	Tuesday May 11	22	Monday May 10
	"	11 AM	Tuesday May 11	11 AM	Tuesday May 11	23	Monday May 10
Afternoon watch	First	**Noon**	**Tuesday May 11**	**Noon**	**Tuesday May 11**	**Noon**	**Tuesday May 11**
	"	01 PM	Tuesday May 11	01 AM	Wednesday May 12	01	Tuesday May 11
	"	02 PM	Tuesday May 11	02 AM	Wednesday May 12	02	Tuesday May 11
	"	03 PM	Tuesday May 11	03 AM	Wednesday May 12	03	Tuesday May 11
	"	04 PM	Tuesday May 11	04 AM	Wednesday May 12	04	Tuesday May 11

Table 2: Different days in use at the beginning of the 19th century

4. GEOGRAPHICAL POSITION

Before the 19th century navigational instruments were unsophisticated, chronometers at sea were unknown and it was not uncommon for vessels in those days, when crossing the Atlantic, to be 5°, 6° and even 10 degrees of longitude away from their computed position. Ships sailed in company and requested convoys for protection. The speed of the fastest in the convoy was controlled by the slowest of them all. Because the navigator was unable to calculate the longitude, navigation was done by "running down the latitude" i.e. the practice to steer south until the latitude of their port was reached and then to steer due east (or west) along the same latitude until they made land. After the thermal investigations of the Gulfstream by Benjamin Franklin and Sir Charles Blagden around 1775 the sea thermometer came in use for navigation across the Atlantic.

Clocks that kept time at some reference position, usually the home port, were carried on board most ships at the beginning of the 19th century. If time at a reference longitude was known, navigators could take "lunar distance" measurements from key stars and the moon, and use look up tables to determine their longitude. When the sky was overcast, navigators were forced to calculate the ship's position by dead reckoning. With the speed of the ship, established with a log line (see Appendix II), the true course steered and determined leeway, it was possible to calculate an estimated noon position.

The position by dead reckoning was deduced from the last observation of latitude or longitude. In Dutch logs prior to the Brussels' Conference, it was common to leave the longitude, found by dead reckoning, uncorrected during the whole trip (KNMI, 1853). American and British ships normally logged the longitude with respect to the meridian of Greenwich. Distances were given in leagues or nautical miles (see Appendix II).

Logs in the MC showing remarks on geographical position

Of all ships, only the following give some information about the way the geographical position was determined:

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Brig Boxer	1796	74	354	887	The latitude was obtained by a meridian altitude of the moon
Ship Ann McKim	1843	87	527	71	The latt-s and long-s with a cross over them are not by observation but by "day's work" *[edtr.: dead reckoning]*
Ship San Giovanni	1853	27	96	204	Longitude W. of Paris

5. CURRENT

The reported current is the difference in miles between the position of the ship found by dead reckoning and by observation in the 24 hours before noon. The current per hour is the effect of the current on the ship divided by 24. In this way, strong currents may be crossed without being detected (Maury, 1848). Suppose a vessel sailing at the rate of 10 knots, would cross a current 30 miles broad running at a rate of 4 knots. The vessel would be exposed to the current 3 hours, be carried 12 miles out of her course and log 240 miles during the 24 hours. The usual method would be to divide these 12 miles by 24 and say that the vessel has had a current of half a knot and a breadth of 240 miles instead of a current of 4 knots and 30 miles broad.

To prevent such erroneous inferences, men-of-war were recommended regularly to determine their position by observation in the afternoon and at night, as well as AM and at noon. Merchantmen were requested, in the manner most convenient to themselves, to enter the limits of currents and their set and temperature under the head of Remarks (Reel 85, Vol. 511, Maury's explanations, 1848). The current set is always the true direction.

Logs in the MC showing remarks on ocean currents

Of all the ships the following have information on currents:

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Bark Albert Edward	1847	75	376	694	The amplitudes and azimuths were observed in the most favorable weather and with the utmost care; - for it is only by allowing the correct variation that a good approximation of the set of a Current can be arrived at
Bark Albert Edward	1848	32	119	416	All bearings are Magnetic except these used to show the bearing of any place and the set of the Current which is in the true direction
Ship Nebraska	1848	77	388	243	Direction true
Ship Saratoga	1848	76	381	208	The current was obtained by taking the difference between the dead reckoning and the observed reckoning and are of course widely incorrect
Schooner Lydia	1850	16	52	501	The currents are estimated
Ship India	1851	33	122	171	The Currents and other Bearings are their true Courses
Ship Peruvian	1852	22	77	608	The courses of the currents are calculated for the true course, the other courses are by compass
Ship Molay	1853	15	50	683	My Currents are the difference between D.R. & Obs.
Ship San Giovanni	1853	27	96	204	Knots in 24 hours

Name	Year	Reel	Volume	Sequence	Remarks
Ship Antelope	1855	61	209	344	True course; in miles per hour
Ship Marion	1855	74	288	152	Direction true
Bark Etha	1859	65	218	275	The current marked is true course

In the digitization process the above information was lost.

6. COMPASS VARIATION

In order to calculate the true direction of the courses the variation of the compass (= magnetic deviation) should be determined with an azimuth compass or bearing compass (Fig. 1). The difference between a compass bearing of the sun at sunrise or sunset, and the true bearing, looked up in a table, gives the variation. A bearing compass holds a card divided in degrees and is additionally equipped with a sighting apparatus on top of the box in order to take bearings from celestial bodies, landmarks, or the ship's wake to determine the leeway. The portable bearing compass, suspended in a small wooden box, could be placed anywhere on the ship. However, the local compass deviation due to the ship's iron was neglected in this way. A man-of-war could carry 74 heavy iron guns, but a compass deviation table was not available on board. During the first half of the 19th century compass deviation tables were seldom if ever given in the logbooks.

Many ships did not have an azimuth compass on board. They used the variation taken from variations charts, tables or from other ships who sailed the same route before. In this respect, consider the remark of Captain R.W. Foster (Ship Garrick, 1854; Maury, 1854) sailing between New York and Liverpool: "Such is the selfishness of merchants that not one out of 50 will allow the ship an azimuth compass, thousands may be expended on embellishments".

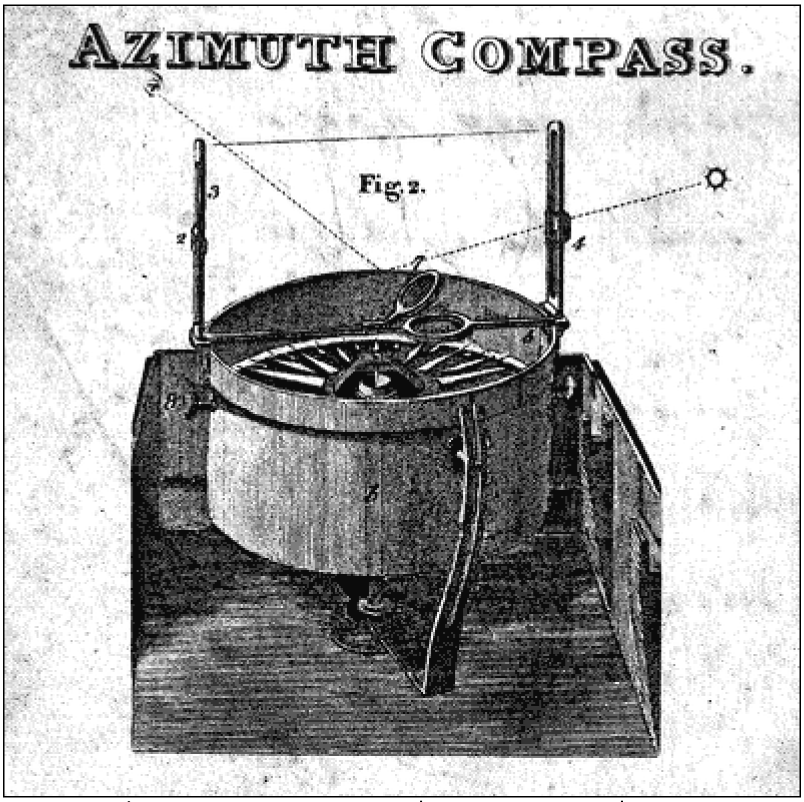


Figure 1: Bearing or Azimuth compass around 1820

Admiralty ships of the Dutch East India Company (VOC) usually carried three bearing compasses. For instance Admiralty ship **Zeeland**, 1786: One azimuth compass on the half deck, one bearing compass on the poop deck, and one in the waist of the ship. Sometimes all compasses were situated on the half deck.

The magnetic variation was determined by the average of the horizon morning bearing, an azimuth bearing and the horizon evening bearing. If the variation be easterly, allow it to the right hand of the course steered but if westerly, to the left hand by which you will obtain the true course.

On smaller ships, the observations of the variation of the compass could be taken but seldom exactly. Vessels of about a 100 tons burden most of the time are being too unstable for correct bearings. On the jumping little ships the needle was in too unsteady a state (Maury, 1851). Packet ships of 300 to 400 tons burden were sailing regular between New York and Liverpool monthly around 1820. Ships of 2000 tons burden were sailing on a daily base around 1850.

Logs in the MC showing remarks on the compass variation

The following logs give information on the compass variation:

Name	Year	Reel	Volume	Sequence	Remarks
Ship Bengal	1804	71	252	695	Variation both estimated and observed
Bark Albert Edward	1847	75	376	694	All bearings are Magnetic except those used to show the Bearing and Distance of any place and the Set of the Current, - which is in the true direction
Bark Home	1848	73	281	269	The variation allowed as per Table LIII, page 330, Bowditch. Not having an Azimuth compass on board
Schooner Lydia	1850	16	52	501	No Azimuth compass on board and no means of observing the Variation correctly and have therefore used Barlow's Table
Bark J. E. Donnell	1851	39	147	42	All bearings in this log by compass
Ship Arabella	1853	16	51	296	No Azimuth compass aboard
Brig Mozambique	1854	73	333	330	Compass needle not to be trusted (Portuguese: *A agulha não merece confiança*)
Ship Ringleader	1855	33	124	628	Courses are by compass
Steamer Arctic	1856	45	175	461	Our compasses will prove troublesome, there being now a difference between them of two points
Ship Robert H. Dixey	1857	60	207	402	Ship has 2 common light compasses, one of brass, one of wood. One heavy compass below & fitted for stormy weather. Local variation undetermined
Schooner Lewis Perry	1858	60	206	261	No local deviation of the compass has ever been observed on board of her. All courses and bearings mentioned in this log are by compass unless otherwise expressed

7. AIR PRESSURE

Prior to the Brussels' Conference, the barometer was mainly used to warn the mariners of changes in weather by the fluctuations in air pressure. The accuracy of the absolute pressure values received little attention. Makers seldom, if ever, determined the real errors of these instruments, or if known the corrections were never or seldom provided to the customer. Sailors often did not notice the barometer when it ranges high, whether the weather is fair or foul they consider that so long as it stands high they have every security for carrying a heavy press (Maury, 1855).

A remark was made for the first time in 1773 that a ship's barometer (Nairne & Blunt) was fixed in gimbals and kept in a perpendicular position by a weight fastened to the bottom of it. The bore of the upper part of the glass tube is about 0.3 inch in diameter and four inches long. To this a glass tube with a bore of 0.05 inch in diameter is joined. The two joined glass tubes form the tube of the barometer.

At the Brussels' Conference it was observed: "That an instrument so rude and so abundant in error, as the marine barometer generally in use, should in this age of invention and improvement be found on board any ship, will doubtless be regarded hereafter with surprise; and that it will be wondered how an instrument so important to meteorology and so useful for navigation, should be permitted to remain so defective that meteorologists, in their investigations concerning the laws of atmospheric pressure, are compelled, in great measure, to omit all reference to the observations which have been taken with them at sea" (Maury, 1855).

Maury also stated that the barometer is one of the most imperfect instruments used for navigation. It is common to find them with an undiscovered error of 0.5 inch (sic!). Observations with the common marine barometer are worth little and observations with the aneroid barometer "next to nothing" (Maury, 1855).

7.1. ***The common marine barometer***

Around 1830 the marine barometer commonly used had its frame largely made of wood - mahogany and rosewood - a boxwood cistern with an adjustable leather (chamois) bottom and the scale and vernier in a glass-fronted case. Wooden marine barometers are sensitive to air moisture, which made the observations unreliable. For this reason, the Dutch Prof. Buys Ballot rejected all the observations from wooden barometers (KNMI, 1853). Marine barometers with wooden frames and cisterns continued to be made until 1854. In 1853 the Kew marine barometer, developed by Patrick Adie, was constructed in order to meet the requirements of the Brussels' Conference. The difficulties encountered in the common marine barometers were overcome with this new barometer. Its distinguishing characteristics consisted of an iron cistern having no adjustment, the tube below the scale contracted and with a shortened scale to compensate for variation of mercury level in the cistern. Other advantages of this barometer were that only corrections for temperature and index error had to be applied. Capacity and capillary corrections were not necessary any more.

At the Brussels' Conference it was adopted that the barometer should have an attached thermometer and if none were attached, one should be tied to the lower end of the barometer. The thermometer of the barometer often was placed in a separate small cabinet attached to the barometer frame. Sometimes the thermometer was attached to the inside of a little door that covered the vernier and barometer scales (Fig. 2). Recommended good marine barometers around 1854 are the Kew pattern of Patrick Adie, 395 Strand, London and the standard marine barometers furnished by James Green, 422 Broadway, New York.

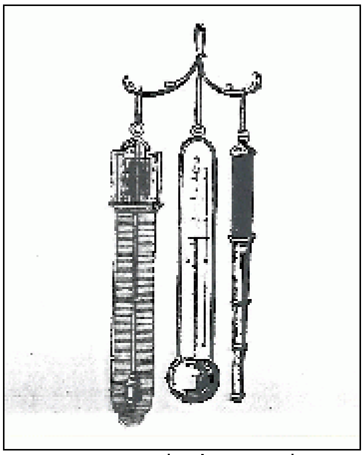


Figure 2: Barometer, thermometer and telescope hanging in the captain's cabin

7.2. ***Observation time of the barometer***

Often barometer observations were taken only at meridian each day or at midnight instead of 9 am as prescribed by the Maury Explanations. Often "Noon" is then written in the header of the barometer column.

7.3. ***Location of the barometer***

The best place for fixing a marine barometer on board is amidships, between the cabin windows rather than at the side. The barometer will not be so much affected in that situation by the violent rolling or lurching of a ship in a heavy sea. But in cabins where this cannot be done, it is advisable to nail something soft on that part of the ship's side against which the cistern of the instrument is likely to strike (Dennis, 1825).

It is difficult to imagine that the seaman would have mounted the valuable barometer in the open air exposed to all weather elements and not in the protection of the cabin. This can be illustrated by a report of the schooner **Fawn** sailing from Baltimore to Jamaica in 1852 and running into a hurricane. "On the 29th, continued gales, sometimes little lulls, when the wind would come again with increasing force. My wife in the cabin states the barometer still falling. From 7 hours 30 minutes P.M. until 10 P.M. a gradual change took place in the wind, and my wife told me, after I went below, that the barometer had not fallen since 10 P.M." (Maury, 1854).

Generally, the barometer was not kept in the open air. The usual place for the barometer was the captain's cabin. The stoves in the cabin and the heat of the crew below the captain's cabin however tend to equalize the cabin temperature (Maury, 1852).

Logs in the MC showing the location of the barometer

The following ships in the MC give information on the location of the barometer:

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Ship Defiance	1853	48	180	84	Barometer ... hanging in lower cabin
Bark Rebecca	1854	67	222	198	Barometer suspended in the skylight where sun comes on it afternoon
Ship Ez	1854	56	199	632	The Stove pipe was close to the Barometer caused a uniform temp.
Bark Garland	1855	48	180	177	Having a stove in the Cabin it necessarily affects the attached thermometer
Brig Globe	1855	55	196	284	One Mercurial Barometer ... The barometer is placed in the cabin, which is on deck about ten to twelve feet above the level of the sea when loaded
Ship Livingston	1855	47	179	428	Having a fire in the cabin I consider it is hardly worth noting the thermometer attached
Ship Emilia	1856	50	186	357	Barometer hangs in a house on deck, companion way or entrance at the cabin
Ship Great Republic	1856	45	175	771	The thermometer attached to barometer will differ from the other as the barometer is hung under the cabin skylight where the reflecting of the sun can strike it
Ship Ann Maria	1857	62	212	455	set the fire *[edtr.: stove]* on in the cabin
Ship John Q. Adams	1857	68	226	593	Attached thermometer on deck on account of a fire *[edtr.: stove]* in the cabin until to the 22nd
Ship Robert H. Dixey	1857	60	207	402	Barometer & attached thermometer in the forward cabin
Ship Ocean Telegraph	1859	49	184	336	The barometer hangs in the cabin where it feels the effects of the stoves

7.4. ***Barometric corrections***

The instruments used in the MC were for the most part the old-fashioned marine barometers, to which no corrections have been applied (Maury, 1860).
Air pressure observations from mercurial barometers prior to the Brussels' Conference should be corrected for:

- Capacity,
- Capillarity,
- Temperature,
- Height,
- Index,
- Gravity (latitude).

7.4.1. Capacity or cistern correction

The relation between the diameter of the mercury in the cistern around the tube and the diameter of the mercury in the tube at the top of the mercury column is called the capacity.

Capacity correction = (reading - neutral point) / capacity

The neutral point of the barometer is the reading at a temperature of 0° Celsius, where point zero of the scale coincides with the mercury level in the cistern. The sign of the correction determines how the correction should be applied. Usually a depression of the mercury level is found. Both capacity and neutral point should be noted on the first pages of the ship's logbook. However, this information is seldom if ever available in abstracts of the MC.

7.4.2. Capillarity correction

The fine capillary glass tube of the barometer causes a depression of the mercury level in the tube, causing a reading of the barometer that is too low. The size of the error depends on the diameter of the glass tube.

Diameter (mm)	Correction (mm)
10.0	+0.42
9.5	+0.47
9.0	+0.53
8.5	+0.60
8.0	+0.68
7.5	+0.77
7.0	+0.88
6.5	+1.00
6.0	+1.44

Source: Bouvard. Mémoire de l'Academy Royal des Science de l'Institut de France. Tom VII, p. 332.

A practical problem concerning ship's barometer was that the constricted tubes with small bores usually broke when firing the ship's guns. The British Hydrographer Fitzroy attacked this serious problem in naval vessels around 1860. He developed a marine barometer with the tube shock-mounted in rubber.

7.4.3. Temperature correction

Prior to the Brussels' Conference the temperature of the mercury was mostly not observed because the attached thermometer was out of order or missing. Often the cabin temperature was observed instead of the temperature of the mercury.

The first reference of the practice of fixing a thermometer with its bulb in the barometer cistern, for ascertaining the proper temperature of the mercury, is found in a paper by Newman in the Quarterly Journal of Science for 1824.

One of the most influential and for many years widely used sets for the temperature correction was published by Guyot. The set contained separate tables for barometers in English inches, with brass scales, the same with glass or wooden scales, for metric barometers with brass scales and for barometers graduated in Paris lines (Guyot, 1859).

7.4.4. Index correction

The index correction, caused by instrumental errors, is related to the positioning of point zero on the scale. To determine this error, the barometer was compared to a standard barometer of which the errors were accurately known. Inexperienced use or negligent treatment of the barometer could change the index correction; therefore additional inspectional observations were necessary. Often contamination of the mercury or air bubbles inside the mercury caused a depression of the barometer reading.

7.5. *Factors influencing the absolute accuracy of the barometer by the movements of the ship*

Square-rigged sailing ships were very difficult to trim and most of the time they were rolling and pitching due to the waves and swell. Also during calms the ships were rolling on high swell as much as at wind force 11 on the waves. Pumping of the mercury in the tube and free and forced oscillations of the barometer caused by the movements of the ship were able to reduce the barometric height (Adie, 1819).

> Ship Buckinghamshire, 1816: "The motion of the ship, which will often make the quicksilver in the common tube plunge, or rise or fall, in such a degree as to make it very difficult to come within at least one or two tenths of an inch of the truth, even in the largest ships".

The motions of roll, pitch and yaw of the ship were often responsible for incorrect values when barometers were suspended to the bulkhead. This was caused by swinging of the marine barometer on its gimbals and the motion of the support itself. Marine barometers were frequently made with spiral springs fastened to the bulkhead. In a rolling sea, this would prevent major damage to the barometer. However, during bad weather often the springs were not released during the observation, which could lead to discrepancies between the measured air pressure and the real air pressure.

7.5.1. Free oscillations

Due to swinging on its gimbals the barometer is inclined away from the vertical hence the reading is greater. In particular, if the long axis of the barometer tube deviates from the vertical by an angle A, when the observed reading of the barometer is r, the correction to overcome this error is:

$$\text{Correction} = -r\ (1-\cos A)$$

At an angle of 1.0° the correction would be -0.0046 inch or -0.155 hPa and at an angle of 5° already -3.9 hPa.

7.5.2. Forced oscillations

In 1923, the effect of the motion of the support itself due to the rolling of the ship was determined. A theoretical relationship was figured out showing the relative error due to the forced oscillations neglecting the effect of the free oscillations that might be present simultaneously. The motion of the support gives rise to a centrifugal force having a component vertically downward and this component is added to the local acceleration of gravity. Whether the mean displacement of the mercury is one of depression or elevation depends on whether the centrifugal force on the mercury is strong enough to overcome the run up of the mercury in the tube (Giblett, 1923). For Kew barometers after 1854 the result is an elevation of the order of a millibar or hectoPascal (Gold, 1908). Also it was determined which adjustments could be made in order to cause the opposing effects cancel out. This was done by altering the position of the point of suspension moving it up or down the barometer tube (Duffield and Littlewood, 1921).

7.5.3. Height of the barometer above sea level

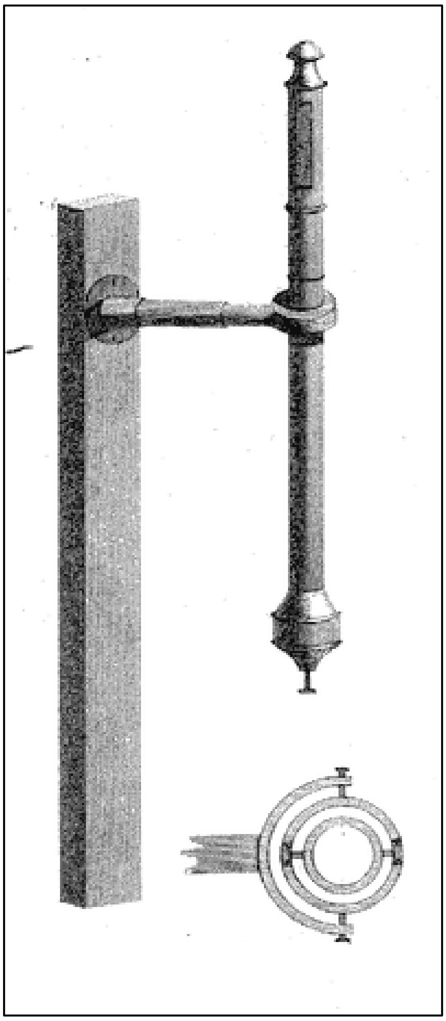
On board square rigged ships and clippers the barometer height usually varied between 7 and 20 feet above the level of the sea depending on the load of the ship.

Logs in the MC showing remarks on the barometer height above the level of the sea

Name	Year	Reel	Volume	Sequence	Remarks
Ship Defiance	1853	48	180	84	Passage to Callao the height of the barometer above the level of the sea about 12 feet. Passage home about 10 feet
Bark Levanto	1854	47	179	456	Mean height above the sea level is 12 feet
Bark Rebecca	1854	67	222	198	Height of Barometer from sea is 15(?) feet
Ship Shooting Star	1854	47	178	39	Mean height of bar. above sea 10 feet
Ship Bremen	1856	45	175	737	mean height of Barometer above the sea, 16 feet
Ship Emilia	1856	50	186	357	Barometer about 18 feet from sea surface
Ship Roebuck	1856	59	205	415	Barometer height 15 feet
Ship S. H. Talbot	1856	53	193	493	Mercurial 19 feet above level of sea
Bark Ottawa	1857	48	182	737	Cargo hay: cistern of barometer 12 feet above the level of the sea; Cargo Pitch pine lumber: cistern of barometer 9 feet 6 inch above the level of the sea; Cargo sugar: cistern of barometer 9 feet above the level of the sea.
Bark Sam Slick	1857	59	205	402	Barometer about seven feet above water
Bark Sarah H. Snow	1857	62	212	748	Mean height of (aneroid) barometer 12 feet 6 inches
Ship Beverly	1857	49	185	485	Barometer 13 feet above the water
Ship Robert H. Dixey	1857	60	207	402	Barometer from 15 to 20 feet above the sea level
Ship S. H. Talbot	1857	53	193	505	Barometer height 18 feet above level of the sea
Ship S. H. Talbot	1857	53	193	511	Barometer height 12 feet above level of the sea
Brig Wanderer	1858	57	200	80	Mean height of the barometer (aneroid) above the level of the sea 6 feet
Ship Ocean Telegraph	1859	49	184	336	The barometer is twelve feet above the level of the sea
Ship Prima Donna	1859	52	190	38	Outward: Height of the Barometer above the Sea 12 feet; Homeward in Ballast: Height of Barometer above the Sea 21 feet.
Steamer General Serrano	1859	49	183	155	Cistern of Barometer 8 feet above Sea level
Ship Escort	1860	49	183	71	Barometer suspended twenty feet above the level of the sea

7.5.4. Gravity correction

The gravity correction was normally applied after the journey. This correction was standard for mercury barometers but there were also barometer that did not need gravity correction. The next section presents an overview of the barometers.



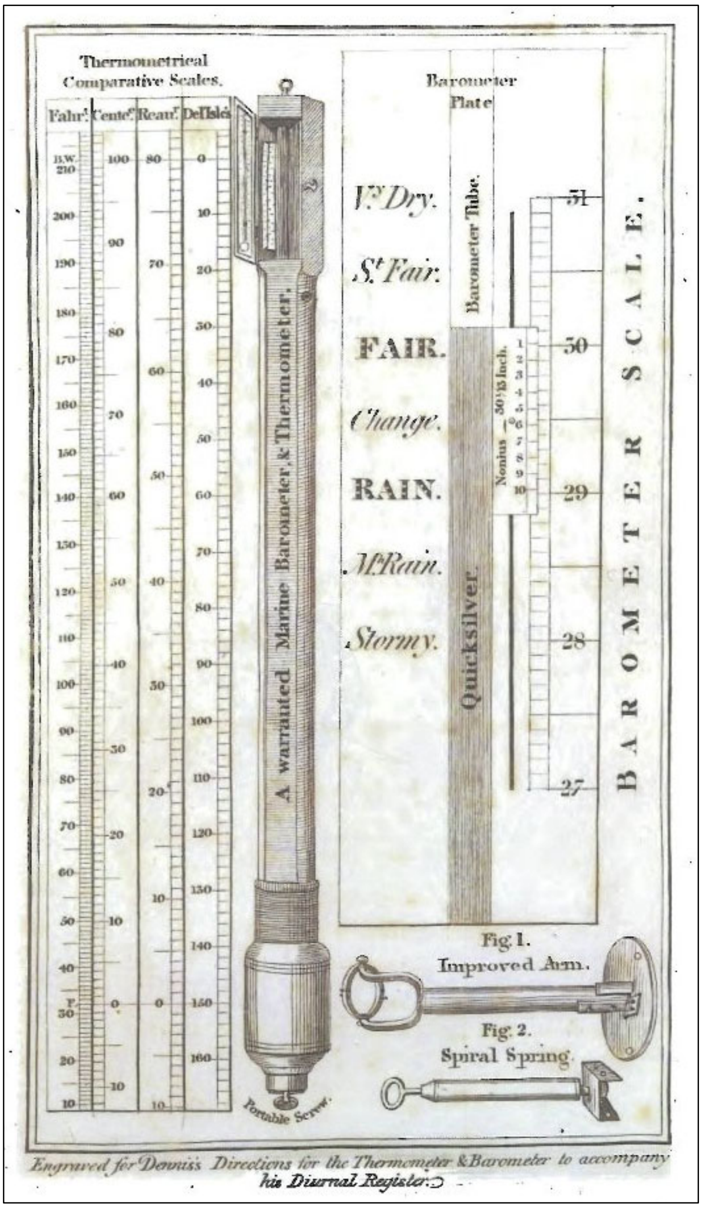


Figure 3: Common marine mercury barometers in use around 1820

7.6. ***Types of barometers used in the MC***

All logs in the MC showing remarks on the mercurial barometer

Name	Year	Reel	Volume	Sequence	Remarks
Ship Preble	1845	74	354	837	The daily mean range of the barometer was noted
Ship Yorktown	1845	74	354	857	The daily mean range of the barometer was noted
Ship Saratoga	1848	76	381	207	From the given daily temperature range (e.g. 75 to 70) the minimum value was digitized
Ship Telasser	1850	33	122	42	Barometer same as always is in the trade winds about 30"
Brig Daniel	1851	41	155	278	Our barometer acts very strange & I think must be imperfect
Ship Morning Light	1853	8	24	711	Greens standard 29.76 inches, M. Light 29.55 inches *[edtr.: Barometer compared to standard 0.21 inch too low]*
Bark Hyperion	1854	21	70	375	Note My barometer usually stands 5/10 of a degree lower but otherwise is an excellent indicator for a change in the weather
Bark Paladin	1854	16	51	92	The Paladins bar' is of very low grade say 40/100 lower than the Swans which was of a high grade
Brig Winthrop	1854	56	199	566	Greens standard: 29.84 – Ship's barometer 29.70 inch
Ship Garrick	(Maury, 1854)				Barometer corrected and compared by Messrs. Parkinson & Fredshaw with the standard at Liverpool. June 1854
Ship Midnight	1854	47	178	227	Barometer Spencer Browning
Ship Shooting Star	1854	47	178	39	Barometer and compasses compared by T.S. Negus & Co. New York and pronounced correct
Brig Globe	1855	55	196	284	On board one mercurial barometer with thermometer attached. The barometer was compared before sailing by L.B. Francis of Philadelphia with the standard at his place and found correct
Ship Antelope	1855	61	209	344	Did not get on board early enough to compare the barometer on ship with the Green standard
Ship F. W. Baily	1855	73	282	414	Barometer is a french one, Pautraud, Rochefort. Thermometer on the same by Réamur. In the column of water marked depth I have marked the thermometer temperature of air when I took height of the barometer
Ship Flying Fish	1855	11	33	300	During this voyage the Barometer has been noted three times daily, at 4 p.m., 8 p.m. and at meridian.

Name	Year	Reel	Volume	Sequence	Remarks
Ship Samuel Russell	1855	62	210	34	There is a correction of 15/100 to be subtracted from the passage out from the Barometer. Thermometer was correct
Ship Shooting Star	1855	61	208	200	Barometer 0.24 below standard at Geo Manning's 142 Pearl St. New York, 0.16 below standard at Negro's Wall St. N.Y.
Bark John Carver	1856	59	205	367	The Barometer in use has no Thermometer attached to it
Ship Emilia	1856	50	186	357	Barometer carefully adjusted
Ship Pavana	1856	58	202	12	My Bar stood before leaving 0.26 below the standard at the Mr. Mannings office
Ship Roebuck	1856	59	205	415	Barometer stands about ,26 below a standard instrument
Ship Romance of the Sea	1856	67	233	485	The Observations by Barometer are by the Marine Bar. which was compared with Geo Manning's before sailing and found correct. I have also an aneroid which differs from the other 3/10
Ship Art Union	1857	53	193	312	Barometer 3/100 above standard
Ship Game Cock	1857	65	217	56	I have Mercurial & Aneroid Barometer & Sympiesometer. In the "Barometer Column" I shall give the reading of the Mercurial. In good weather the M. and A. Bar. reads the same.
Schooner Rosamond	1858	68	226	621	Barometer 3/10 less compared to standard
Ship Winfield Scott	1859	58	203	480	Barometer compared with Geo Manning's New York. Manning's 29.81, Ships 29.46
Ship Leopold	1861	85	498	11	(German) Barometer Correction +0,05

7.7. *The Sympiesometer*

In 1818 Alexander Adie from Edinburgh patented the first practical sympiesometer (Adie, 1819). He wanted to provide a more compact and accurate instrument to the marine trade. But also one that could more quickly have its readings adjusted for temperature. Sympiesometers mostly were screwed firmly to the bulkhead, rather than gimbaled like a mercury barometer.

The sympiesometer consists of two parts (see Fig. 4). One is a traditional mercury thermometer that is needed to calculate the expansion or contraction of the fluid in the barometer proper. The other is the barometer, consisting of a J-shaped tube open at the lower end and closed at the top, with small reservoirs at both ends of the tube. The lower end of the J and its associated reservoir were filled with colored almond oil, while the upper portion and its reservoir were filled with hydrogen gas. Increasing air pressure would cause the oil to be pushed out of the lower reservoir and into the tube, compressing the hydrogen gas into the upper reservoir. The pressure was indicated by the position of the top of the oil. To correct for temperature a sliding scale was used; the operator would first use the thermometer to set the scale and then measure the pressure.

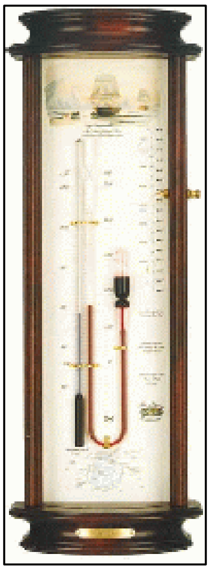


Figure 4: Sympiesometer, 1818

General remarks on the sympiesometer

Purdy quoted Lieut. William Robertson on the sympiesometer (Purdy, 1845). Robertson was on the Northern Expedition of 1818 and stated: "The sympiesometer is a most excellent instrument, and shows the weather far better than the marine barometer. In short, the barometer is of no use compared to it". In the publication Purdy quoted Mr. Stevenson on board the yacht of the Commissioners of the Northern Lighthouses, as saying: "the common marine barometer and Adie's sympiesometer which were in the cabin of the vessel indicated an approaching change of weather."

All logs in the MC showing the use of the sympiesometer

The following ships indicate the use of the sympiesometer. Because this type of metadata has not been digitized and gravity correction in the MC has been applied throughout the dataset before going into ICOADS, the pressure observations from these ships have been overcorrected:

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Ship Favourite	1847	29	106	188	Symp
Ship Valparaiso	1850	26	92	245	Sympiesometer
Bark Matanzas	1853	24	85	778	I have W.J. Jessie improved sympiesometer which I like very much in the Atlantic
Bark Gleaner	1854	15	50	876	Andie & Son Sympiesometer instead of a Barometer & noted at 9 A.M.
Ship Margaret Mitchell	1854	58	202	54	Symp
Ship Siam	1854	67	222	182	Sympiesometer
Bark Reindeer	1855	45	174	276	Sympiesometer
Ship Marion	1855	74	288	157	Sympiesometer + 0.50
Brig Peerless	1856	51	188	17	Simpiesometer
Ship James Baines	1856	59	204	258	Sympiesometer every 6 hours

7.8. ***The aneroid barometer***

The aneroid barometer was invented in 1843 (see Fig. 5). The mechanism consists of a small metallic cylinder which is exhausted of its internal air. The sides of this cylinder were prevented from collapsing by a series of springs and levers. This acted on a moving hand or index, showing the equivalent height of the mercury in an ordinary barometer. Its principal advantages were portability and quick and easy reading without need for gravity and temperature corrections like the mercurial barometer, provided that the instrument contains proper temperature compensation by itself. Another claim is that it clearly showed minute changes which the oscillating or pumping motion of the mercury in bad weather would not allow to be estimated.

Ship's aneroid barometers were considered unreliable by scientist of that time because they showed an erratic behavior due to temperature changes that affected the levers and springs inside the instrument. In the Netherlands an exception was made for instruments manufactured in the factory of Naudet (former Vidi) in Paris. Buys Ballot considered other brands as toys (Buys Ballot, 1889). Aneroid barometers were only corrected for index and height above sea level. Gravity difference did not act upon the observations and the instruments are compensated for temperature.

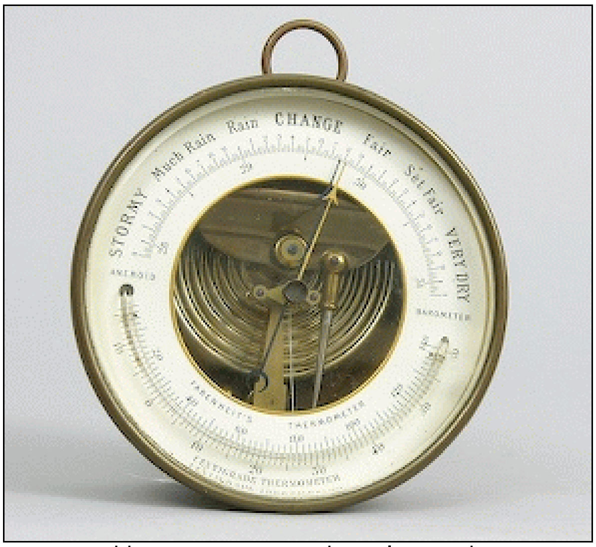


Figure 5: Aneroid barometer as used on clipper ships around 1850

About 68 ship logs of the MC (4.5% of the voyages) show air pressure observations that have been observed by the aneroid barometer or sympiesometer. Consequently, for these observations, the air pressures in the MC are overcorrected.

All logs in the MC showing the location/accuracy of the aneroid barometer

Name	Year	Reel	Volume	Sequence	Remarks
Bark Kirkland	1849	82	425	320	The barometer is a circular aneroid one, hanging under the skylight, in the Cabin
Ship Louis Phillipe	1849	38	142	137	The barometer used during the voyage was one of the aneroids and its performance was admirable. The only objection to it being that there is no means of noting very minute changes and that the pointer vibrates through about .05 when the ship is rolling
Steamer Constitution	1850	29	105	142	In the barometer column the letters *a* and *m* indicate *aneroid* and *mercurial* barometer. Aneroid was digitized
Ship Arcole	1851	19	62	81	I have used Aneroid Barometer which is graduated to centimeters & millimeters
Ship Robin Hood	1855	48	189	266	My barometer (aneroid) is placed in the lower cabin in my room
Ship Phantom	1856	57	201	663	The Ships Barometer (aneroid) by which the following observations have been taken range below the standard 0.42
Bark Hannibal	1857	59	205	480	Aneroid error 5/100 below mercury
Bark Sarah H. Snow	1857	62	212	748	Barometers (aneroids), thermometer attached
Schooner Lewis Perry	1857	55	197	482	... my Barometer being an Aneroid because I had no place in my small cabin to suspend a mercurial one
Schooner Lightning	1857	57	200	169	The Barometer in use is an Aneroid and appears to be below the Standard
Ship Midnight	1857	64	216	341	Barometer aneroid; add 5/100
Bark Rainbow	1858	57	200	235	... my old aneroid which I find very correct
Brig Wanderer	1858	57	200	80	Barometer (aneroid) ... compared at Newyork with the Standard Barometer of Mr. Seaman to low 0.17”
Ship Eagle Wing	1859	65	218	361	Barometer aneroid, and a very good one, always telling the truth about the weather

All logs in the MC showing the use of the aneroid barometer

Name	Year	Reel	Volume	Sequence	Remarks
Bark Kirkland	1848	73	281	148	Aneroid
Ship Louis Phillipe	1849	38	142	137	The Barometer used during the passage was one of the Aneroids
Ship Louis Phillipe	1849	51	189	465	Note Barometer: “S” means Spencer & Norris “H” means Hasser & Barthers “A” means Aneroid

Name	Year	Reel	Volume	Sequence	Remarks
Ship Vandalia	1849	15	47	34	The barometers are marked the first being the common marine barometer and the other the aneroid. Aneroid digitized
Bark Mollie Metcalf	1850	56	198	88	Aneroid
Ship Arcole	1851	19	62	81	I have used aneroid barometer
Ship Yorkshire	1851	38	145	719	Barometer 29, Aneroid 28 5/10
Bark Lucia Maria	1852	10	29	456	Observations with an Aneroid Bar.
Ship Golden West	1852	27	96	29	Aneroid
Ship John Holland	1852	27	96	60	I am using the Aneroid Barometer
Ship Orpheus	1852	39	147	239	The Barometer is an Aneroid No. 463 apparently of English manufacture, without a thermometer. It was adjusted to Jeninuts(?) standard mercurial before leaving. It is the same with which I have traveled a good deal in the interior of California and appears to be a good one... Later, upon arrival in Sydney: The above mentioned barometer is not to be trusted.
Ship White Squall	1852	31	115	450	From the 16th of April Aneroid Barometer 4 tenths above Mercurial until May 21st. Remark in Maury Sailing Directions 1854, p. 475 about this barometer: "Four-tenths to be deducted from the Aneroid, for each day up to the 21st of May, for want of adjustment" (Maury, 1854)
Bark Sophronia	1853	5	12	877	Aneroid
Ship Albert Gallatin	1853	11	34	584	Aneroid
Ship Banster	1853	5	12	820	Aneroid
Ship Eagle	1853	4	6	386	Aneroid
Ship Eagle	1853	11	34	347	Aneroid
Ship Eagle	1853	37	140	547	Aneroid
Ship John Gilpin	1853	3	5	620	Aneroid Barometer
Ship Vandalia	1853	45	175	519	From 9th October 1853 to March 6th 1854 the barometer is the aneroid
Bark Levanto	1854	47	179	456	Aneroid, no error that I am aware of I has Fahrenheit's thermometer attached
Bark Sophronia	1854	24	85	804	Aneroid
Schooner Surf	1854	3	4	304	Aneroid
Ship Eagle	1854	15	48	438	Aneroid
Ship Galatea	1854	74	288	66	Aneroid
Ship George Raynes	1854	3	4	284	Aneroid
Ship Germantown	1854	47	178	113	Uses only barometer is an Aneroid, out of order. It use was to indicate changes but we have not had a good opportunity to compare it
Ship Golden State	1854	48	180	193	Aneroid
Ship Torrent	1854	55	197	356	Instruments on board one Aneroid Barometer
Bark D. M. Hall	1855	67	223	358	Aneroid
Bark Sophronia	1855	74	288	160	Aneroid

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Ship Jamestown	1855	52	191	338	An Aneroid Barometer has been in use since August 28th, 1855
Ship Australia	1856	63	214	339	Aneroid Bar.
Ship Blondel	1856	57	201	705	My barometer is aneroid
Ship Haidee	1856	51	188	143	Aneroid
Bark Sam Slick	1857	59	205	402	Aneroid
Brig Foaming Sea	1857	59	205	466	Aneroid
Gunboat Banterer	1857	59	205	362	Aneroid
Ship Sabine	1857	55	197	605	Aneroid
Ship Swordfish	1857	59	205	554	Aneroid
Brig Wanderer	1858	57	200	80	Barometer (aneroid)

8. TEMPERATURE

8.1. *General comments on thermometers*

Prior to the Brussels' Conference it is rare to find a thermometer that has no serious error (Maury, 1855). The errors of thermometers sometimes result from inequalities in the bore of the tube, sometimes from errors of division on the scale. Maury recommended certain brands of thermometers: "The makers who have furnished the best and cheapest thermometers, which have fallen under my observation, are Mr. James Green, 422 Broadway, New York and Messrs. Negretti & Zambra, 11 Hatton Garden, London. None of the thermometers of either of these makers have errors exceeding a fraction of one degree" (Maury, 1855).

After the Brussels' Conference Mr. Welsh of Kew in England compared many hundreds thermometers for the Navy with the Kew standard. None of the thermometers had errors exceeding half a degree (+/- 0.5) in any part of the scale; generally, their maximum amount of error did not amount to half that quantity.

The location of the thermometers was not prescribed. Some placed the thermometer in full sunlight; others exposed it completely to the wind while others placed the thermometer in a sheltered or shaded spot.

All logs in the MC showing the location of the air thermometer

Name	Year	Reel	Volume	Sequence	Remarks
Brig Osprey	1828	80	412	466	Air temperature in cabin
Ship Andalusia	1848	75	375	620	In cabin
Ship Stephen Lurman	1848	88	534	194	During the month of November 1848 air temperature observed in cabin
Ship Stephen Lurman	1848	88	534	195	From January 1849 air temperature observed on deck
Bark Kirkland	1849	82	425	320, 321	I unfortunately broke a good thermometer, at Hampton Roads, and procured a cheap little affair at Norfolk, from which (nailed outside near the cabin door & under the stairway to the quarter-deck,) all the observations on board are taken
Bark Golden Era	1852	31	115	428	In the companion way
Bark Suwarrow	1854	15	50	658	Air temperature measured in the shade
Ship Robin Hood	1855	48	180	226	The thermometer hung up on the outside forward part of the cabin house on deck
Ship Robert H. Dixey	1857	60	207	402	Thermometer marina in the forward cabin
Ship Prima Donna	1859	52	190	38	Deck obs Thermometer hanging in the Binnacle

All logs in the MC showing general remarks on the thermometer

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Ship Jamestown	1845	74	354	848	Mean temp of air; mean temp of water
Ship Preble	1845	74	354	837	Mean Temp Air & Water
Ship Yorktown	1845	74	354	857	Mean Range Air & Water
Ship Saratoga	1848	76	381	207	From the daily range, max and min value, the min value digitized
Ship Telasser	1850	33	122	42	Air is not worth noticing change 40 times in 24 hours. Average 78°; Water about the same as the air no diff. Worth noticing avg. 76°
Ship Dale	1854	66	220	297-301	Thermometer corrections (between 1.1 and 2.1 degrees Fahrenheit) are given in the header of the log for dry bulb, wet bulb, water thermometer, and thermometer attached to the barometer. The thermometers have been compared at Boston Navy Yard
Ship Malay	1854	58	203	367	Temperature correction +1.0 Fahrenheit
Brig Globe	1855	55	196	284	Two copper air and water thermometers. The thermometers are graduated both to Fahrenheit and Centigrade, but the Fahrenheit reading is given in the abstract
Ship Emilia	1856	50	186	357	Thermometers carefully adjusted
Ship Garrick	1856	45	174	200	The thermometer used is that of Fahrenheit and has been well ascertained for correction of error
Ship Post	1856	51	189	722	Temperature correction +3.5 Fahrenheit
Ship S. H. Talbot	1856	53	193	493	Water and air temperatures corrected before noting in columns
Ship Tropic	1859	48	181	430	I will say that there is an error of about 18° *(sic)* in my thermometer up to 13 February
Ship Leopold	1861	85	498	11	(German) Correction air and water temperature + 0.5 Fahrenheit

8.2. ***Dry- and wet-bulb temperatures***

All logs in the MC showing remarks on the air temperature

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Ship Flying Fish	1855	11	33	300	The thermometer noted is one attached to the barometer and observed at the same time *(4 p.m., 8 a.m. and at meridian)*
Brig Daniel	1851	41	155	280	The temperature of the thermometer attached to the barometer is given in the column air temperature

The following two remarks may shed some light on the measurement of wet-bulb temperature. First, Maury stated that when the thermometer is used as a hygrometer two thermometers should be placed on their stand, in a safe and shaded place (Maury, 1855). One of the two should have cotton, linen, or muslin rag lightly tied round the bulb and wetted. And second, Davy stated: "The hygrometrical observations were made with two thermometers, one of which had its bulb covered with an absorbent substance, and wetted with water. The degrees in the column show the descent of the mercury by the cold, produced by evaporation" (Davy, 1819).

8.3. ***Seawater temperatures***

Maury (Maury's explanations 1848, Reel 85, Vol. 511, Seq. No. 344) recommended the frequent use of the water thermometer to detect ocean currents: "In any given latitude where there is no current, the temperature of the water may be determined upon philosophical principles."... "Any change of 2° or more, however, in the temperature of the water, and the time at which the change is noticed, should be carefully entered with the Remarks, in a few words, thus: W.T., 2, P.M., 68°" (Water Temperature at 2 Post Meridiem, 68 degrees Fahrenheit).

Logs with seawater temperature remarks

The information in the following logs provide us with some background as to how seawater temperature was measured:

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Schooner Taney	(Maury, 1851)				The usual method for sailing ships was to haul up the water in a clean wooden bucket and place it in the shade. After the thermometer has remained in the bucket for two or three minutes, the thermometer should be read with the bulb remaining immersed until the observation is completed

Name	Year	Reel	Volume	Sequence	Remarks
Steamer Georgia	(Maury, 1852)				The sea surface temperature was measured very accurate with immersed thermometer in a bucket filled several times through the cock of the ship
Bark Albert Edward	1847	75	376	694	Temperatures lined underneath are those of the Sea
Bark Kirkland	1849	82	425	321	"... the Captain calls from our stateroom any one near for the height of thermometer, looks at the barometer & guesses at the temperature of the ocean! I presume the last; for my thermometer has certainly never been placed in the briny sea since I came on board
Ship Orpheus	1852	39	147	239	The thermometer is one of Barry's London, a large scale and is well divided. The temperature of the water is determined by drawing a bucket of water and immediately immersing the thermometer in it
Brig Globe	1855	55	196	284	Two copper water thermometers. The temperature of the water is taken by drawing the water in a wooden bucket and letting the thermometer in it at least three minutes
Ship Robin Hood	1855	48	180	266	Water temperature in a bucket from a long side
Ship Petrel	1856	66	221	757	The temperature of the water is taken from the surface throughout
Ship Wild Pigeon	1858	57	200	63	Water taken 8 feet below the level of the sea
Ship Illustrious	1860	56	198	18	Substract 4° from temp. given by water thermometer No. 3
Ship Line and Fritz	1861	85	501	125	It is very desirable to know the temperature of the water. Even for a few feet below the surface. Therefore, those vessels that are provided with the means of letting water into the hold, would render a valuable surface by drawing a bucket of water through the cock daily, and recording its temperature. Let the water so drawn run a little while first so that it may be of natural temperature. State the depth of the cock below the water, in the column for Remarks

8.4. ***Temperature at depth***

Purdy states: “Mr. Wales, who accompanied Captain Cook, has given the temperature of the sea, as found in different depth and places. His apparatus for trying the same consisted of a square wooden tube of about 18 inches long, and 3 inches square externally. It was fitted with a valve at the bottom, and another at the top, and had a contrivance for suspending the thermometer exactly in the middle of it. When it was used it was fastened to the deep-sea line, just above the lead, so that, all the way it descended, the water had a free passage through it, by means of the valves, which were then both open; but the instant it began to be drawn up, both the valves closed by the pressure of the water, and, of course, the thermometer was brought up in a body of water of the same temperature with that it was let down to. With this instrument, which is much the same with one formerly described by Mr. Boyle, in his observations on the saltiness of the sea, water was fetched up from different depths and its temperature accurately noticed in different seasons and latitudes” (Purdy, 1845).

The **Steamer Arctic** (1856. Reel 45, Vol. 175, Seq. No. 462) noted: “On one occasion two thermometers were sent to the bottom in very deep water and one indicated a temperature of 21 deg and the other 24 deg. On examining and comparing the rest of the thermometers I found them all differing from each other so much and some of the hands being broken, I was sure that they could not be used with any proper results (Appeared in *The Daily Union*, December 25, 1856 - Washington; Abstract of soundings and temperature taken on board the United States ARCTIC in her survey for a telegraphic route between St. John, Newfoundland and Valentia Bay, Ireland, 1856).

Purdy stated that the more common method has been to sink a register thermometer, with a metallic case and graduation (metals speedily acquiring the temperature of the surrounding medium) and marking the change of temperature which had taken place (Purdy, 1839). Thus, if the index marking the maximum had not been moved forward, while the minimum index had been driven back, it was considered that the temperature had diminished to the point marked by the latter index. These instruments are far from expensive; but as it is essential to have them exact, they should always be obtained from well-known makers.

9. WIND DIRECTION AND FORCE

Wind direction and force, which set the pace of the voyage, was very important for square-rigged ships. Mariners tried to keep away from calm and baffling wind areas. Consider in this respect e.g. a remark of Norie: “A long calm is often more fatal to a ship than the severest tempest for if tight and in good condition she may sustain in good condition whereas in a long calm the provisions and water may be entirely consumed without any opportunity of obtaining a fresh supply” (Norie, 1828). In addition, Purdy states that “it was therefore not unusual during those days that captains looked for gales and hurricanes consciously because the more wind, the more speed” (Purdy, 1845). To what extent this might have influenced the logbook observations is not known.

9.1. *Wind Direction*

Usually the wind direction has been logged with double compass points and determined through the use of the position of the dog-vane, placed on the weather-side of the quarterdeck or wind-vanes worn at each masthead and used as wind direction indicators. The weather-side denotes the side of a ship under sail upon which the wind blows or which is to the windward. Also compass bearings were taken from the wave or cloud direction to determine the wind direction.

Despite Maury’s directions up until around 1850 the apparent wind direction of the vanes usually was not adjusted for the speed of the ship to get the true wind direction (KNMI, 1866). This is a factor that needs to be considered during the analysis of wind observations.

Prior to the Brussels’ Conference wind directions either were logged “true”, relative to the geographical north or “by compass”, relative to the magnetic north. At the Brussels’ Conference it was adopted to log only the magnetic wind direction. The idea was to determine the true wind direction afterwards. The Maury abstract logs show the wind direction often by compass, the variation logged into a separate column. But sometimes also true or mixed in the same log:

Name	Year	Reel	Volume	Sequence	Remarks
Ship Malabur	1848	82	425	346, 347	*true* or *per compass* written after the wind direction notation in the wind column; e.g. *S by E per compass* or *SSE (true)*

Maury divided the day into three parts of 8 hours each or two watches when compiling his Wind or Pilot charts. A division into 4 hours or one watch he considered too small. Originally he started with the general wind direction during 24 hours given the wind directions between the winds varied.

Wind direction given in one column:

Name	*Year*	*Remarks*
Maury Explanations	1848	In the column *Winds* enter the general direction of the wind during the 24 hours and explain under *Remarks* on the opposite page, as to force, steadiness, etc.

Wind direction given in two columns:

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Ship Preble	1845	74	354	839	Wind force and direction most prevailing during A.M. and P.M.

Wind direction given in three columns:
The observers were asked to enter the wind direction for the point of the compass from which it has most prevailed for the eight hours: First, Middle and Latter part. In order that the three parts are the same for all observers it is necessarily prescribed that the first part always is from noon till 8 pm, the middle part from 8 pm till 4 am and the latter part from 4 am till noon (Buys Ballot, 1853).

At the Brussels' Conference the civil day was adopted starting the day at midnight instead of noon. Whether the time kept on board be sea or civil time, from noon till 8 pm is understood to be what in common parlance among seamen is known as the first part. In like manner, from 8 pm to 4 am whether the day commences at noon or midnight, is understood to be the middle part. A remark then appeared in the logs: "Whether the day commences at noon or midnight, always call from noon to 8 pm First Part". It is believed, however, that, as a rule, seamen only record the wind which was blowing at the time of observation, what makes a rough estimate over the last eight hours doubtful (Toynbee, 1875)

Logs presenting information about the way wind was to be determined and written down

Name	*Year*	*Reel*	*Volume*	*Sequence*	*Remarks*
Bark Nancy	1842	25	86	30	Enter the wind for the point of the compass from which it has most prevailed for the eight hours
Ship Abr. N. Howland	1848	31	117	733	Always enter the points of the compass between which the wind varies. You will give the exact point of the compass at which the wind holds and make no such entries as Northward, Eastward, Southward, Westward but states the point precisely as ENE – SSW etc. as the case may be. And when the winds are variable instead of entering them as variable from Southward and Northward for instance, enter them from SSE to W; in other words so as to show the points of the compass between which they do vary.
Ship Massachusetts	1848	28	103	613	Enter the wind for the point of the compass from which it has most prevailed for the eight hours
Brig Hanover	1849	88	534	73	To avoid, as far as practicable, the inconvenience of vague entries, as to the winds, the day has been divided off into first, middle, and latter parts, of eight hours each. Enter, therefore, in the proper column, the exact point from which the wind has most prevailed during such part, and state the prevailing character of the wind for each of the three parts - whether fresh, moderate, squally, light, baffling, or calm. In noting the direction of the wind, care should always be taken to allow for the effect which the rate of the ship's sailing has upon the direction of the wind
Brig Charles McLaughlan	1852	25	86	33	Divide the 24 hours into three parts, and enter the *point* of the compass from which the wind may be said most to have prevailed during that part. If calms and baffling airs have most prevailed, record it as calm or "baffling" for the entire part. Enter under the head of Remarks, force of wind ...

All logs in the MC showing the true wind direction

Name	Year	Reel	Volume	Sequence	Remarks
Ship Henry Clay	1848	73	281	214	True course of the winds allowing for variation
Ship Ohio	1848	73	281	157	True
Bark Racehorse	1850	43	165	604	The winds throughout this abstract are entered from the true course
Ship Preble	1850	21	72	597	The winds in this abstract are corrected for variation
Ship Molay	1853	15	50	684	Direction of the wind true – not magnetic
Schooner Conquest	1856	51	188	352	Direction of wind, from clouds too etc. true courses having made approximate allowance for the variation

All logs in the MC showing the magnetic wind direction

Name	Year	Reel	Volume	Sequence	Remarks
Bark Albert Edward	1848	75	376	694	All bearings are magnetic except these used to show the bearing of any place and the set of current which is the true direction
Brig R. Dezalda	1848	73	281	78	Winds by compass
Ship Nebraska	1848	77	388	243	Winds per compass
Bark Mollie Metcalf	1850	56	198	88	Winds by compass
Brig Daniel	1851	41	155	278	The Winds & Courses here are marked per Compass
Ship Great Britain	1851	43	164	419	Winds per compass
Ship India	1851	33	122	171	I here state that the courses of the winds marked in this log are by compass, the currents and other Bearings are their true Courses
Ship Peruvian	1852	22	77	608	The courses of the currents are calculated for the true course, the other courses are by compass
Ship Roscuis	1853	11	34	320	The direction of the winds given in this abstract is by compass bearings
Bark Gleaner	1854	15	50	876	The directions of the wind per compass
Ship Henry Ware	1854	33	124	790	The direction of wind by compass
Ship Midnight	1854	47	178	227	Wind per compass
Bark Petrea	1855	63	214	416	The winds are per compass, the currents true
Ship Garrick	1855	45	174	201	Wind direction always by compass
Ship Actos	1857	54	194	95	Direction of the wind is not corrected for variation in this abstract
Brig Josephine	1858	65	218	517	By compass
Bark Etha	1859	65	218	275	The wind marked is by compass
Ship Eagle Wing	1859	65	218	361	Winds & Courses by Compass

Anomalous wind direction notations:

The German S**hip Gloriana** (1851-1854. Reel 85, Vol. 506) shows an anomalous wind direction notation. The direction of the ship's head and of the wind is shown by Raper's symbols given the magnetic directions. The observations are registered by the degree of latitude in which they are taken.

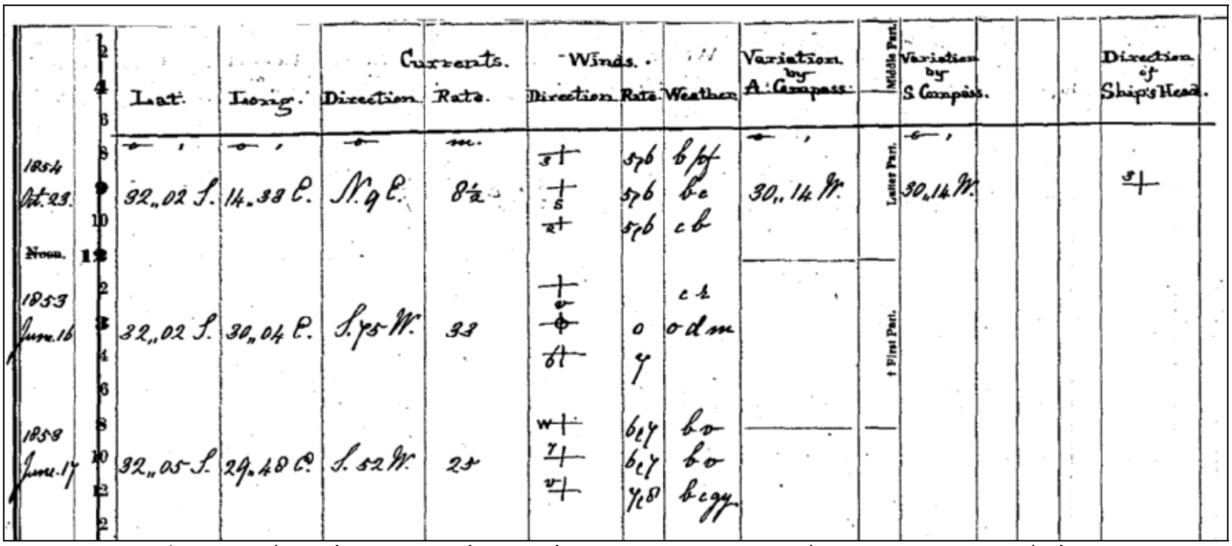
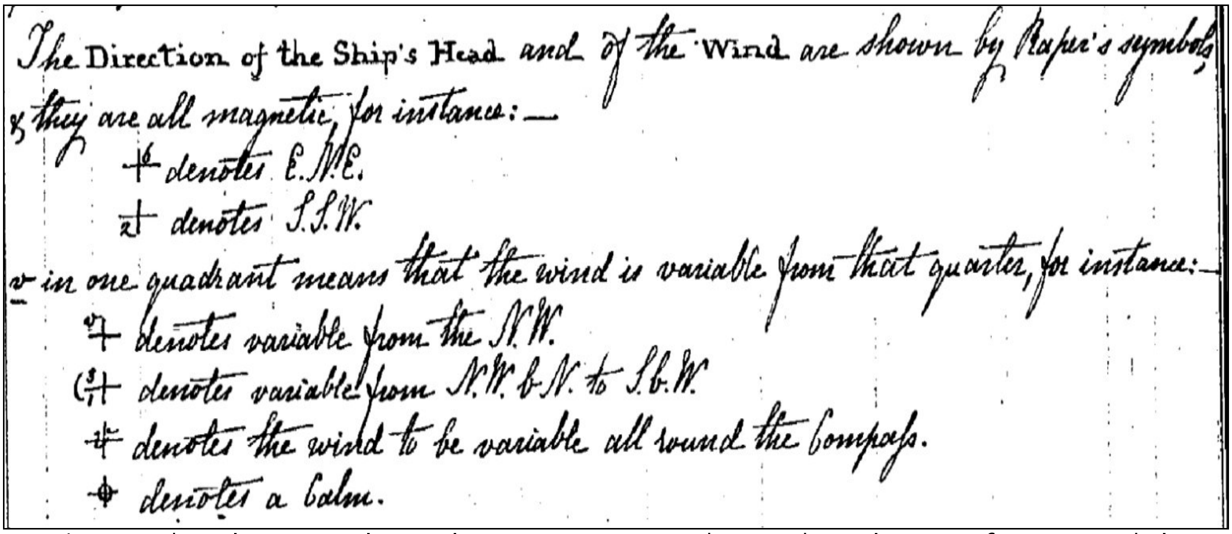


Figure 6: Ship Gloriana (Reel 85, Vol. 506, Seq. No. 227) showing Raper's symbols



The Direction of the Ship's Head and of the Wind are shown by Raper's symbols & they are all magnetic, for instance:—
denotes E.N.E.
denotes S.S.W.
v in one quadrant means that the wind is variable from that quarter, for instance:—
denotes variable from the N.W.
denotes variable from N.W. b N. to S b W.
denotes the wind to be variable all round the Compass.
denotes a Calm.

Figure 7: Ship Gloriana (Reel 85, Vol. 506, Seq. No. 185) showing the explanation of Raper's symbols

9.2. *Wind Force*

During the first half of the 19th century the Beaufort wind force scale was not commonly in use. Towards the end of the 18th century the Englishman Alexander Dalrymple, the first Hydrographer of the English "East India Company", introduced a wind force scale with 12 scale parts (1-12) for maritime use. Dalrymple included this scale in his "Treatise on Navigation", which was examined by the English commander Sir Francis Beaufort and probably gave him the idea for his scale (Konvitz, 1983). In 1832 an article appeared in the "Nautical Magazine" titled "The Log Board" with the recommendation to universally use the Beaufort scale. On December 28, 1838 the scale was officially introduced in the English Navy through a memorandum to "All Captains and Commanding Officers of Her Majesty's Ships and Vessels" (Wood, 1838). The Beaufort scale was adopted at the Brussels' Conference in 1853 for universal use in abstract logs. Often it is not clear whether the Dalrymple scale or the Beaufort scale has been used in the Maury logs. Note the staggered wind force numbers like "Light breeze" or "Fresh gale" in Table 3.

Dalrymple's scale		**Beaufort's scale**	
		0	Calm
1	Faint air, i.e. just not calm	1	Light air
2	Light air	2	Light breeze
3	Light breeze	3	Gentle breeze
4	Gentle breeze	4	Moderate breeze
5	Fresh breeze	5	Fresh breeze
6	Gentle gale	6	Strong breeze
7	Moderate gale	7	Moderate gale
8	Brisk gale	8	Fresh gale
9	Fresh gale	9	Strong gale
10	Strong gale	10	Whole gale
11	Hard gale	11	Storm
12	Storm	12	Hurricane

Table 3: The Dalrymple wind force scale compared with Beaufort wind force scale

All logs in the MC showing anomalous wind force scales

- ✓ **Ship Preble, 1845**. Reel 74, Vol. 354, Seq. No. 839
  0 - Calm
  1 - Light airs
  2 - Light breezes
  3 - Moderate breezes
  4 - Fresh breezes
  5 - Moderate gales
  6 - Fresh gales
  7 - Tremendous gales
  8 - Hurricanes & Tornadoes

- ✓ **Whalers** (always using the same abbreviations) Reel 10, Vol. 30, Seq. No. 514. Reel 40, Vol. 150, Seq. No. 18. etc.
  Lt or lt - Light winds
  Mod - Moderate winds
  Bsk or bk - Brisk
  Fr or frh - Fresh
  Stg - Strong
  Hvy - Heavy
  Pls - Pleasant
  Sqly - Squally

- ✓ **Ship Louis Phillipe, 1849**. Reel 38, Vol. 142, Seq. No. 137. "In the absence of any other scale by which to denote the strength of the wind I have made the following and have used it throughout this journal"
  0 - Calm
  1 - Light air
  2 - Light breeze which will fill the Top Gall. Sails
  3 - Moderate breeze (Royals & Top Gall. Stud Sails)
  4 - Fresh breeze (Top Gall. sails)
  5 - Strong breeze (Reefed Topsails)
  6 - Moderate gale (double reefed)
  7 - Fresh gale (three reefs with reefed courses)
  8 - Heavy gale

- ✓ **Ship Louis Phillipe, 1849**. Reel 51, Vol. 189, Seq. No. 465. "For the winds"
  0 - Calm
  1 - Light air
  2 - Light breeze, one that will fill the Top...
  3 - Moderate breeze
  4 - Fresh breeze (Top Gall. sails)
  5 - strong breeze (Double reefed with Topsails)
  6 - Moderate gale
  7 - Fresh gale
  8 - a Heavy gale

✓ **Ship James Baines, 1856**. Reel 59, Vol. 204, Seq. No. 258.
Wind force 11 numbers.
Force of the wind denoted by figures (sailing by the wind); Winds for every 6 hours, variation allowed for.

0 - Calm
1 - Steerage way
2 - 1 to 2 Knots
3 - 3 to 4 Knots
4 - 5 to 6 Knots
5 - Royals in
6 - Single Reefs
7 - Double Reefs
8 - Tripple Reefs
9 - Close Reefed
10 - Close reefed Main S and foresail

✓ **Brig Ohio, 1850**. Reel 43, Vol. 166, Seq. No. 779.

0 - Calms
4 - in Royals
6 - in Top Gall sails
7 - sing reef Top sails
8 - double reefs
9 - close reefs
10 - Gale

$\frac{10}{\bullet}$ - Heavy gale

$\frac{10}{\bullet\bullet}$ - Hurricane

9.3. *Wind force conversion scales*

Logs in the MC showing wind force conversion scales.

The scales below can be used to convert the wind force to the Beaufort scale

- ✓ **Jeffrey Dennis, 1825**. From 10 years average (Dennis, 1825)

Description	*miles/hour*	*feet/second*
Light airs	1 - 3	1.47 – 4.40
Breeze	4 - 5	5.87 – 7.33
Brisk Gale	10 - 15	14.67 – 22.00
Fresh Gale	20 - 25	29.34 – 36.67
Strong Gale	30 - 35	44.01 – 51.34
Hard Gale	40 - 45	58.68 – 66.01
Storm	50 - 60	73.35 – 88.02
Hurricane	80 - 100	117.36 – 146.70

- ✓ **Thomas Arnold, 1822** (Arnold, 1822)

Description	*miles/hour*
Hardly perceptible	1
Just perceptible	2 – 3
Gentle pleasant breeze	4 – 5
Pleasant fresh breeze	10 – 15
Very brisk	20 – 25
High wind	30 – 35
Very high wind	40 – 45
A gale of wind	50
A heavy gale	60
A hurricane	80

Below, 2 examples are given of ships that seem to have their own conversion scales.

- ✓ **Ship Fanchon, 1850**. Reel 28, Vol. 100, Seq. No. 48

Description	*knots*
Strong Breeze	To carry Top Gal Sails. Royals & 8 to 9 knots
Fresh Breeze	6 to 7 knots
Moderate Breeze	4 to 5 knots
Light Breeze	2 to 3 knots
Light Airs	1 to 1½ knots

- ✓ **Ship Illustrious**, **1861**. Reel 84, Vol. 488, Seq. No. 174
  Another method of indication; Beaufort 1 - 12 corresponding to land 1 – 6
  (The land notation is that given daily in the "Times" and used at many Observatories)

Land	*Description*	*Beaufort*
1	Light	1 – 3
2	Moderate	3 – 5
3	Fresh	5 – 7
4	Strong	7 – 8
5	Heavy	8 – 10
6	Violent	10 – 12

10. WEATHER ABBREVIATIONS

In some of the MC logs weather abbreviations are presented.

Logs in the MC using the Beaufort notation

- ✓ **Ship Valorous, 1858**. Reel 84, Vol. 489, Seq. No. 192 and
- ✓ **Ship Illustrious, 1861**. Reel 84, Vol. 488, Seq. No. 174

Notation	*Description*	*Notation*	*Description*
b	Blue sky	p	Passing Showers
c	Clouds (detached)	q	Squally
d	Drizzling Rain	r	Rain
f	Foggy	s	Snow
g	Gloomy	t	Thunder
h	Hail	u	Ugly (threatening) appearance of Weather
l	Lightning	v	Visibility. Objects at a distance unusually visible
m	Misty (hazy)	w	Wet (Dew)
o	Overcast		

NOTE; a bar (–) or a dot (.) under any letter augments its signification

Other ships in the MC using abbreviations:

- ✓ **Brig Ohio, 1850.** Reel 43, Vol. 166, Seq. No. 779
  Abbreviations for the weather

Notation	*Description*	*Notation*	*Description*
c.	clear	Hz	Hazy
p.c.	passing clouds with blue sky between	Sh	Showry
cl.	Cloudy constant passing with ...	S.n.	Snow
o.c.	Overcast. no sky to be seen	H.i.	Hail
Sq	Squally wind and rain	S.l.	Sleet
$\underset{\bullet}{\underline{\text{Sq}}}$	Very hard and frequent squalls	F.g.	Foggy
Th	Thunder	$\underset{\bullet}{\underline{\text{T}}}$	Extraordinary thunder
L	Lightning	$\underset{\bullet}{\underline{\text{L}}}$	Extraordinary lightning
R	Rain	$\underset{\bullet}{\underline{\text{R}}}$	Extraordinary rain

✓ **Whaling voyages (**Abbreviations used throughout Reel 18, Vol. 59.)

Notation	Description	Notation	Description
S x W	S by W	Cl	Cloudy
S	Strong	Tk	Thick
Gales	Gales	Hzy	Hazy
Lt	Light	Cldy	Cloudy
F	Fine	Mod	Moderate
Fr	Fresh	Baf	Baffling
Sq	Squally	Var	Variable
C	Calms		

✓ **Whaling voyages** (abbreviations used throughout Reel 21, Vol. 71 and Reel 27, Vol. 98

Notation	Description	Notation	Description
1st	First	Gl	Gales
Mid	Middle	Cm	Calm
Lat	Latter	Rt	Right (whale)
Plt	Pleasant	Sp	Sperm (whale)
Cdy	Cloudy	Bl	Black (whale)
Tk	Thick	Tk	Took (whale)
Fg	Fog or foggy	Thd	Thunder
Rn	Rain or rainy	Lt	Lightning
Sq	Squalls or squally	Hzy	Hazy
Stg	Strong	Hy	Heavy
Mod	Moderate	Hl	Hail
Fh	Fresh	Rgd	Rugged
Bk	Brisk		

11. ABBREVIATIONS

AM	Ante Meridiem
CNODC	China National Oceanographic Data Center
EDADS	Environmental Document Access and Display System
HISKLIM	Historisch Klimaat (Historical Climate)
hPa	Hecto Pascal
ICOADS	International Comprehensive Ocean-Atmosphere Data Set
KNMI	Koninklijk Nederlands Meteorologisch Instituut (Royal Netherlands Meteorological Institute)
LMR6	Long Marine Report, version 6
MC	U.S. Maury Collection (1796-1861)
NARA	National Archives and Records Administration
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration
PM	Post Meridiem
RECLAIM	RECovery of Logbooks And International Marine data
UK	United Kingdom
US	United States
USA	United States of America
VOC	Verenigde Oostindische Compagnie (United East-India Company)
WSSRD	Web Search Store Retrieve Display

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APPENDIX I: Foreign Abstract logs

This appendix presents a complete overview of the foreign logs in the MC (other than US and British). These logs sometimes deviate from the American logs in units and other metadata. This is probably not taken into account in the digitization of the MC.

Norway, Contributions from the Norwegian Government:

- ✓ **Misc ships (**Reel 74, Vol. 350, Seq. No. 772)
  Longitude with respect to Greenwich
- ✓ **Frigate Dessideria, Frigate Freia, Corvette Nordetjernen and Corvette Nidaros, 1854** (Reel 74, Vol. 350, Seq. No. 773)
  Barometer - English inches;
  Temperatures - Réamur.

Sweden:

- ✓ **Brig John, 1850/1851 (**Reel 11, Vol. 33, Seq. No. 292)
  Civil time; Latitude and Longitude given for each noon.
  Variation is taken from charts.
  Barometer and Thermometer not compared, but believed to be correct.
  Therm of Fahrenheit
  The winds and weather given as they have been from the preceding noon.
  Bearings of compass & distances in miles, 60 to a degree

Denmark:

- ✓ **Ship Valkyrien, 1851 (**Reel 15, Vol. 48, Seq. No. 299)
  Air pressure - Sympiesometer;
  Air temperature - Réamur.

Germany:

- ✓ **Bark Adler, 1851** (Reel 74, Vol. 288, Seq. No. 14)
  Temperature Réamur at noon.
- ✓ **Bark Dolphin, 1854** (Reel 3, Vol. 5. Seq. No. 537)
  Temperature Réamur at 9 am.
- ✓ **Ship Mary Ross, 1858** (Reel 46, Vol. 177, Seq. No. 615)
  Civil time
  Air pressure - English inches (to low, unreliable);
  Thermometer attached - Réamur;
  Air temperature - Centigrade;
  Water temperature - Réamur;
  Also aneroid and sympiesometer observations.

The Netherlands:

- ✓ **Ship Princess Sophia, 1852** (Reel 31, Vol. 115. Seq. No. 262)
  Latitude and Longitude at meridian. Longitude with chronometer;
  Currents per 24 hours, distances in miles 15 to a degree (1 Dutch mile = 4 nautical miles);
  Air pressure - English inches;
  Temperatures - Fahrenheit;
  Wind direction - magnetic;
  Wind force - Beaufort scale.
- ✓ **Steamer Amsterdam, 1853** (Reel 11, Vol. 34. Seq. No. 374)
  Air pressure - millimeters;
  Temperatures - Fahrenheit;
  Currents true, distances in miles 15 to a degree.

France:

- ✓ **Ship Paulista, 1854** (Reel 3. Vol. 4. Seq. No. 163)
  Air pressure - millimeters
  Temperatures - Fahrenheit
- ✓ **Ship Paulista, 1855** (Reel 73. Vol. 282, Seq. No. 411)
  Air pressure - millimeters
  Temperatures - Fahrenheit
- ✓ **Ship Saint Germain, 1855** (Reel 73, Vol. 282, Seq. No. 418
  Thermometer - Centigrade
- ✓ **Corvette Eurydice, 1857** (Reel 60, Vol. 206, Seq. No. 272)
- ✓ Air pressure - millimeters
  Temperatures - Celsius
- ✓ **Steamer Magere, 1858** (Reel 60, Vol. 206, Seq. No. 314)
  Air pressure at noon - millimeters
  Air temperature at noon - Celsius
  Sea surface temperature - Celsius at 6 am and at 6 pm
  Wind direction - per compass
  Wind Force abbreviations:
  C - Calme (calm)
  P.C - Presque calme (almost calm)
  P.B. - Petite brise (gentle breeze)
  J.B. - Jolie brise (moderate breeze)
  B.B. - Bonne brise (fresh breeze)
  V.F - Vent frais (strong breeze)
  VgF - Vent grand frais; Voilure très réduite (moderate gale, all sails reduced)
- ✓ **Ship San Giovanni, 1853**. Sardinian frigate (Reel 27, Vol. 96, Seq. No. 204)
  Air Pressure - Paris inches;
  Thermometer attached - degrees Celsius.

Spain:

- ✓ **Ship Cervantes, 1858** (Reel 46, Vol. 177, Seq. No. 436)
  All observations in the abstract log are corrected for errors, less the barometer;
  Barometer index correction +0.16 inch;
  Barometer mean height above the sea 17 feet;
  Day commences at noon.

Portugal:

- ✓ **Frigate D. Fernando, 1854** (Reel 73, Vol. 282, Seq. No. 310)
  Air pressure - English inches;
  Temperatures - Fahrenheit.
- ✓ **Cutter Andorinha, 1854** (Reel 73, Vol. 282, Seq. No. 298)
  Air pressure - English inches;
  Temperatures - Fahrenheit.
- ✓ **Frigate Santa Isabel**, **1854** (Reel 73, Vol. 282, Seq. No. 302)
  Air pressure - English inches;
  Temperatures - Fahrenheit.
- ✓ **Corvette Porto, 1854** (Reel 73, Vol. 282, Seq. No. 319)
  Air pressure - English inches;
  Temperatures - Fahrenheit.
- ✓ **Brig Mozambique, 1854** (Reel 73, Vol. 282, Seq. No. 328)
  Air pressure - English inches;
  Temperatures - Fahrenheit.
- ✓ **Corvette Goa, 1856**. Reel 57, Vol. 200, Seq. No. 116
  Air pressure - meters
  Temperatures - Celsius
- ✓ **All Portuguese ships**:
  Sea surface temperatures with the help of a bucket of fresh seawater;
  Wind direction is the prevailing wind during one of the three parts of the day.

Brazil:

- ✓ **Ship D. Izabel**, **1860** (Reel 53, Vol. 192, Seq. No. 296)
  Nautical time;
  Longitude from Greenwich;
  Air pressure - English inch;
  Therm. attached - Fahrenheit;
  Dry bulb - Celsius;
  Wet bulb - Celsius;
  Water temperature - Fahrenheit.

Russian men-of-war:

- ✓ **Steamer Astrachan, 1858** (Reel 69, Vol. 227, Seq. No. 17)
  Civil time;
  Barometer - English inch;
  Thermometer attached - Réamur;
  Temperature of wet and dry bulb by Celsius thermometers (centigrade).
- ✓ **Sloop Voevoda, 1857** (Reel 69, Vol. 227, Seq. No. 40)
  Civil time;
  Barometer - English inch;
  Thermometer attached - Réamur;
  Temperature of wet and dry bulb by Celsius thermometers (centigrade).
- ✓ **Sloop of war Novick, 1857** (Reel 69, Vol. 227, Seq. No. 193)
  Civil time;
  Barometer - English inch;
  Thermometer attached - Réamur;
  Temperature of wet and dry bulb by Celsius thermometers (centigrade).
- ✓ **Sloop Bogarin, 1857** (Reel 69, Vol. 227, Seq. No. 254)
  Civil time;
  Barometer - English inch;
  Thermometer attached - Réamur;
  Temperature of wet and dry bulb by Celsius thermometers (centigrade);
  From **1859**, second part, aneroid barometer marked by (.) in the log and digitized.
- ✓ **Frigate Ascold, 1857-1860** (Reel 69, Vol. 227, Seq. No. 342)
  Dates are of the new style (Civil time);
  Longitude from Greenwich;
  The direction of the wind by points of compass without correction for variation;
  The frigate's compass has no deviation;
  Barometer without corrections, thermometer attached Réamur;
  Temperature of wet and dry bulb by Celsius thermometers (centigrade);
  Current is shown by point of compass on which it is stretched.

APPENDIX II: Leagues, nautical miles, fathoms

Leagues

During the 18th century and the first part of the 19th century sailors commonly used leagues instead of the smaller nautical miles in estimating distances at sea. The most commonly used leagues are:

Language	Original expression	In one degree	Nautical miles
Dutch	Duitse mijl	15	4
Spanish	Legua maritime	20	3
French	Lieue marine	20	3
English	Sea-league	20	3

The Dutch "Duitse mijl"

At the beginning of the 17th century the "Duitse", "Dietse" or "Duytsche" mile of 4 nautical miles or "15 on a degree" was commonly used in the Netherlands. Sometimes Dutch sailors used a mile of 19 on a degree or 1500 "Rheinlandse roede" as well. From the end of the 18th century until the first half of the 19th century the "Duitse mijl" was between 7408m and 7420m long. French mariners used to call the "Duitse mijl": "Milles Hollandaises".

The Spanish "Legua maritime"

The Portuguese astronomer Faleiro stated in the 16th century that the earth circumference holds 6000 leguas making 1 arc degree 16⅔ leguas long. At the same time he stated that others would like 17 or 17½ leguas correspond to 1 arc degree making the earth circumference 6120 or 6300 leguas respectively. Spanish sailors used Philips V's "geographical league" of 1/17.5 degree or 3.429 nautical miles (6350.5m). From the 18th century onwards the international marine league or 3 nautical miles (5556m) was used.

Nautical miles

During the 19th century the use of leagues was abolished and the nautical mile appeared instead in the logs. The latter is defined generally as the mean length of the arc of 1 minute of latitude. According to the spheroid of Bessel the length of this arc varies from 1842.7m (6045.71297 feet; 1 English foot = 0.30479449m) at the equator to 1861.3m (6106.73769 feet) at the poles (Bessel, 1842). The mean value, 1852m (6076.22533 feet) is the number given in the "Annuaire du Bureau des Longitudes" as the length of a nautical mile (International Meteorological Tables, 1890).

A slightly different value was adopted in England (UK) and America (USA) i.e. 1853.152m (6080 feet). This is the length of 1 minute of arc of a great circle of the earth according to the Clarke spheroid (Clarke, 1866). It is also the length of 1 minute of arc on the meridian at latitude 48fflN. The value officially recognized by the British Admiralty is 1853.152m. The US nautical mile has been defined as the length of 1 minute of arc measured at a great circle in relation to a circumference of the Clarke spheroid (Clarke, 1866). This mile contains 6080.20 U.S. feet or 6080.22 English feet (1853.248m). (Moody, 1952).

In the Netherlands the length of a nautical mile or "zeemijl", has been calculated from the spheroid according to Bessel (Bessel, 1842):
Circumference equator = 40,070,368m.
Circumference meridian = 40,003,423m.

Royal Dutch Navy: 1 Zeemijl = 40,070,368 / (360*60) = 1855.109m.
Dutch merchant service: 1 Zeemijl = 40,003,423 / (360*60) = 1852m (L'Honoré Naber, 1901).

Fathoms

A measure of six feet used for a variety of purposes at sea to regulate the length of e.g. the cables and rigging, and to divide the log-lines and sounding-lines (Falconer, 1780).

Fathoms as a unit of speed

"Log lines: cords or lines of about 120 till 150 fathoms long; used to be thrown over the lee side of a ship to determine the speed with the help of marks or knots in the log line, together with a half minute sand glass. The length of each knot ought to be the same part of a sea mile as half a minute is of an hour. This line, from the distance of about 10, 12, or 15 fathoms of the log, has certain knots or divisions, which ought to be at least 50 feet from each other" ... "Mariners, rather than quit the old way, though known to be erroneous, use glasses for half minute ones that run but 24 or 25 seconds. They have also used a line of 45 feet to 30 seconds or a glass of 28 seconds to 42 feet. When this is the case, the distance between the knots should be corrected by the following proportion: as 30 is to 50, so is the number of seconds of the glass to the distance between the knots upon the line" (Falconer, 1815). In the logs of ships of war and East Indiamen the knot was divided into eight fathoms of six feet each (Norie, 1828) and indicated in the header by K (knots) and F (fathoms) or HK (half knots).

Fathoms as a unit of depth

To measure the water depth sailors use to throw a line with a weight tied to the end into the water, wait until it hit the bottom, pull it back up, while measuring the length of the line from finger tip to finger tip. The arm span of an average sailor was 6 feet and called a fathom. There are two plummets used for this purpose in navigation. One of them is called the *hand lead*, weighing about 8 or 9 pounds, and the other the deep-sea lead, weighing from 25 to 30 pounds. The hand lead line, which is usually 20 fathoms in length, is marked every two or three fathoms so, that the depth of the water may be ascertained either in the day or night. At the depth of 2 fathoms there are marks of black leather, at 5 fathoms there is a white rag; at 7 fathoms a red rag, and so on. If a person spots the mark of the two fathoms in the water close to the surface he calls: "by the mark, two." The *deep-sea lead* is marked with two knots at 20 fathoms, 3 at 30, 4 at 40, and so on till the end of the line. It is also marked with a single knot in the middle of each interval, i.e. at 25, 35 and 45 fathoms, etc.

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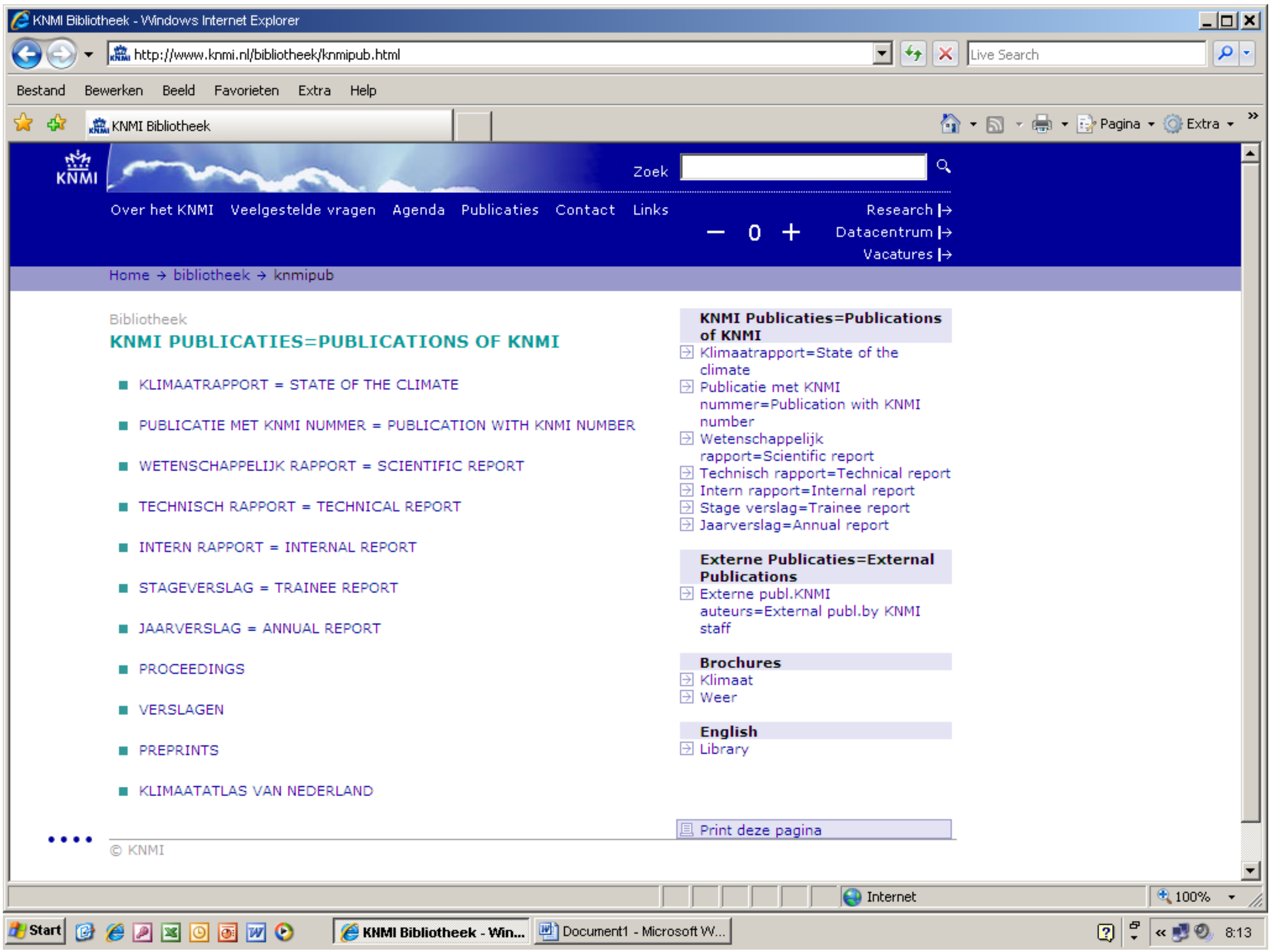

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