Smithsonian Contributions to Knowledge.

239

OBSERVATIONS

ON

TERRESTRIAL MAGNETISM

AND ON THE

DEVIATIONS OF THE COMPASSES

OF THE UNITED STATES IRON CLAD MONADNOCK DURING HER CRUISE FROM PHILADELPHIA
TO SAN FRANCISCO, IN 1865 AND 1866.

BY

WM. HARKNESS, M.D.,
PROFESSOR OF MATHEMATICS, UNITED STATES NAVY.

WASHINGTON CITY:
PUBLISHED BY THE SMITHSONIAN INSTITUTION.
[APRIL, 1873.]

SMITHSONIAN CONTRIBUTIONS TO KNOWLEDGE.
239

OBSERVATIONS

ON

TERRESTRIAL MAGNETISM

AND ON THE

DEVIATIONS OF THE COMPASSES

OF THE UNITED STATES IRON CLAD MONADNOCK DURING HER CRUISE FROM PHILADELPHIA
TO SAN FRANCISCO, IN 1865 AND 1866.

BY

WM. HARKNESS, M.D.,
PROFESSOR OF MATHEMATICS, UNITED STATES NAVY.

[ACCEPTED FOR PUBLICATION, SEPTEMBER, 1871.]

INTRODUCTORY NOTE.

THIS paper was originally an official report presented to the Navy Department by Professor Harkness; but, as that department made no use of it, the National Academy of Sciences, in August, 1867, passed a resolution asking for the manuscript. This request was complied with; and, an abstract of the paper having been read to the Academy in April, 1869, it was referred to a commission consisting of the President of the Academy, Professors J. H. C. Coffin, and F. Rogers, in accordance with whose recommendation it is now published by the Smithsonian Institution.

JOSEPH HENRY,
Secretary S. I.

COLLINS, PRINTER,
PHILADELPHIA.

TABLE OF CONTENTS.

SECTION I.

INTRODUCTION.

SECTION II.

DESCRIPTIONS OF STATIONS.

SECTION III.

ASTRONOMICAL OBSERVATIONS.

SECTION IV.

OBSERVATIONS ON TERRESTRIAL MAGNETISM.

SECTION V.

OBSERVATIONS ON THE MAGNETISM OF THE SHIP.

REPORT ON MAGNETIC OBSERVATIONS.

SECTION I.

INTRODUCTION.

On the fifth of October, 1865, I was ordered to the U. S. Iron-clad Monadnock[1] for the purpose of making observations on the action of her compasses during the cruise which she was about to undertake from Philadelphia to San Francisco, by way of the Straits of Magellan. She was then fitting out at the Philadelphia Navy Yard, and the work on her was so far advanced that it was expected she would sail in about two weeks. As the department had not previously intimated its intention of assigning me to this duty, and as everything relating to the number and kind of observations to be made, and the instruments required, was left entirely to my own discretion, it will be seen that the time available for making plans and collecting the necessary apparatus was very limited.

The plan of observation ultimately adopted was that at every port in which we remained for more than twenty-four hours the following operations should be gone through with. 1st. The ship should be swung, and as her head pointed successively to each of the thirty-two true magnetic points, the reading of every compass on board should be recorded for each point. 2d. That at such of the compasses as were so situated as to render it possible, the horizontal force and inclination should be determined. 3d. The position of the dividing line between the north and south polarity should be traced on each turret. 4th. The magnetic declination, inclination, and horizontal force should be determined on shore. While at sea it was intended to observe the declination—and consequently the deviation—and horizontal force daily, by means of the standard compass; but this turned out to be impracticable, because the only place in the ship where it was possible to mount that instrument was on top of the after pilot-house; a situation

---

[1] The Monadnock is a double-turreted vessel of the monitor type. During the cruise in question, Lieutenant Commander Francis M. Bunce, U. S. N., was her captain, and she was attached to the squadron commanded by Commodore (now Rear-Admiral) John Rogers, U. S. N., at whose special request I was detailed by the Navy Department to make the observations which are the subject of this paper.

where no binnacle could be put, and where the compass was nearly on a level with the top of the smoke-stack. Thus, while at sea, the position occupied by it was almost constantly enveloped in smoke and gas, rendering it absolutely necessary, whenever we left port, to dismount the instrument in order to preserve it from injury.

Owing to the very short time at my disposal previous to sailing, there was great difficulty in providing proper instruments, but I succeeded in obtaining all that were absolutely necessary. The following is a list of them:

1 Portable Declinometer and stand.
1 Five-inch Altitude and Azimuth Instrument.
1 Dip Circle, with two needles, each three and a half inches long.
1 Pair of eight-inch Bar Magnets.
1 Pair of eleven-inch Bar Magnets.
2 Admiralty Standard Compasses, with stands and deflectors.
1 Burt's Solar Compass and stand.
1 Prismatic Sextant of six inches radius.
1 Mercurial Artificial Horizon.
1 Pocket Chronometer, Fletcher, No. 906.
1 Silver Comparing Watch.
2 Pocket Thermometers.
2 Pocket Compasses.
2 Magnetic Needles, not mounted, each 2.75 inches long, and 0.33 of an inch broad.
1 Fifty feet Chesterman's Patent Tape Line.
1 Case of Drawing Instruments.
1 Gunter's Scale, two feet long.

The portable declinometer belonged to the U. S. Coast Survey, and was kindly lent by Prof. J. E. Hilgard.

The small unmounted magnetic needles were intended to be used for measuring the relative horizontal force on shore and at each of the compasses on board ship. For this purpose it was proposed to vibrate one of them on shore, and then taking it on board ship to the compass at which it was desired to measure the relative horizontal force, to remove the compass card from the centre-point, and putting the small needle in its place, vibrate it again. Unfortunately the small needles were not finished till just before we left Philadelphia, and there was no opportunity of trying them till after we were at sea, when, to my great regret, it was found that the jewels were so small that they would not fit on the centre-point of any compass on board, thus rendering them entirely useless. Under the circumstances, for horizontal force on board ship it was necessary to rely entirely upon measures made with the deflectors belonging to the Admiralty standard compasses—a method certainly not so convenient, and, owing to the constant swinging of the ship when at anchor, probably not so accurate as counting the vibrations of a small needle.

The observations on terrestrial magnetism, and for latitude, time, and true bearings, were all made by myself and recorded by Mr. Corrin F. Smith, who was captain's clerk on the Monadnock, and acted as my assistant when I was observing. My best thanks are due to him for the efficient manner in which he performed his duties, sometimes under circumstances of very considerable physical discomfort.

The reductions and discussions in this report have been made by me, so that I am personally responsible, not only for the general plan of the work, but for every figure contained in it. All the results have been very carefully checked, and it is hoped no material error will be found in them; still, absolute accuracy is scarcely to be expected in any work involving so many figures, the more especially as much of it has been done during moments snatched from other and more pressing professional duties.

The observations naturally divide themselves into three classes: 1st. Those relating to astronomy. 2d. Those relating to terrestrial magnetism. 3d. Those relating to the magnetism of the ship. As that is the order in which they must necessarily be reduced, they will be so treated of in the subsequent sections of this report.

SECTION II.

DESCRIPTIONS OF STATIONS.

UNLESS otherwise stated, the assumed positions of light-houses, forts, etc., have been taken from the English Admiralty Charts, or from the English Admiralty List of Lights, the latest editions obtainable in 1865 being employed. The longitudes are counted from the meridian of Greenwich.

The method used in testing a station for local attraction by means of fore and back sights with a compass, was as follows: The compass was set up at the station, and the bearing of a point distant one hundred yards, or more, was observed. Then the compass was transferred to that point, and the bearing of the station was observed. These two bearings should evidently differ from each other by 180°; if they did not, it was certain that local attraction existed at one or both of the points, and a new station was sought for. This process is almost certain to detect any strictly local magnetic attraction, but it will not suffice to demonstrate the existence of an abnormal state of the magnetic elements extending over a large territory.

PHILADELPHIA, *Pa.* The magnetic observations were made at a spot on the east bank of the Delaware river, about twenty feet from the water's edge. It is nearly southeast from the U. S. Navy Yard, from which it is distant about three-quarters of a mile. The soil is a dark—nearly black—earth, which appears to have been deposited by the river. The approximate position of the station was

Lat. 39° 55′ N.
Long. 5^h 0^m 32^s W.

GOSPORT, *Va.* The magnetic observations were made on a white sandy beach, on the west bank of the Elizabeth river, about thirty feet from the water's edge. From the place where the instruments stood, the flagstaff in the U. S. Navy Yard bore due north by compass, and was distant about half a mile.

Assuming the position of the flagstaff to be lat. 36° 49′ 32″ N., long. 5^h 5^m $9^s.8$ W., as stated by the authorities at the Navy Yard, the position of the spot occupied by the instruments is approximately

Lat. 36° 49′ 0″ N.
Long. 5^h 5^m $9^s.8$ W.

The ship was swung at the compass station in Hampton Roads, on November 1st, 1865, in the usual manner. Her position at the time was lat. 36° 58′ N., long. 76° 20′ W. Joint XII on the after turret was 14.4 inches to port.

St. Thomas, *West Indies.* The ship was swung in this harbor, on November 18th, 1865, in the usual manner. Her position at the time was lat. 18° 19′ N., long. 64° 56′ W. Joint XII on the after turret was 14.4 inches to port.

The observations on shore were made in Long Bay, at a spot about thirty feet from the water's edge, on a gravelly beach, to the eastward of the town. From the place where the instruments stood the true bearing of Fort Cowell, at the entrance to the harbor, is S. 34° 50′ W., and it is distant about one mile.

Assuming the position of Fort Christian to be lat. 18° 20′ 27″ N., long. 4^h 19^m $42^s.7$ W., then, according to the English Admiralty Chart, the position of the spot where the instruments were set up is

Lat. 18° 20′ 22″ N.
Long. 4^h 19^m $40^s.6$ W.

Isle Royal, *Salute Islands.* An attempt was made to swing the ship here, on November 30th, 1865, in the usual manner, but it failed on account of the continual rain which shut off the view of the distant azimuth mark. The position of the ship at the time was lat. 5° 17′ N., long. 52° 33′ W. Joint XII on the after turret was 0.6 of an inch to starboard.

The magnetic and astronomical observations on shore were made on the southwest side of the island, at a spot from which the corner made by the southeast and southwest faces of the government coal sheds bears N. 64° W. (true), and is distant one hundred and thirty-two feet. The place was examined carefully for local attraction by taking fore and back sights with a compass, but none could be detected. The position occupied by the instruments is in

Lat. 5° 17′ 29″ N.
Long. 3^h 30^m $11^s.4$ W.

The latitude was determined from a single set of circummeridian altitudes of the sun observed by me, and the longitude was taken from the French chart.

Ceara, *Brazil.* An attempt was made to swing the ship here, on December 19th, 1865, in the usual manner, but although a very favorable opportunity was chosen, she could only be made to turn through ten points. Her position at the time was lat. 3° 44′ S., long. 38° 34′ W. Joint XII on the after turret was 0.6 of an inch to starboard. The wind, current, and sea are so strong here that vessels at anchor in the roads always ride with their heads nearly in the same direction, never swinging more than about three points.

At this place there is no harbor whatever, merely an open roadstead. A heavy surf is constantly running on the beach, and as there are almost no facilities for landing in small boats, getting the instruments on shore involved a good deal of trouble and some risk. However, I succeeded in landing them safely, and obtained a very good set of observations on the white sand beach at a spot about one hundred and fifty feet from the water's edge, and from which the true bearing of the southeast corner of the custom-house on the wharf is N. 53° 19′ W., and its distance two hundred feet. From the same spot the true bearing of

Point Macoripe Light-house is N. 75° 38′ E. The position occupied by the instruments is in

Lat. 3° 43′ 59″ S.
Long. 2^h 34^m 6^s W.

The latitude was deduced from my own observations, and the longitude was taken from the list of geographical positions given in Raper's Navigation.

PERNAMBUCO, *Brazil.* The ship was not swung in this port because there was not room to do it in the position where she took her coal, and as she only remained in the harbor twenty-four hours, there was not time to take up another position in order to swing.

The magnetic and astronomical observations on shore were made on the white sand beach, at a spot from which the true bearing of the salient angle of the southeast bastion of Fort Brum is N. 15° 46′ W., and its distance four hundred and thirty feet.

Assuming the position of the light-house, near to Fort Picao, to be lat. 8° 3′ 42″ S., long. 2^h 19^m $26^s.8$ W., as it is given in the English Admiralty List of Lights, edition of 1866, then, according to the English Admiralty Chart, the position occupied by the instruments is in

Lat. 8° 3′ 37″ S.
Long. 2^h 19^m $28^s.2$ W.

BAHIA, *Brazil.* The ship was swung in this harbor, on December 30th, 1865, in the usual manner. Her position at the time was lat. 12° 59′ S., long. 38° 31′ W. Joint XII on the after turret was 0.6 of an inch to starboard.

The magnetic and astronomical observations of December 27th were made at a spot, one hundred and fifty feet from the water's edge, situated in a cocoanut grove on the beach about half-way between Monserat Point and Fort Victoria. The soil is a coarse white sand. It was not possible to get any bearings which would define the exact position, but the above directions are sufficient to enable any one to find the place very nearly.

Assuming the position of Fort St. Antonio Light to be lat. 13° 0′ 55″ S., long. 2^h 34^m $6^s.9$ W., then, according to the English Admiralty Chart, the position occupied by the instruments is in

Lat. 12° 56′ 55″ S.
Long. 2^h 34^m $0^s.5$ W.

RIO JANEIRO, *Brazil.* The ship was swung in this harbor, on January 10th, 1866, in the usual manner; but, owing to a strong wind which was blowing at the time, it was not possible to get her through more than seventeen points. Her position was lat. 22° 54′ S., long. 43° 9′ W. Joint XII on the after turret was 0.8 of an inch to port.

During the whole week we were at Rio there was not one clear day. Consequently it was extremely difficult to make astronomical observations, and it was only by patiently watching for the sun and seizing the opportunities when it was momentarily visible through breaks in the clouds, that the few sights necessary in order to complete the magnetic observations were obtained.

With a single exception, all the magnetic and astronomical observations were made at a spot from which the true bearing of the entrance on the north face of Fort Caraguata (erroneously spelled Gravata on the English charts) is S. 70° W., and its distance fifty-five feet. There were no guns in the fort at the time. The surrounding country is very hilly, the bare, coarse, granite rocks cropping out everywhere from the hill-sides, but in the more level places they are thinly covered with earth. Assuming the position of Fort Villegagnon to be lat. 22° 54′ 42″ S., long. 2^h 52^m $36^s.0$ W., then, according to the English Admiralty Chart, the position occupied by the instruments is in

Lat. 22° 54′ 5″ S.
Long. 2^h 52^m $30^s.7$ W.

The exception referred to above is some observations of the sun for time, made on January 9th. They were got on Rat Island, the spot where naval officers usually go to rate their chronometers when lying in this harbor. Assuming the position of Fort Villegagnon as above, then, according to the English Admiralty Chart, the position of Rat Island is

Lat. 22° 53′ 45″ S.
Long. 2^h 52^m $37^s.9$ W.

Monte Video, *Uruguay.* The ship was swung in this harbor, on January 24th, 1866, in the usual manner. We first attempted to get her around about 1 P. M., but owing to the force of the wind and tide we only obtained ten points, viz., those from E. by S. to S. S. W. Just at sunset we tried it again, and succeeded in getting the remainder of the circle. It was nearly dark when we finished, but as the distant object used for an azimuth mark shone plainly against the sky, there was sufficient light to see pretty distinctly when it was in range with the sights of the compass.

The readings of part of the circle on the After Ritchie compass were lost, owing to the failure of daylight and delay in procuring a lantern. The officer who usually read the After Azimuth compass was on shore at the time, and the duty of making the observations at that instrument was assigned to another, but it turned out that he did not understand how to read an azimuth compass, and his observations were worthless.

While we were lying at Monte Video the tide was very irregular. Most of the time the ship only swung to it about 90°, but two or three times she swung 180°. At the time we swung her to obtain the deviation of the compasses her position was lat. 34° 55′ S., long. 56° 13′ W., and joint XII on the after turret was 4.5 inches to port.

The greater part of the magnetic observations on shore were made on January 18th, at a station on the ground occupied by Tomkinson's slaughtering establishment. The instruments were set up at a spot where there are four large umbu trees standing in a line. The exact position may be recovered by means of the following true bearings. The corner made by the south and west sides of the dwelling-house bears N. 39° E., and is distant about one hundred feet. The light-house on the Mount, on the west side of the harbor, bears N. 59° 0′ W. The water's edge is distant from the station about four hundred feet. The soil is a thin stratum of very poor earth, covering a greenish-colored slaty rock, which crops out in many places. Assuming the position of the light-house on the Mount to be lat. 34° 53′ 15″ S., long. $3^h\ 44^m\ 59^s.0$ W., then, according to the English Admiralty Charts, the position occupied by the instruments is in

Lat. 34° 53′ 39″ S.
Long. $3^h\ 44^m\ 55^s.8$ W.

As a check, some magnetic observations were made, on January 19th, at a station from which the true bearing of the light-house on the Mount is N. 89° 41′ W., and the true bearing of the light on the Cathedral is S. 17° 42′ W. Assuming the position of the light-house to be as stated above, and the light on the cathedral to be in lat. 34° 54′ 20″ S., long. $3^h\ 44^m\ 50^s.0$ W., as given in the English Admiralty List of Lights in South America, edition of 1865, the geographical position of this station was

Lat. 34° 53′ 16″ S.
Long. $3^h\ 44^m\ 48^s.3$ W.

It will be observed that the difference of longitude between the lights on the Mount and on the cathedral, as deduced from the Admiralty List cited above, cannot be made to agree with the positions given on the English Admiralty Chart.

On January 24th some observations for time were made on Rat Island. Assuming the position of the light-house on the Mount to be as stated above, then, according to the English Admiralty Chart, the position of the station on Rat Island was

Lat. 34° 53′ 18″ S.
Long. $3^h\ 44^m\ 52^s.9$ W.

Sandy Point, *Straits of Magellan*. The ship was swung in this harbor, on February 10th, 1866, in the usual manner. Her position at the time was lat. 53° 11′ S., long. 70° 55′ W. Joint XII on the after turret was 4.5 inches to port. While we were lying here the ship was perfectly free to swing to the tide, but she generally turned through an arc of only about ninety degrees, namely, from W.N.W. to N.N.E.

The observations on shore were made in the meadow, between the settlement and the beach, at a spot from which the true bearing of the flagstaff was N. 47° 8′ W., and its distance about eight hundred feet. The soil is sandy, and there is no rock anywhere near. The place was examined for local attraction by taking fore and back sights with a compass, but nothing of the kind could be detected.

Assuming the position of the flagstaff to be lat. 53° 10′ 15″ S., long. $4^h\ 43^m\ 36^s.0$ W., as given on the English Admiralty Chart, edition of 1861, the position occupied by the instruments is in

Lat. 53° 10′ 20″ S.
Long. $4^h\ 43^m\ 35^s.3$ W.

VALPARAISO, *Chile*. The ship was swung in this harbor, on April 4th, 1866, in the usual manner. Her position at the time was lat. 33° 2′ S., long. 71° 38′ W. Joint XII on the after turret was 4.25 inches to port. While we were lying at Valparaiso the ship was perfectly free to swing to the tide, and she turned in all directions.

The observations taken on shore March 2d were made on the south end of the white sand beach at the Estero de Quilpue, at a spot about two hundred and fifty feet from the rocks. Assuming the position of Fort San Antonio to be lat. 33° 1′ 53″ S., long. $4^h\ 46^m\ 46^s.0$ W., then, according to the English Admiralty Chart, the position of this station was approximately

Lat. 33° 1′.4 S.
Long. $4^h\ 46^m\ 31^s$ W.

The observations of March 19th, and all taken subsequently to that date, were made at a spot distant about six hundred and fifty feet, nearly true north, from the most northern of the custom-houses. The instruments were set up, near to the water's edge, on the public road which here runs along under a high bank of rock. The true bearing of the flagstaff at Fort San Antonio, on the top of the hill, was S. 31° 45′ W., and its estimated distance was seven hundred feet. Assuming the position of the fort to be as stated above, the position occupied by the instruments is in

Lat. 33° 1′ 47″ S.
Long. $4^h\ 46^m\ 45^s.7$ W.

Both this station and that of March 2d were carefully tested for local attraction by taking fore and back sights with a compass, but none could be detected.

In adopting $4^h\ 46^m\ 46^s.0$ as the longitude of Fort San Antonio, I have followed Raper, but this value is doubtless too large. Capt. Jas. M. Gilliss, U. S. N., from a series of occultations and moon culminations, observed during the years 1850–51–52, determined the longitude of the Observatory on the hill of Santa Lucia, in Santiago, to be $4^h\ 42^m\ 33^s.8$. Dr. Moesta, from subsequent observations up to the year 1862, corrected this value to $4^h\ 42^m\ 33^s.0$. Capt. Gilliss, by means of the electric telegraph, found the difference of longitude between the Observatory at Santiago and Mr. Mouatt's Observatory at Valparaiso to be $3^m\ 56^s.5$. Hence, adopting Dr. Moesta's value of the longitude of Santiago, we have

$4^h\ 46^m\ 29^s.5$ W.

as the longitude of Mr. Mouatt's Observatory; but I have been unable to find any description of its position, and consequently cannot refer this longitude to Fort San Antonio.

Findlay, in his "Directory to the South Pacific Ocean," edition of 1863, gives for the longitude of Fort San Antonio $4^h\ 46^m\ 28^s.8$, and quotes Dr. Moesta as the authority. The Connaissance des Temps, for the year 1868, on the same authority gives $4^h\ 46^m\ 27^s.5$ for the same position. Which of the two values is nearest correct I am unable to say.

CALLAO, *Peru*. The ship was swung in this harbor, on April 29th, 1866, in the usual manner. Her position at the time was lat. 12° 3′ S., long. 77° 14′ W. Joint

XII on the after turret was 5.5 inches to port. While we were lying at Callao the ship was perfectly free to swing to the tide, but the wind and current were so strong that she did not do so, but always lay with her head pointing in a southerly direction.

The observations taken on shore, April 26th, were made on the northeast side of San Lorenzo Island, about two and a half miles southeast of the light-house. The island is a mass of hills, rising to an elevation of more than a thousand feet, composed of loose friable rock which seems to be of volcanic origin, and which is constantly disintegrating into a fine yellow sand. The place selected for making the observations is at the foot of a gorge where there is a beach, about a quarter of a mile long, of the yellow sand mentioned above. On the beach stand a number of fishermen's huts, and a few steps back, at the foot of the gorge, stands a large, square, two-story house. The spot where the instruments stood is on the southeast end of the beach, a little beyond the fishermen's huts, and just above high-water mark. Assuming the position of the light-house to be lat. 12° 4′ 0″ S., long. 5^h 9^m $18^s.0$ W., the position occupied by the instruments is in

Lat. 12° 5′ 14″ S.
Long. 5^h 9^m $9^s.1$ W.

The place was carefully tested for local attraction by taking fore and back sights with a compass, but none could be detected.

PAYTA, *Peru.* We remained in this port only from 2^h 30^m P. M. of May 6th, 1866, till 6^h P. M. of May 7th, and there was neither time nor opportunity to swing the ship. However, a complete set of magnetic observations were made on shore at a station on the beach four-tenths of a mile northwest of the large iron building which stands just back from the mole, and is used by the government as a custom-house, etc. As nearly as could be determined from angles carefully measured, and plotted on the English Admiralty Chart, this station is identical with the one occupied by the officers of H. B. M. surveying vessel "Beagle," in the year 1836, when making their observations for determining the position of Payta. According to their determinations it is in

Lat. 5° 5′ 36″ S.
Long. 5^h 24^m $22^s.0$ W.,

the longitude depending upon the position of the northeast bastion at Panama, New Granada, which is taken to be 5^h 18^m $4^s.6$ W.

The instruments were set up, just above high-water mark, on the gray sand beach, about fifty feet back from which the land rises into bluffs, two hundred feet high, composed of a hard yellow earth, alternating with sedimentary rocks. The station was carefully examined for local attraction, by taking fore and back sights with a compass, but none could be detected.

PANAMA, *New Granada.* The ship was swung in this roadstead, on May 20th, 1866, in the usual manner. Her position at the time was lat. 8° 55′ N., long. 79° 30′ W. Joint XII on the after turret was 5.5 inches to port. While we were lying here the ship was swinging freely in all directions to the wind and tide.

The observations taken on shore, May 14th, were made on the northern side of Flamenco Island, to the westward of a small cocoanut grove, and northeast of the Naval Cemetery. The instruments were set up about ten feet north of the most western of the ruins which are to be found there. The island is rocky, but at this station the rocks are covered with earth. The spot was carefully tested for local attraction by taking fore and back sights with a compass, but none could be detected.

If we assume the position of the northeast bastion at Panama to be lat. 8° 56′ 56″ N., long. 5^h 18^m $4^s.6$ W., as given by Capt. H. Kellet, R. N., then, according to the English Admiralty Chart, the position occupied by the instruments is in

Lat. 8° 54′ 31″ N.
Long. 5^h 18^m $1^s.8$ W.

ACAPULCO, *Mexico.* The ship was swung in this harbor, on June 1st, 1866, in the usual manner. Her position at the time was lat. 16° 50′ N., long. 99° 52′ W. Joint XII on the after turret was 5.5 inches to port. During the three days we were lying at Acapulco the ship was swinging freely to the wind and tide.

At the extreme south end of St. Lucia Bay, in this harbor, are two cocoanut groves, the most western of the two containing the graves of a number of our naval officers. The western end of the eastern grove is the place where the observations taken on shore, on May 30th, were made. The trees come almost close down to high-water mark, and the soil is a gray sand. The instruments were set up about forty feet from high-water mark, at a spot from which the true bearing of the gate of Fort St. Diego is N. 6° 22′ E.

If we assume the position of this gate to be lat. 16° 50′ 56″ N., long. 6^h 39^m $29^s.0$ W., as given on the English Admiralty Chart, then, according to that chart, the position occupied by the instruments is in

Lat. 16° 50′ 3″ N.
Long. 6^h 39^m $29^s.4$ W.

MAGDALENA BAY, *Lower California.* An attempt was made to swing the ship in this bay, on June 9th, 1866, in the usual manner, but owing to a very stiff breeze which was blowing at the time, she could only be turned through fourteen points. Her position was lat. 24° 38′ N., long. 112° 6′ W. Joint XII on the after turret was 5.5 inches to port. During the three days that we lay in this bay the wind was so strong that the ship did not swing to the tide, but rode with her head constantly to the west.

As it is difficult to describe the land-marks here, the most convenient way of giving positions will be to refer them to the English Admiralty Chart, the position formerly occupied by Capt. Sir Edw. Belcher's observatory being taken to be lat. 24° 38′ 18″ N., long. 7^h 28^m $25^s.4$ W., as given on the chart.

On June 8th a landing was effected at a spot on the beach, about a mile south of the position of Capt. Belcher's observatory, for the purpose of making a set of magnetic observations; but, after getting a time sight, it was found that there was a great deal of local attraction, nearly all the stones on the beach being magnetic, and consequently it was useless to attempt anything there. The approximate position of this spot is

Lat. 24° 38′ N.
Long. 7^h 28^m 24^s W.

On June 9th, after going to the extreme northern end of the bay, and pulling a short distance up a creek, a place was found which, upon careful examination by taking fore and back sights with a compass, seemed to be entirely free from all local attraction. The land there is composed of fine white-sand hillocks, which are constantly being shifted by the wind, and are so loose that a man will sink halfway to his knees in walking over them. The only place where the surface was sufficiently solid to admit of the instruments being set up was below high-water mark, where the sand was wet. A complete set of magnetic observations were made there, which, however, were not as satisfactory as could have been wished, owing to the magnets being disturbed by a stiff breeze which shook the instruments, and from which there was no shelter. The position of this station was

Lat. 24° 39′ 36″ N.
Long. 7^h 28^m 26^s.2 W.

It was on the east side of the creek (on its left-hand bank), at a place where there is a sharp bend in its course, and can easily be found by plotting the position, given above, on the chart.

SAN DIEGO BAY, *California.* We were only in this harbor from 11 A.M. of June 15th, 1866, till 11 A.M. of June 16th, and there was no time to swing the ship. However, during the afternoon of the 15th a complete and very satisfactory set of magnetic observations were made on shore at a spot on the beach near the extreme southern end of the slightly rising ground at La Playa. The instruments were set up just above high-water mark, and nearly due east of the U.S. Coast Survey Astronomical Station. The true bearing of the light-house on Point Loma was S. 3° 56′ W., and its distance exactly two statute miles in a direct line. The spot was tested for local attraction by taking fore and back sights with a compass, but none could be detected.

The position of the station, according to the U.S. Coast Survey Chart, was

Lat. 32° 41′ 58″ N.
Long. 7^h 48^m 52^s.6 W.

SAN FRANCISCO, *California.* The ship was swung in this harbor, on June 23d, 1866, in the usual manner. Her position at the time was lat. 37° 48′ N., long. 122° 22′ W. Joint XII on the after turret was 5.3 inches to port. While we were lying here the ship was swinging freely to the wind and tide.

The observations taken on shore June 26th were made on the sand beach in a cove on the east side of Yerba Buena Island, the instruments being set up just at high-water mark, and about one hundred and fifty feet north of a long pier which runs out over a mud flat. The place was tested for local attraction by taking fore and back sights with a compass, but none could be detected.

According to the U.S. Coast Survey Chart the position of this station was

Lat. 37° 48′ 46″ N.
Long. 8^h 9^m 22^s.6 W.

SECTION III.

ASTRONOMICAL OBSERVATIONS.

THE observations contained in this section were all made on the sun, and are for the determination of latitude, local time, and true bearings. The instruments used were a prismatic sextant of six inches radius, by Pistor and Martins; a mercurial artificial horizon; and a pocket mean time chronometer, by Fletcher, marked number 906.

The index correction of the sextant was usually obtained by measuring the diameter of the sun, both on and off the arc. For determining the density of the atmosphere thermometers with Fahrenheit scales, and a mercurial barometer graduated to English inches, were employed.

The refractions have been computed by means of BESSEL'S tables, as given in LOOMIS' "Practical Astronomy;" from which book the tabular parts of the reductions to the meridian have also been taken. The necessary fundamental data have been obtained from the American Nautical Almanac.

Observations of circummeridian altitudes of the sun for latitude were made in sets of twelve, so arranged as to eliminate both the sun's semi-diameter, and all errors depending on the roof of the artificial horizon.

Circummeridian Altitudes of the Sun for Latitude, observed at the south front of Fort Christian, St. Thomas, November 17th, 1865.

10h	55m	0s	105°	14′	20″	$2\overline{\odot}$
	55	48		15	20	
	56	14		16	50	
10	57	3		18	0	
11	0	31		21	40	
	1	5		22	20	
	1	33	104	18	10	$2\underline{\odot}$
	2	9		18	20	
	2	46		18	25	
	3	28		18	50	
	3	59		18	55	
	4	29		18	40	

Index correction.

359°	11′	10″	0°	15′	50″
	11	10		16	10
	11	40		16	20
35	11	20.0	0	16	6.7

Correction = + 16′ 16″.7

Ex. ther. 83°
At. ther. 86
Bar. 30.16 inches.

Mean of chronometer times		11h	0m	2s.0
Chronometer slow of local mean time		0	40	47.3
Equation of time	+		14	47.1
Local apparent time		11	55	36.4
Mean of observed double altitudes		104°	48′	19″.2
Index correction	+		16	16.7
Apparent altitude of sun's centre		52	32	18.0
Refraction	—		0	42.1

Parallax	+ 0°	0′	5″.3	
Reduction to meridian	+	1	19.4	
Sun's declination	—19	6	59.1	
Latitude	18°	20′	0″	N.

Circummeridian Altitudes of the Sun for Latitude, observed at Isle Royal, Salute Islands, November 28th, 1865.

10h	13m	57s.	125°	50′	30″	
	14	35.5		49	30	
	15	9.5		49	30	$2\underline{\odot}$
	15	52		49	20	
	16	24.5		48	50	
	17	1.5		48	40	
	17	38	126	52	10	
	18	14.5		51	10	
	20	17		48	20	$2\overline{\odot}$
	21	9		46	10	
	31	46.5		30	0	
	32	30		26	50	

Index correction.

359°	11′	10″	0°	16′	0″
	11	10		16	0
359	11	10	0	16	0

Correction = +16′ 25″.0

Ex. ther.	91°
At. ther.	85
Bar.	30.13 inches.

Mean of chronometer times	10h	19m	37s.9	
Chronometer slow of local mean time	1	30	19.4	
Equation of time	+	11	42.6	
Local apparent time	12	1	39.9	
Mean of observed double altitudes	126°	15′	55″.0	
Index correction	+	16	25.0	
Apparent altitude of sun's centre	63	16	10.0	
Refraction	—	0	27.1	
Parallax	+	0	3.9	
Reduction to meridian	+	2	35.7	
Sun's declination	—21	24	8.5	
Latitude	5°	17′	29″	N.

Observations for time were usually made in such a manner as to eliminate both the sun's semi-diameter and all errors which might be produced by the roof of the artificial horizon. For full details of the method see page 33 of the "Reports on Observations of the Total Eclipse of the Sun, August 7, 1869," published by the U. S. Naval Observatory, Washington.

The reduction of the observations for time has been effected by means of the following formulæ:

$$a = \frac{A + \omega}{2} - r + p$$

$$S = \frac{a + d + \phi}{2}$$

$$\sin \tfrac{1}{2} t = \sqrt{\sin (S - a) \cos S \sec \phi \operatorname{cosec} d}$$

$$dt = t + \tau - T$$

T = mean of observed chronometer times.

A = mean of observed double altitudes.

ω = index correction.

r = refraction.

p = parallax.

a = true geocentric altitude of sun's centre.
d = sun's polar distance, measured from the elevated pole.
ϕ = latitude of place where observation is made.
t = hour angle at the pole.
τ = equation of time.
dt = correction of chronometer to reduce the reading of its face to local mean time.

Double Altitudes of the Sun, for Time, observed at the flagstaff in the Navy-yard at Portsmouth, Va., October 29th, 1865.

8^h	51^m	7^s	49°	27′	50″	$2\overline{\odot}$	Index correction, = + 15′ 42″
	51	42		38	20		
	52	22		49	30		
	53	23	50	7	40		
	53	56.5		17	50		
	54	47	50	32	20		
	55	50	49	47	0	$2\underline{\odot}$	
	56	25		57	20		
	56	57.5	50	6	20		
	57	59.5		24	50		
	58	32.5		34	30		
	59	13.5		45	50		

Ex. ther. 50°. At. ther. 92°. Bar. 30.40 inches.
Refraction = — 125″ Sun's declination — 13° 35′ 16″
Parallax = + 8 Latitude + 36 49 32

Mean of observed double altitudes	50°	7′	27″
Local apparent time	9^h	6^m	$40^s.8$
Equation of time . . . .—		16	10.6
Local mean time	8	50	30.2
Mean of chronometer times	8	55	11.3
Chronometer fast of local mean time	0	4	41.1
Longitude west	5	5	9.8
Chronometer slow of Greenwich mean time	5	0	28.7

Double Altitudes of the Sun for Time, observed at the flagstaff in the Navy-yard at Portsmouth, Va., October 29th, 1865.

3^h	11^m	55^s	40°	10′	10″	$2\underline{\odot}$	Index correction, =+15′ 42″
	12	54	39	51	20		
	13	32.5		38	30		
	14	9.5	40	30	30	$2\overline{\odot}$	
	14	51		17	0		
	15	36.5		2	20		
	16	52.5	39	37	30		
	17	37		23	10		
	18	24.5		8	30		
	19	16.5	37	46	0	$2\underline{\odot}$	
	20	2		31	30		
	20	55.5		20	10		

Ex. ther. 55° At. ther. 79 Bar. 30.36 inches.
Refraction = — 170″.1 Sun's declination — 13° 40′ 42″.0
Parallax = + 8.0 Latitude + 36 49 32.

Mean of observed double altitudes . . , . . .	39°	16′	23″.3
Local apparent time	3^h	27^m	$51^s.9$

Equation of time . . . .—	0^h	16^m	$11^s.6$
Local mean time	3	11	40.3
Mean of chronometer times	3	16	20.4
Chronometer fast of local mean time	0	4	40.1
Longitude west	5	5	9.8
Chronometer slow of Greenwich mean time	5	0	29.7

Double Altitudes of the Sun for Time, observed at Fort Christian, St. Thomas, West Indies, November 13th, 1865.

9^h	0^m	$42^s.5$	84°	32′	50″	$2\underline{\odot}$
	1	21.5		46	20	
	2	2		57	30	
	3	2.5	85	16	50	
	4	4		35	10	
	4	54	85	51	0	
	6	0.5	87	15	20	$2\overline{\odot}$
	6	41		28	30	
	7	10		37	0	
	7	54.5		50	20	
	8	21.5		59	20	
	8	48.5	88	7	0	

Index correction.

359°	10′	50″	0°	16′	20″
	11	0		16	10
	11	10		16	40
359	11	0.0	0	16	23.3

Correction = + 16′ 18″.4

Ex. ther.	84°	At. ther.	86°	Bar.	30.12 inches.
Refraction	= — 57″.7			Sun's declination	— 18° 5′ 2″.5
Parallax	= + 6.2			Latitude	+ 18 20 27.

Mean of observed double altitudes	86°	26′	25″.8
Local apparent time	10^h	1^m	$20^s.0$
Equation of time . . . .—		15	31.2
Local mean time	9	45	48.8
Mean of chronometer times	9	5	5.2
Chronometer slow of local mean time	0	40	43.6
Longitude west	4	19	42.7
Chronometer slow of Greenwich mean time	5	0	26.3

Double Altitudes of the Sun for Time, observed at Isle Royal, Salute Islands, November 28th, 1865.

8^h	47^m	58^s	109°	58′	20″	$2\underline{\odot}$
	48	35	110	9	50	
	49	8		20	0	
	49	58		35	30	
	50	31		45	50	
	50	56.5		52	50	
	51	44.5	112	13	0	$2\overline{\odot}$
	52	39.5		30	0	
	53	13.5		40	0	
	53	47		50	0	
	54	19	113	0	0	
	54	53.5		10	0	

Index correction.

359°	11′	0″	0°	15′	50″
	11	0		16	0
	10	50		16	10
359	10	56.7	0	16	0.0

Correction = + 16′ 31″.6

Ex. ther.	93°	At. ther.	85°	Bar.	30.13 inches.
Refraction	= — 36″.3			Sun's declination	— 21° 23′ 30″.3
Parallax	= + 4.9			Latitude	+ 5 17 29.

Mean of observed double altitudes	111°	35′	26″.6
Local apparent time	10^h	33^m	$31^s.8$
Equation of time . . . .—		11	43.8
Local mean time	10	21	48.0
Mean of chronometer times	8	51	28.6

Chronometer slow of local mean time.	1^{h} 30^{m} $19^{s}.4$
Longitude west	3 30 11.4
Chronometer slow of Greenwich mean time	5 0 30.8

Double Altitudes of the Sun for Time, observed at Ceara, Brazil, December 13th, 1865.

1^{h} 15^{m} $13^{s}.5$	63° 0′ 0″	$2\underline{\odot}$
15 58.5	62 40 0	
16 41	20 0	
17 3.5	10 0	
17 26	62 0 0	
18 43	62 30 0	$2\overline{\odot}$
19 5	20 0	
19 26.5	10 0	
19 50	62 0 0	
20 11.5	61 50 0	

Index correction.

359° 11′ 0″	0° 16′ 0″
10 50	10
10 40	0
359 10 50.0	0 16 3.3

Correction = + 16′ 33″.3

Ex. ther. 84° At. ther. 82° Bar. 30.05 inches.
Refraction = — 89″.5 Sun's declination — 23° 12′ 4″.0
Parallax = + 7.4

Mean of observed double altitudes	62° 18′ 0″.0
Mean of chronometer times	1^{h} 17^{m} $57^{s}.8$
Equation of time . . . .—	5 20.9

Reducing this observation with latitude = — 3° 43′ 15″, we find the chronometer 2^{h} 26^{m} $29^{s}.6$ slow of local mean time. Reducing it with latitude = — 3° 44′ 15″, we find the chronometer 2^{h} 26^{m} $32^{s}.0$ slow of local mean time.

Double Altitudes of the Sun for Time, observed at Ceara, Brazil, December 14th, 1865.

7^{h} 2^{m} $0^{s}.5$	99° 30′ 0″	$2\overline{\odot}$
2 24.5	40 0	
2 49	50 0	
3 12.5	100 0 0	
3 36	10 0	
6 9	100 10 0	$2\underline{\odot}$
6 32.5	20 0	
6 57.5	30 0	
7 21.5	40 0	
7 45.5	100 50 0	

Index correction.

359° 10′ 30″	0° 16′ 10″
40	20
40	20
359 10 36.7	0 16 16.7

Correction = + 16′ 33″.3

Ex. ther. 81° At. ther. 82° Bar. 30.12 inches.
Refraction = — 45″.9 Sun's declination — 23° 14′ 46″.2
Parallax = + 5.6

Mean of observed double altitudes	100° 10′ 0″.0
Mean of chronometer times	7^{h} 4^{m} $52^{s}.8$
Equation of time . . . .—	4 59.5

Reducing this observation with latitude = — 3° 43′ 15″, we find the chronometer 2^{h} 26^{m} $33^{s}.7$ slow of local mean time. Reducing it with latitude = — 3° 44′ 15″, we find the chronometer 2^{h} 26^{m} $30^{s}.9$ slow of local mean time.

Double Altitudes of the Sun for Time, observed at Ceara, Brazil, December 14th, 1865.

$11^h\ 51^m\ 51^s$	100° 50′ 0″	$2\overline{\odot}$
52 14.5	40 0	
52 37	30 0	
53 1.5	20 0	
53 26	10 0	
56 0	98 0 0	$2\underline{\odot}$
56 23	97 50 0	
56 48	40 0	
57 11.5	30 0	
57 34	20 0	

Index correction.

359° 10′ 50″	0° 15′ 50″
40	16 20
20	16 0
359 10 36.7	0 16 3.3

Correction = + 16′ 40″.0

Ex. ther. 86° At. ther. 83° Bar. 30.00 inches.

Refraction = — 45″.6 Sun's declination — 23° 15′ 27″.4

Parallax = + 5.6

Mean of observed double altitudes	99° 5′ 0″.0
Mean of chronometer times	$11^h\ 54^m\ 42^s.6$
Equation of time	— 4 53.7

Reducing this observation with latitude = — 3° 43′ 15″, we find the chronometer $2^h\ 26^m\ 30^s.7$ slow of local mean time. Reducing it with latitude = — 3° 44′ 15″, we find the chronometer $2^h\ 26^m\ 33^s.1$ slow of local mean time.

In order to determine both the latitude of Ceara and the error of the chronometer from the three observations which have just been given, we proceed as follows:

Comparing the error obtained on the afternoon of December 13th, with that obtained on the afternoon of December 14th, we find that the chronometer was losing 1.17 seconds per day; and this rate is independent of any small change in the adopted value of the latitude.

By means of this rate, reducing all the observed chronometer errors to $2^h\ 26^m$ P. M. December 14th, and then plotting them according to Sumner's method, we get for the place of observation

Latitude 3° 43′ 59″ S.

and for the chronometer,

Chronometer slow of local mean time	$2^h\ 26^m\ 32^s.5$
Longitude west	2 34 6
Chronometer slow of Greenwich mean time	5 0 38.5

Double Altitudes of the Sun for Time, observed at Pernambuco, Brazil, December 23d, 1865.

$7^h\ 30^m\ 15^s$	118° 10′ 0″	$2\overline{\odot}$
30 39.5	20 0	
31 3	30 0	
32 52.5	118 10 0	$2\underline{\odot}$
33 15	20 0	
33 40	30 0	

Index correction.

359° 10′ 50″	0° 16′ 0″
50	16 10
359 10 50.0	0 16 5.0

Correction = + 16′ 32″.5

Ex. ther. 83° At. ther. Bar.

Refraction = — 32″.1 Sun's declination — 23° 26′ 31″

Parallax = + 4.5 Latitude — 8 3 37

Mean of observed double altitudes	118° 20′ 0″.0
Local apparent time	$10^h\ 9^m\ 3^s.5$
Equation of time	— 0 31.2
Local mean time	10 8 32.3

Mean of chronometer times	7h	31m	57s.5
Chronometer slow of local mean time	2	36	34.8
Longitude west	2	19	28.2
Chronometer slow of Greenwich mean time	4	56	3.0

Double Altitudes of the Sun for Time, observed at Bahia, Brazil, December 27th, 1865.

6h 52m 10s	98° 30′ 0″	$2\overline{\odot}$
52 31.5	40 0	
52 54.5	50 0	
54 32	98 30 0	$2\underline{\odot}$
54 53.5	40 0	
55 16.5	50 0	

Index correction.

359° 10′ 40″	0° 16′ 10″
50	0
359 10 45.0	0 16 5.0

Correction =+16′ 35″.0

Ex. ther. 88°	At. ther.	Bar.	
Refraction = — 45″.9		Sun's declination	— 23° 19′ 33″.8
Parallax = + 5.7		Latitude	— 12 56 55.

Mean of observed double altitudes	98°	40′	0″.0
Local apparent time	9h	14m	22s.5
Equation of time	+	1	27.3
Local mean time	9	15	49.8
Mean of chronometer times	6	53	43.0
Chronometer slow of local mean time	2	22	6.8
Longitude west	2	34	0.5
Chronometer slow of Greenwich mean time	4	56	7.3

Double Altitudes of the Sun for Time, observed at the Light-house in Fort St. Antonio, Bahia, Brazil, December 29th, 1865.

8h 14m 46s.5	134° 50′ 0″	$2\overline{\odot}$
15 10	135 0 0	
15 31	10 0	
15 56	20 0	
16 19.5	30 0	
17 17.5	134 50 0	$2\underline{\odot}$
17 44	135 0 0	
18 7	10 0	
18 31.5	20 0	
18 54	30 0	

Index correction.

359° 10′ 50″	0° 16′ 0″
50	10
40	10
359 10 46.7	0 16 6.7

Correction =+16′ 33″.3

Ex. ther. 84°	At. ther.	Bar.	
Refraction = — 22″.1		Sun's declination	— 23° 13′ 31″.1
Parallax = + 3.3		Latitude	— 13 0 55.

Mean of observed double altitudes	135°	10′	0″.0
Local apparent time	10h	36m	25s.7
Equation of time	+	2	27.6
Local mean time	10	38	53.3
Mean of chronometer times	8	16	49.7
Chronometer slow of local mean time	2	22	3.6
Longitude west	2	34	6.9
Chronometer slow of Greenwich mean time	4	56	10.5

Double Altitudes of the Sun for Time, observed at Rio Janeiro, Brazil, January 9th, 1866.

5h 13m 17s	47° 40′ 0″	$2\overline{\odot}$
13 39	50 0	
14 3.5	48 0 0	
14 26.5	10 0	
15 43	47 40 0	$2\underline{\odot}$
16 8	50 0	
16 29	48 0 0	
16 53	10 0	

Index correction.

359° 10′ 40″	0° 16′ 0″
30	15 50
359 10 35.0	0 15 55.0

Correction = + 16′ 45″.0

Ex. ther.	74°	At. ther.	77°	Bar.	29.94 inches.
Refraction	= — 123″.2.			Sun's declination	— 22° 6′ 24″.6
Parallax	= + 7.9			Latitude	— 22 54 5.

Mean of observed double altitudes	47° 55′ 0″.0
Local apparent time	7h 11m 19s.5
Equation of time	+ 7 23.8
Local mean time	7 18 43.3
Mean of chronometer times	5 15 4.9
Chronometer slow of local mean time	2 3 38.4
Longitude west	2 52 30.7
Chronometer slow of Greenwich mean time	4 56 9.1

Double Altitudes of the Sun for Time, observed at Rat Island, harbor of Rio Janeiro, January 9th, 1866.

7h 27m 0s	108° 0′ 0″	$2\overline{\odot}$
27 20	10 0	
27 42.5	20 0	
28 4.5	30 0	
28 26.5	40 0	
29 21	108 0 0	$2\underline{\odot}$
29 45	10 0	
30 5	20 0	
30 26.5	30 0	
30 48	40 0	

Index correction.

359° 10′ 30″	0° 15′ 50″
40	50
40	50
359 10 36.7	0 15 50.0

Correction = + 16′ 46″.6

Ex. ther.	75°	At. ther.	77°	Bar.	29.94 inches.
Refraction	= — 39″.8			Sun's declination	— 22° 5′ 37″.3
Parallax	= + 5.1			Latitude	— 22 53 45.

Mean of observed double altitudes	108° 20′ 0″.0
Local apparent time	9h 25m 0s.7
Equation of time	+ 7 26.0
Local mean time	9 32 26.7
Mean of chronometer times	7 28 53.9
Chronometer slow of local mean time	2 3 32.8
Longitude west	2 52 37.9
Chronometer slow of Greenwich mean time	4 56 10.7

Double Altitudes of the Sun for Time, observed at Monte Video, Uruguay, January 18th, 1866.

4h 0m 26s.5	45° 50′ 0″	$2\underline{\odot}$
0 51.5	40 0	
1 17	30 0	
2 3.5	10 0	
3 5.5	45 50 0	$2\overline{\odot}$
3 30	40 0	
3 56.5	30 0	
4 46	10 0	

Index correction.

359° 10′ 30″	0° 15′ 50″
40	40
40	40
359 10 36.7	0 15 43.3

Correction = + 16′ 50″.0

Ex. ther. 76° At. ther. 79° Bar. 30.02 inches.
Refraction = — 130″.2 Sun's declination — 20° 26′ 55″.2
Parallax = + 8.0 Latitude — 34 53 39

Mean of observed double altitudes		45°	32′	30″.0
Local apparent time		5^h	3^m	$5^s.2$
Equation of time	+		10	51.4
Local mean time		5	13	56.6
Mean of chronometer times		4	2	29.6
Chronometer slow of local mean time		1	11	27.0
Longitude west		3	44	55.8
Chronometer slow of Greenwich mean time		4	56	22.8

Double Altitudes of the Sun for Time, observed on Rat Island, harbor of Monte Video, Uruguay, January 24th, 1866.

2^h	29^m	$1^s.5$	82°	30′	0″	$2\underline{\odot}$
	29	25.5		20	0	
	29	50.5		10	0	
	30	13.5	82	0	0	
	30	38.5	81	50	0	
	31	38.5	82	30	0	$2\overline{\odot}$
	32	3		20	0	
	32	26		10	0	
	32	51	82	0	0	
	33	16	81	50	0	

Index correction.

359°	10′	10″	0°	15′	40″
	10	10			40
	10	10			20
359	10	10.0	0	15	33.3

Correction = + 17′ 8″.3

Ex. ther. 74° At. ther. Bar.
Refraction = — 62″.7 Sun's declination — 19° 6′ 33″.8
Parallax = + 6.5 Latitude — 34 53 18

Mean of observed double altitudes		82°	10′	0″.0
Local apparent time		3^h	30^m	$5^s.7$
Equation of time	+		12	29.2
Local mean time		3	42	34.9
Mean of chronometer times		2	31	8.4
Chronometer slow of local mean time		1	11	26.5
Longitude west		3	44	52.9
Chronometer slow of Greenwich mean time		4	56	19.4

Double Altitudes of the Sun, for Time, observed at Sandy Point, in the Straits of Magellan, February 7th, 1866.

9^h	59^m	$24^s.5$	90°	30′	0″	$2\overline{\odot}$
10	0	11		40	0	
	1	1		50	0	
	1	49.5	91	0	0	
	2	37.5		10	0	
	4	39.5	90	30	0	$2\underline{\odot}$
	5	27.5		40	0	
	6	18.5		50	0	
	7	9	91	0	0	
	7	58.5		10	0	

Index correction.

359°	10′	20″	0°	15′	40″
		30			50
		35			35
359	10	28.3	0	15	41.7

Correction = + 16′ 55″.0

Ex. ther. 52° At. ther. 70° Bar. 30.04 inches.
Refraction = — 56″.9 Sun's declination — 15° 14′ 15″.6
Parallax = + 6.1 Latitude — 53 10 20

Mean of observed double altitudes		90°	50′	0″
Local apparent time		10^h	2^m	$2^s.2$
Equation of time	+		14	25.5

Local mean time		10^{h}	16^{m}	$27^{s}.7$
Mean of chronometer times		10	3	39.6
Chronometer slow of local mean time		0	12	48.1
Longitude west		4	43	35.3
Chronometer slow of Greenwich mean time		4	56	23.4

Double Altitudes of the Sun for Time, observed near Valparaiso, Chile, March 2d, 1866.

3^{h}	50^{m}	$15^{s}.5$	62°	0′	0″	$2\underline{\odot}$
	50	39.5	61	50	0	
	51	3		40	0	
	51	51.5		20	0	
	52	52	62	0	0	$2\overline{\odot}$
	53	15.5	61	50	0	
	53	39.5		40	0	
	54	30		20	0	

Index correction.

359°	10′	40″	0°	15′	0″
		45			5
		40			10
359	10	41.7	0	15	5.0

Correction = + 17′ 6″.6

Ex. ther. 67° At. ther. Bar.

Refraction = — 92″.4 Sun's declination — 7° 1′ 53″

Parallax = + 7.4 Latitude — 33 1.4

Mean of observed double altitudes . . , . .		61°	42′	30″.0
Local apparent time		3^{h}	49^{m}	$44^{s}.3$
Equation of time	+		12	17.9
Local mean time		4	2	2.2
Mean of chronometer times		3	52	15.8
Chronometer slow of local mean time		0	9	46.4
Longitude west		4	46	31
Chronometer slow of Greenwich mean time		4	56	17.4

Double Altitudes of the Sun for Time, observed in Valparaiso, Chile, March 29th, 1866.

2^{h}	36^{m}	55^{s}	73°	30′	0″	$2\underline{\odot}$
	37	40		15	0	
	38	23		0	0	
	40	1.5	73	30	0	$2\overline{\odot}$
	40	45.5		15	0	
	41	28.5		0	0	

Index correction.

359°	10′	20″	0°	14′	50″
		50			45
		45			55
359	10	38.3	0	14	50.0

Correction = + 17′ 15″.8

Ex. ther. 71° At. ther. 69° Bar. 30.23 inches.

Refraction = — 75″.1 Sun's declination + 3° 31′ 38″

Parallax = + 6.9 Latitude — 33 1 .47

Mean of observed double altitudes		73°	15′	0″.0
Local apparent time		2^{h}	43^{m}	$52^{s}.0$
Equation of time	+		4	47.0
Local mean time		2	48	39.0
Mean of chronometer times		2	39	12.2
Chronometer slow of local mean time.		0	9	26.8
Longitude west		4	46	45.7
Chronometer slow of Greenwich mean time		4	56	12.5

Double Altitudes of the Sun for Time, observed in Valparaiso, Chile, April 7th, 1866.

9^{h}	36^{m}	$26^{s}.5$	77°	30′	0″	$2\overline{\odot}$
	37	16.5		45	0	
	38	9	78	0	0	
	40	1.5	77	30	0	$2\underline{\odot}$
	40	53		45	0	
	41	44.5	78	0	0	

Index correction.

359°	10′	50″	0°	15′	10″
		50			10
		50			10
359	10	50.0	0	15	10.0

Correction = + 17′ 0″.0

Ex. ther. 67° At. ther. 65° Bar. 30.17 inches.
Refraction = — 69″.8 Sun's declination + 6° 53′ 28″.6
Parallax = + 6.7 Latitude — 33 1 47

Mean of observed double altitudes		77°	45′	0″.0
Local apparent time		9h	46m	19s.6
Equation of time	+		2	8.9
Local mean time		9	48	28.5
Mean of chronometer times		9	39	5.2
Chronometer slow of local mean time		0	9	23.3
Longitude west		4	46	45.7
Chronometer slow of Greenwich mean time		4	56	9.0

Double Altitudes of the Sun for Time, observed in Valparaiso, Chile, April 7th, 1866.

9h 43m 15s.5	79° 30′ 0″	
44 6.5	45 0	$2\overline{\odot}$
45 0.5	80 0 0	
46 57	79 30 0	
47 49.5	45 0	$2\underline{\odot}$
48 44.5	80 0 0	

Index correction

= + 17′ 0″.0

Ex. ther. 67° At. ther. 65° Bar. 30.17 inches.
Refraction = — 67″.3 Sun's declination — 6° 53′ 35″.4
Parallax = + 6.6 Latitude — 33 1 47

Mean of observed double altitudes		79°	45′	0″.0
Local apparent time		9h	53m	14s.0
Equation of time	+		2	8.8
Local mean time		9	55	22.8
Mean of chronometer times		9	45	58.9
Chronometer slow of local mean time		0	9	23.9
Longitude west		4	46	45.7
Chronometer slow of Greenwich mean time		4	56	9.6

Double Altitudes of the Sun for Time, observed in Valparaiso, Chile, April 14th, 1866.

3h 50m 20s.5	36° 30′ 0″	
51 1.5	15 0	$2\underline{\odot}$
51 39	0 0	
53 7	36 30 0	
53 46	15 0	$2\overline{\odot}$
54 24.5	0 0	

Index correction.

359° 10′ 40″	0° 14′ 50″
40	45
45	50
359 10 41.6	0 14 48.3

Correction = + 17′ 15″.0

Ex. ther. 65° At. ther. 66° Bar. 30.13 inches.
Refraction = — 170″.3 Sun's declination + 9° 33′ 33″.6
Parallax = + 8.1 Latitude — 33 1 47

Mean of observed double altitudes		36°	15′	0″.0
Local apparent time		4h	3m	13s.2
Equation of time	+		0	11.6
Local mean time		4	3	24.8
Mean of chronometer times		3	52	23.1
Chronometer slow of local mean time		0	11	1.7
Longitude west		4	46	45.7
Chronometer slow of Greenwich mean time		4	57	47.4

Double Altitudes of the Sun for Time, observed on the Island of San Lorenzo, near Callao, Peru, April 26th, 1866.

11^h	17^m	45^s	123°	0′	0″	$2\overline{\odot}$
	18	52		15	0	
	20	3		30	0	
	22	46	123	0	0	$2\underline{\odot}$
	24	2		15	0	
	25	18		30	0	

Index correction.

359°	11′	10″	0°	15′	0″
		10			0
359	11	10.0	0	15	0.0

Correction = + 16′ 55″.0

Ex. ther.	80°	At. ther.	Bar.
Refraction	= — 29″.2.	Sun's declination	+ 13° 35′ 18″
Parallax	= + 4.0	Latitude	— 12 5 14

Mean of observed double altitudes	123°	15′	0″.0
Local apparent time	11^h	12^m	$33^s.0$
Equation of time	—	2	18.8
Local mean time	11	10	14.2
Mean of chronometer times	11	21	27.7
Chronometer fast of local mean time	0	11	13.5
Longitude west	5	9	9.1
Chronometer slow of Greenwich mean time	4	57	55.6

Double Altitudes of the Sun for Time, observed at Payta, Peru, May 7th, 1866.

8^h	40^m	$44^s.5$	62°	0′	0″	$2\overline{\odot}$
	41	17.5		15	0	
	41	51		30	0	
	43	1.5	62	0	0	$2\underline{\odot}$
	43	34.5		15	0	
	44	7.5		30	0	

Index correction.

359°	11′	30″	0°	15′	0″
		25			0
		25			0
359	11	26.7	0	15	0.0

Correction = + 16′ 46″.6

Ex. ther.	78°	At. ther. 80°	Bar. 30.06 inches.
Refraction	= — 90″.7	Sun's declination	+ 16° 50′ 46″
Parallax	= + 7.3	Latitude	— 5 5 36

Mean of observed double altitudes	62°	15′	0″.0
Local apparent time	8^h	19^m	$22^s.3$
Equation of time	—	3	38.1
Local mean time	8	15	44.2
Mean of chronometer times	8	42	26.1
Chronometer fast of local mean time	0	26	41.9
Longitude west	5	24	22.0
Chronometer slow of Greenwich mean time	4	57	40.1

Double Altitudes of the Sun for Time, observed on Flamenco Island, Panama Bay, May 14th, 1866.

9^h	24^m	59^s	95°	0′	0″	$2\overline{\odot}$
	25	31		15	0	
	26	3.5		30	0	
	27	12	95	0	0	$2\underline{\odot}$
	27	43.5		15	0	
	28	15		30	0	

Index correction.

359°	11′	30″	0°	15′	10″
		20		14	55
		20		14	40
359	11	23.3	0	14	55.0

Correction = + 16′ 50″.8

Ex. ther.	85°	At. ther. 85°	Bar. 30.10 inches.
Refraction	= — 49″.5	Sun's declination	+ 18° 39′ 49″
Parallax	= + 5.7	Latitude	+ 8 54 31

Mean of observed double altitudes	95° 15′ 0″.0
Local apparent time	9h 10m 13s.5
Equation of time	— 3 53·1
Local mean time	9 6 20.4
Mean of chronometer times	9 26 37·3
Chronometer fast of local mean time	0 20 16.9
Longitude west	5 18 1.8
Chronometer slow of Greenwich mean time	4 57 44·9

Double Altitudes of the Sun for Time, observed at Acapulco, Mexico, May 30th, 1866.

10h 25m 36s	89° 0′ 0″	$2\overline{\odot}$
26 5·5	15 0	
26 38·5	30 0	
27 49·5	89 0 0	$2\underline{\odot}$
28 22	15 0	
28 54	30 0	

Index correction.

359° 11′ 10″	0° 15′ 0″
0	14 40
20	15 0
359 11 10.0	0 14 53·3

Correction = + 16′ 58″.3

Ex. ther. 89° At. ther. 85° Bar. 30.10 inches.

Refraction = — 54″.5

Parallax = + 6.0

Sun's declination + 21° 48′ 7″

Latitude + 16 50 3

Mean of observed double altitudes	89° 15′ 0″.0
Local apparent time	8h 48m 38s.4
Equation of time	— 2 46.4
Local mean time	8 45 52.0
Mean of chronometer times	10 27 14.2
Chronometer fast of local mean time	1 41 22.2
Longitude west	6 39 29.4
Chronometer slow of Greenwich mean time	4 58 7.2

Double Altitudes of the Sun for Time, observed in Magdalena Bay, Lower California, June 8th, 1866.

5h 20m 49s	100° 45′ 0″	$2\underline{\odot}$
21 23	30 0	
21 56	15 0	
23 8.5	100 45 0	$2\overline{\odot}$
23 41.5	30 0	
24 5	15 0	

Index correction.

359° 10′ 50″	0° 14′ 40″
11 20	14 50
10 30	15 0
359 10 53·3	0 14 50.0

Correction = + 17′ 8″.4

Ex. ther. 69° At. ther. 70° Bar. 30.02 inches.

Refraction = — 46″.4

Parallax = + 5·4

Sun's declination + 22° 53′ 42″

Latitude + 24 38

Mean of observed double altitudes	100° 30′ 0″.0
Local apparent time	2h 53m 42s.3
Equation of time	— 1 14·5
Local mean time	2 52 27.8
Mean of chronometer times	5 22 32.2
Chronometer fast of local mean time	2 30 4·4
Longitude west	7 28 24.0
Chronometer slow of Greenwich mean time	4 58 19.6

Double Altitudes of the Sun for Time, observed at La Playa, San Diego Bay, California, June 15th, 1866.

5^h	16^m	41^s.	112°	30′	0″	$2\underline{\odot}$
	17	16		15	0	
	17	51.5		0	0	
	19	10	112	30	0	$2\overline{\odot}$
	19	46		15	0	
	20	21.5		0	0	

Index correction.

359°	11′	30″	0°	14′	50″
		35			30
		20			50
359	11	28.3	0	14	43.3

Correction = + 16′ 54″.2

Ex. ther.	71°	At. ther.	72°	Bar.	30.12 inches.
Refraction	= — 37″.4			Sun's declination	+ 23° 20′ 22″
Parallax	= + 4.7			Latitude	+ 32 41 58

Mean of observed double altitudes	112°	15′	0″.0
Local apparent time	2^h	27^m	$47^s.3$
Equation of time	+ 0		11.3
Local mean time	2	27	58.6
Mean of chronometer times	5	18	31.1
Chronometer fast of local mean time	2	50	32.5
Longitude west	7	48	52.6
Chronometer slow of Greenwich mean time	4	58	20.1

Double Altitudes of the Sun for Time, observed on Yerba Buena Island, San Francisco Bay, California, June 26th, 1866.

4^h	16^m	$40^s.5$	75°	15′	0″	$2\overline{\odot}$
	17	18		30	0	
	17	55.5		45	0	
	19	18.5	75	15	0	$2\underline{\odot}$
	19	54.5		30	0	
	20	30		45	0	

Index correction.

359°	11′	30″	0°	14′	30″
		35			50
		25			50
359	11	30.0	0	14	43.3

Correction = + 16′ 53″.4

Ex. ther.	67°	At. ther.		Bar.	
Refraction	= — 72″.5			Sun's declination	+ 23° 22″ 7″
Parallax	= + 6.6			Latitude	+ 37 48 46

Mean of observed double altitudes	75°	30′	0″.0
Local apparent time	8^h	2^m	$58^s.4$
Equation of time	+	2	29.6
Local mean time	8	5	28.0
Mean of chronometer times	4	18	36.2
Chronometer fast of local mean time	8	13	8.2
Longitude west	8	9	22.6
Chronometer fast of Greenwich mean time	0	3	45.6

The chronometer used in making this observation was T. S. and J. D. Negus' No. 1287.

True bearings were determined by measuring with a sextant the angle between the sun's limb and some well-defined terrestrial object, the time being noted at the instant the angle was observed. If the terrestrial object was much elevated above the horizon its angular altitude was also measured. Knowing the latitude of the place of observation, the local time, and the sun's declination, the sun's zenith distance and true bearing were calculated. Then, having the zenith distance of the sun, the zenith distance of the terrestrial object, and the measured angle between the sun and the terrestrial object, the horizontal angle between them was computed, and applying it to the sun's true bearing the true bearing of the terrestrial object at once became known.

The formulæ employed were as follows. Let

T = mean of observed chronometer times.
dt = correction of chronometer to reduce the reading of its face to local mean time.
τ = equation of time.
t = sun's hour angle, or the apparent time.
Ω = mean of observed angular distances between the sun's limb and the terrestrial object.
ω = index correction of sextant.
s = sun's semi-diameter.
a = apparent zenith distance of sun's centre.
b = zenith distance of terrestrial object.
c = true angular distance between the sun's centre and the terrestrial object.
C = horizontal angle included between the sun's centre and the terrestrial object.
ϕ = latitude of the place of observation.
A = azimuth, or true bearing, of sun's centre.
ζ = true zenith distance of sun's centre.
δ = sun's declination.
r = refraction due to apparent altitude of sun's limb.
B = true bearing of terrestrial object.

Then we have

$$t = T + dt + \tau$$

$$\tan M = \frac{\tan \delta}{\cos t}$$

$$\tan A = \frac{\tan t \cos M}{\sin (\phi - M)}$$

$$\tan \zeta = \frac{\tan (\phi - M)}{\cos A}$$

where A is to be taken greater or less than 180°, according as t is greater or less than 180°.

$$a = \zeta - r$$

$$c = \Omega + \omega + s$$

If b is exactly 90°, we have

$$\cos C = \frac{\cos c}{\sin a}$$

But if b is either greater or less than 90°, we have

$$S = \frac{a + b + c}{2}$$

$$\tan \tfrac{1}{2} C = \sqrt{\frac{\sin (S - a) \sin (S - b)}{\sin S \sin (S - c)}}$$

Finally

$$B = A \pm C$$

In a few instances true bearings were obtained by observing the sun when its apparent elevation above the horizon was equal to its diameter. In that case

$$\zeta = 90^\circ$$

and then

$$\cos A = \frac{\sin \delta}{\cos \phi}$$

in which the azimuth will be north or south of the prime vertical according as the sun's declination is north or south.

Observations of the Sun, made October 31st, 1865, to determine the true bearing of the object used as an azimuth mark in swinging the ship at Hampton Roads, Va.

	10^{h} 10^{m} 50^{s}		127° 20′
	11 45		38
	12 15		45
	14 0		128 4
	14 39		8
T	10 12 42	Ω	127 47
Chronometer fast	0 4 50	ω	+ 16
τ	+ 16 16	s	+ 16
Apparent time	10 24 8	c	128 19
t	23° 58′	ζ	55 59
δ	−14 16	r	— 1
ϕ	36 58	a	55 58
M	−15 33	b nearly	90
$\phi - M$	52 31	C	138 26

True bearing of sun	S. 28° 21′ E.
∠ Seminary to sun	138 26
∠ Seminary to Rip Raps	62 44
∠ Rip Raps to tree	114 37
True bearing of tree	S. 10 34 W.

Observations of the Sun, made November 18th, 1865, to determine the true bearing of the object used as an azimuth mark in swinging the ship at St. Thomas, West Indies.

	7^{h} 0^{m} 5^{s}		34° 13′
	2 15		15
	4 45		10
	8 15		12
	9 45		12
T	7 5 1	Ω	34 12
Chronometer slow	0 40 47	ω	+ 16
τ	+ 14 36	s	+ 16
Apparent time	8 0 24	c	34 44
t	59° 54′	ζ	69 48
δ	−19 19	r	— 2
ϕ	18 20	a	69 46
M	−34 57	b nearly	90
$\phi - M$	53 17	C	28 52

True bearing of sun	S. 60° 27′ E.
∠ Sun to Peak	28 52
True bearing of Peak	S. 31 35 E.

Observations of the Sun, made Novem. er 28th, 1865, *to determine the true bearing of the object used as an azimuth mark in swinging the ship at Isle Royal, Salute Islands.*

	$6^h\ 27^m\ 5^s$		74° 50′
	28 59		46
	31 8		40
T	6 29 4	Ω	74 45
Chronometer slow	1 30 19	ω	+ 17
τ	+ 11 45	*s*	+ 16
Apparent time	8 11 8	*c*	75 18
t	57° 13′	ζ	62 4
δ	— 21 22	*r*	— 2
φ	5 17	*a*	62 2
M	— 35 52	*b* nearly	90
φ — *M*	41 9	*C*	73 18

True bearing of sun	S. 62° 24′ E.
∠ Sun to Nob	73 18
True bearing of Nob	S. 10 54 W.

Observations of the Sun, made December 12th, 1865, *to determine the true bearing of the object used as an azimuth mark in swinging the ship at Ceara, Brazil.*

	$3^h\ 11^m\ 8^s$		87° 30′
	13 0		22
	14 32		21
T	3 12 53	Ω	87 24
Chronometer slow	2 26 32	ω	+ 16
τ	+ 5 47	*s*	+ 16
Apparent time	5 45 12	*c*	87 56
t	86° 18′	ζ	85 4
δ	— 23 8	*r*	— 18
φ	— 3 43	*a*	84 46
M	— 81 25	*b* nearly	90
φ — *M*	77 42	*C*	87 56

True bearing of sun	S. 67° 3′ W.
∠ Lantern to sun	87 56
∠ Light-house to Lantern	77 0
True bearing of Light-house	N. 82 7 E.

Observations of the Sun, made December 29th, 1865, *to determine the true bearing of the object used as an azimuth mark in swinging the ship at Bahia, Brazil.*

When the sun's true zenith distance was about 90°, the angle between its nearest limb and a conspicuous tree was measured and found to be 31° 38′, the tree being to the right of the sun.

φ = — 12° 59′ δ = — 23° 12′

True bearing of sun	S. 66° 9′ W.
∠ Sun to tree	31 38
Sun's semi-diameter	0 16
True bearing of tree	N. 81 57 W.

Observations of the Sun, made January 7th, 1866, to determine the true bearing of the object used as an azimuth mark in swinging the ship at Rio Janeiro, Brazil.

	5^h	51^m	30^s		112°	2
		53	45			7
		55	0			12
T	5	53	25	Ω	112	15
Chronometer slow	2	3	32	ω	+	17
τ	—	6	36	s		—
Apparent time	7	50	21	c	112	32
t		62°	25′	ζ	57	9
δ	—	22	22	r	—	1
φ	—	22	54	a	57	8
M	—	41	38	b	85	16
φ — M		18	44	C	120	45

True bearing of sun	S. 77° 21′ E.
∠ Sun to Corcovado	120 45
∠ Corcovado to building	83 8
True bearing of building	N. 53 28 W.

Observations of the Sun, made January 23d, 1866, to determine the true bearing of the object used as an azimuth mark in swinging the ship at Monte Video, Uruguay.

Near sunset, when the true zenith distance of the sun was about 90°, the angle between its nearest limb and the Light-house on the Mount, on the west side of the harbor, was measured. The uncorrected reading of the sextant was 69° 40′, and the sun was to the left of the Light-house.

Ω	69°	40′	φ	—34° 53′
ω	+	17	δ	—19 19
s	+	16		
c	70	13		

True bearing of sun	S. 66° 13′ W.
∠ Sun to Light-house	70 13
∠ Hillock to Light-house	34 18
True bearing of hillock	N. 77 52 W.

Observations of the Sun, made February 9th, 1866, to determine the true bearing of the object used as an azimuth mark in swinging the ship at Sandy Point, in the Straits of Magellan.

	9^h	13^m	57^s		119°	15′
		15	19			32
		16	40			42
T	9	15	19	Ω	119	30
Chronometer slow	0	12	48	ω	+	17
τ	—	14	30	s	+	16
Apparent time	9	13	37	c	120	3
t	—	41°	36′	ζ	50	32
δ	—	14	37	r	—	1
φ	—	53	11	a	50	31
M	—	19	14	b	89	34
φ — M		33	57	C	130	54

True bearing of sun	N. 56° 20′ E.
∠ Mount St. Felipe to sun	130 54
True bearing of Mount St. Felipe	S. 7 14 W.

Observations of the Sun, made April 2d, 1866, *to determine the true bearing of the object used as an azimuth mark in swinging the ship at Valparaiso, Chile.*

	$5^h\ 10^m\ 5^s$ 11 20 12 10		110° 20′ 35 42
T	5 11 12	Ω	110 32
Chronometer slow	0 9 25	ω	+ 17
τ	— 3 32	s	—
Apparent time	5 17 5	c	110 49
t	79° 16′	ζ	83 52
δ	5 7	r	— 8
ϕ	— 33 2	a	83 44
M	+ 25 40	b nearly	90
$\phi - M$	— 58 42	C	110 56

True bearing of sun	N. 79° 49′ W.
∠ Sun to Point	110 56
True bearing of Point	N. 31 7 E.

Observations of the Sun, made April 27th, 1866, *to determine the true bearing of the object used as an azimuth mark in swinging the ship at Callao, Peru.*

	$7^h\ 0^m\ 30^s$ 2 20 3 50		100° 50′ 55 101 1
T	7 2 13	Ω	100 55
Chronometer fast	0 11 1	ω	+ 17
τ	+ 2 27	s	—
Apparent time	6 53 39	c	101 12
t	— 76° 35′	ζ	80 12
δ	13 51	r	— 5
ϕ	— 12 3	a	80 7
M	+ 46 44	b nearly	90
$\phi - M$	— 58 47	C	101 21

True bearing of sun	N. 73° 26′ E.
∠ Sun to flagstaff	101 21
∠ Flagstaff to Light-house.	88 34
True bearing of Light-house	S. 83 21 W.

Observations of the Sun, made May 13th, 1866, *to determine the true bearing of the object used as an azimuth mark in swinging the ship in Panama Bay, New Granada.*

	$6^h\ 17^m\ 3^s$ 18 15		86° 56′ 58
T	6 17 39	Ω	86 57
Chronometer fast	0 20 17	ω	+ 17
τ	+ 3 53	s	—
Apparent time(P.M.)	6 1 15	c	87 14
t	90° 19′	ζ	86 54
δ	18 31	r	— 14
ϕ	8 55	a	86 40
M	89 3	b nearly	90
$\phi - M$	— 80 8	C	86 14

True bearing of sun	N. 71° 49′ W.
∠ Peak to sun	87 14
True bearing of Peak	S. 20 57 W.

Observations to determine the true bearing of the object used as an azimuth mark in swinging the ship in the harbor of Acapulco, Mexico.

When determining the magnetic declination with the portable declinometer, on May 30th, 1866, an observation of the sun with the theodolite gave N. 6° 22′ E. as the true bearing of the gate of Fort St. Diego from the shore station. We then have

True bearing from station to Fort	N. 6° 22′ E.
∠ Monadnock to Fort	26 54
True bearing from station to Monadnock	N. 20 32 W.

True bearing from Monadnock to station	S. 20° 32′ E.
∠ Clump to station	87 45
True bearing of clump	N. 71 43 E.

Observations of the Sun, made June 9th, 1866, to determine the true bearing of the object used as an azimuth mark in swinging the ship in Magdalena Bay, Lower California.

Owing to a combination of unfortunate circumstances, the only available method of determining a true bearing was by observing with the solar compass, set up on the quarterdeck of the ship. In that way I found

True bearing of Peak . . . . S. 46° 30′ E.

which can only be considered as a near approximation to the truth.

Observations of the Sun, made June 23d, 1866, to determine the true bearing of the object used as an azimuth mark in swinging the ship at San Francisco, California.

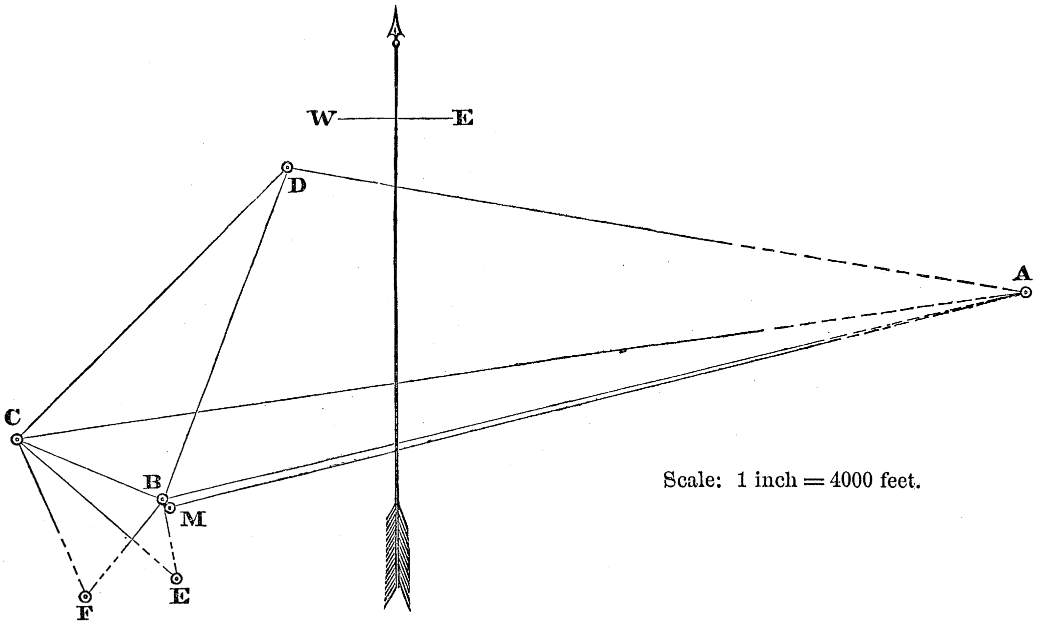
	7h	5m	17s			92°	22′
		6	52				39
		7	55				43
T	7	6	41	Ω		92	35
Chronometer fast	0	3	12	ω		+	17
τ	—	1	51	*s*			—
Apparent time	7	1	38	*c*		92	52
t	—	74	35′	ζ		64	8
δ		23	26	*r*		—	2
φ		37	48	*a*		64	6
M		58	30	*b*		89	51
φ — *M*	—	20	42	*C*		93	16

True bearing of sun	N. 79° 26′ E.
∠ Red Rock to sun	93 16
True bearing of Red Rock	N. 13 50 W.

The following triangulation was made for the purpose of determining the geographical position of some points in and about Ceara, Brazil. The angles were observed on December 14th, 15th, and 16th, 1865. Those between the Powhattan, Monadnock, and Custom-house were not measured simultaneously, and as the two ships were riding at anchor with a considerable amount of chain out, it is probable that they shifted their positions after the angle at the Powhattan was measured, and before the angles at the Monadnock and Custom-house were taken. This will account for the excess of the sum of the three angles over 180°.

In the accompanying sketch the different points are designated as follows:

A = Point Macoripie Light-house.
B = Northeast corner of Custom-house on the wharf.
C = U. S. Iron-clad Monadnock.
D = U. S. Sloop of War Powhattan.
E = most southern of the two steeples on the Church of the Conception.
F = most southern of the two steeples on St. Joseph's Church.
M = Magnetic and Astronomical Station of December 13th and 14th.



The observed angles were as follows:

Angles at B.

D to *A* = 55° 12′
D to *C* = 84 17
F to *C* = 73 12
E to *C* = 125 6
E to *F* = 52 15
A to *E* = 95 6

Angles at C.

D to *A* = 36° 19′
D to *B* = 71 14
B to *F* = 42 28
B to *E* = 15 40

Angles at D.

A to *B* = 101° 35′
B to *C* = 25 13
A to *C* = 126 49

From these we obtain the following corrected

Angles at B.

A to *E* = 95° 11′
E to *F* = 52 9
F to *C* = 73 14
C to *D* = 84 5
D to *A* = 55 21

Angles at C.

D to *B* = 70° 58
D to *A* = 36 14
A to *B* = 34 44
B to *E* = 15 40
E to *F* = 26 48

Angles at D.

A tc *B* = 101° 36′
B to *C* = 24 57

The Powhattan fired a salute, and, from the mean of seven observations, the interval between the flash and report, noted at B, was 6.55 seconds. External thermometer 86°. Hence the distance from B to D was 7526 feet.

Distance from B to M = 200 feet.

Azimuth from M to A = N. 75° 38′ E.

Angle AMB = 128° 57′.

From these data we find the distances between the several points as follows:

AD = 15814 feet.
AC = 21491 "
AB = 18826 "
AM = 18702 "

CE = 4355 feet.
BC = 3358 "
BF = 2516 "

BE = 1443 feet.
CD = 7919 "
CF = 3568 "

Angle BAM = 0° 28′ | Angle AMB = 128° 57′ | Angle ABM = 50° 35′

Azimuth from M to A = N. 75° 38′ E.
" " B to A = N. 76 6 E.

Azimuth from B to E = S. 8° 43′ E.
" " B to F = S. 43 26 W.

Assuming the position of M to be

Lat. 3° 43′ 59″.0 S.
Long. $2^h\ 34^m\ 6^s.00$ W.

we get finally

Station.	Latitude.	Longitude.
B	3° 43′ 57″.8 S.	$2^h\ 34^m\ 6^s.11$ W.
E	3 44 12.0	2 34 5.97
F	3 44 15.9	2 34 7.25
A	3 43 13.3	2 33 54.10

For convenience of reference the results of the observations contained in this section, together with the chronometer comparisons made during the cruise, are here collected and appended.

Observed Latitudes.

Name of station.	Latitude.
Fort Christian, St. Thomas	18° 20′ 0″ N.
Isle Royal, Salute Islands	5 17 29 N.
Magnetic Station, Ceara, Brazil	3 43 59 S.
Custom-house, " "	3 43 58 S.
Church of the Conception, Ceara, Brazil . .	3 44 12 S.
St. Joseph's Church, " "	3 44 16 S.
Point Macoripie Light-house, " "	3 43 13 S.

Errors of Pocket Chronometer, Fletcher, No. 906.

Station.	Date.	Error on Local Mean Time.	Error on Greenwich Mean Time.
Portsmouth, Va. . . .	October 29, 1865	0^h 4^m $41^s.1$ fast	5^h 0^m $28^s.7$ slow
Portsmouth, Va. . . .	" " "	4 40.1 "	0 29.7 "
St. Thomas	November 13, "	0 40 43.6 slow	0 26.3 "
Isle Royal	" 28, "	1 30 19.4 "	0 30.8 "
Ceara	December 14, "	2 26 32.5 "	5 0 38.5 "
Pernambuco	" 23, "	2 36 34.8 "	4 56 3.0 "
Bahia.	" 27, "	2 22 6.8 "	56 7.3 "
Bahia.	" 29, "	2 22 3.6 "	56 10.5 "
Rio Janeiro	January 9, 1866	2 3 38.4 "	56 9.1 "
Rio Janeiro	" " "	2 3 32.8 "	56 10.7 "
Monte Video	" 18, "	1 11 27.0 "	56 22.8 "
Monte Video	" 24, "	1 11 26.5 "	56 19.4 "
Sandy Point	February 7, "	0 12 48.1 "	56 23.4 "
Valparaiso	March 2, "	0 9 46.4 "	56 17.4 "
Valparaiso	" 29, "	9 26.8 "	56 12.5 "
Valparaiso	April 7, "	9 23.3 "	56 9.0 "
Valparaiso	" " "	0 9 23.9 "	4 56 9.6 "
Valparaiso	" 14, "	0 11 1.7 "	4 57 47.4 "
Callao.	" 26, "	0 11 13.5 fast	57 55.6 "
Payta.	May 7, "	0 26 41.9 "	57 40.1 "
Panama	" 14, "	0 20 16.9 "	4 57 44.9 "
Acapulco	" 30, "	1 41 22.2 "	4 58 7.2 "
Magdalena Bay	June 8, "	2 30 4.4 "	58 19.6 "
San Diego	" 15, "	2 50 32.5 "	4 58 20.1 "

This chronometer (Fletcher, 906) was habitually carried in my pocket. It was accidentally allowed to run down on the night of December 17th and 18th, 1865, and after remaining stopped twelve hours was wound and compared. Some time between 5^h P. M. of April 13th and 3^h P. M. of April 14th, 1866, it stopped for about 1^m 37^s, but started again of itself. On June 20th, 1866, when its face showed 6^h 45^m P. M. it stopped without any apparent cause, and, as it would not run again, it became useless.

In observing at San Francisco the box chronometer T. S. and J. D. Negus, No. 1287 was used. The observations on June 26th, 1866, showed it to be

8^h 13^m $8^s.2$ fast of local mean time;

and

0^h 3^m $45^s.6$ fast of Greenwich mean time.

Chronometer Comparisons.

Date.	Fletcher, 906.	T. S. and J. D. Negus, 1317.	T. S. and J. D. Negus, 1287.
October 29, 1865	7^{h} 39^{m} 56^{s}.8 A. M.	12^{h} 44^{m} 0^{s}.0	
October 29, "	2 28 56.0 P. M.	7 33 0.0	
October 31, "	12 8 48.2 "	5 13 0.0	
November 3, "	4 17 33.0 "	9 22 0.0	
November 13, "	8 21 4.8 A. M.	1 26 0.0	
November 13, "	. . . . . .	1 28 0.0	1^{h} 16^{m} 23^{s}.5
November 17, "	12 18 46.0 "	5 24 0.0	
November 28, "	6 55 10.8 "	12 1 0.0	
November 28, "	6 56 56.8 "	. . . .	11 50 0.0
November 28, "	2 39 9.8 P. M.	7 45 0.0	
December 14, "	6 29 23.0 A. M.	11 36 0.0	
December 14, "	6 30 19.8 "	. . . .	11 25 0.0
December 14, "	12 43 22.5 P. M.	5 50 0.0	
December 16, "	8 54 16.0 A. M.	2 1 0.0	
December 16, "	8 56 15.2 "	. . . .	1 51 0.0
December 18, "	9 44 42.8 P. M.	2 47 0.0	
December 23, "	8 7 28.0 A. M.	1 10 0.0	
December 23, "	8 8 32.5 "	. . . .	12 59 0.0
December 29, "	6 22 59.2 "	11 26 0.0	
December 29, "	6 24 9.0 "	. . . .	11 15 0.0
January 9, 1866	6 46 21.8 "	11 50 0.0	
January 9, "	6 46 43.2 "	. . . .	11 38 0.0
January 24, "	12 41 4.0 P. M.	5 46 0.0	
January 24, "	12 41 50.8 "	. . . .	5 34 0.0
April 14, "	4 16 24.4 "	9 29 0.0	
May 7, "	11 34 26.4 A. M.	4 49 0.0	
May 14, "	12 2 49.6 P. M.	5 18 0.0	
May 30, "	11 55 13.2 A. M.	5 12 0.0	
June 8, "	6 28 24.8 P. M.	11 46 0.0	
June 15, "	12 0 46.8 A. M.	5 19 0.0	
June 26, "	. . . . . .	6 34 0.0 P.M.	6 17 0.2

Table showing the True Bearings of the various objects used as azimuth marks in swinging the U. S. Iron-clad Monadnock during her cruise from Philadelphia to San Francisco in 1865 *and* 1866.

Station.	True bearing.
Hampton Roads, Va.	S. 10° 34′ W.
St. Thomas	S. 31 35 E.
Isle Royal, Salute Islands	S. 10 54 W.
Ceara	N. 82 7 E.
Bahia	N. 81 57 W.
Rio Janeiro	N. 53 28 W.
Monte Video	N. 77 52 W.
Sandy Point	S. 7 14 W.
Valparaiso	N. 31 7 E.
Callao	S. 83 21 W.
Panama Bay	S. 20 57 W.
Acapulco	N. 71 43 E.
Magdalena Bay	S. 46 30 E.
San Francisco Bay	N. 13 50 W.

SECTION IV.

OBSERVATIONS ON TERRESTRIAL MAGNETISM.

THE observations of magnetic declination and force were made by means of the same instruments—a portable declinometer, and a transit theodolite.

The Declinometer, kindly lent by the U. S. Coast Survey, and marked D. 22, was originally constructed by Jones, of London, but had been altered in many particulars so as to make it more convenient for field use. It was provided with two collimator magnets which were hollow cylinders of steel, each 0.70 of an inch in external diameter, and 0.58 of an inch in internal diameter. One of them, marked C. 32, was 3.92 inches long; while the other, marked S. 8, was 3.25 inches long. Each of these magnets carried in its south end a lens; and in its north end, at the solar focus of the lens just mentioned, a piece of plane glass on which was cut a scale of equal parts containing one hundred and seventy divisions, each division being equal to 0.00255 of an inch. Both magnets were provided with light sliding brass rings which were intended to be used for keeping them horizontal under great changes of magnetic declination, but the slight play which the magnets had in the stirrup was found quite sufficient for that purpose, and the rings were never employed. The same suspension was used during the whole of the observations. It consisted originally of six parallel fibres of unspun silk, each about nine inches long; but at Callao one of the fibres was accidentally broken, and after that the remaining five were used. The torsion circle, which formed part of the suspension apparatus, was 0.88 of an inch in diameter, divided to every three degrees, and read by means of a vernier to single degrees.

The Transit Theodolite, which perhaps might be more correctly called an altitude and azimuth instrument, was provided with a horizontal and a vertical circle, each five inches in diameter, and each reading by means of two opposite verniers to thirty seconds. The telescope had an object-glass with a clear aperture of one inch, and a focal length of about nine inches. It was provided with two eye-pieces; a direct one magnifying about twenty times, which was employed in almost all the observations; and a diagonal one of lower power, which was sometimes used for objects near the zenith. Both these eye-pieces had colored glasses for observing the sun. The system of wires in the focus of the object-glass was a simple rectangular cross, one wire being vertical, the other horizontal.

For the sake of convenience in setting up the instruments, and also for the perfect security which it affords against changes in the angular value of the divisions of the magnet scales depending upon changes in the distance between them and the telescope, a special table was provided, which was mounted upon a tripod stand, and which carried both the declinometer and theodolite in a fixed and invariable position relatively to each other—the object-glass of the telescope being about three inches from the south end of the magnet.

Pocket Chronometer, Fletcher, No. 906, was always used to note time. Its errors have been already given in detail in Section III.

General remarks on the method of using the instruments. When observations were to be made the tripod stand was set up, and the table, having been placed upon it, was approximately levelled by the eye, and set, by means of a pocket compass, so that its longest side was nearly in the magnetic meridian, the end destined to carry the declinometer being to the north. In packing the declinometer for travelling, the glass suspension tube was never unscrewed from the magnet-box, but when the collimator magnet was lifted from the stirrup a cylinder of wood of the same size was at once substituted, and two pieces of wood, provided for the purpose, were slipped in, one from each side of the magnet-box. These pieces of wood completely filled up the box, and at the same time held the wooden cylinder securely between them in such a manner that it could neither break the suspension fibres, nor allow them to twist in the slightest. With this packing, after the suspension fibres were once thoroughly freed from torsion, they remained so, and it was not necessary to examine them whenever the instrument was used, but only at considerable intervals, thus saving much time in the field. The brass carriers for the deflecting magnet having been screwed, one on each end of the wooden bar, and the bar in its turn having been screwed to the bottom of the magnet-box, the declinometer was placed upon the table in such a position that its three levelling screws fitted into the cavities provided for their reception. Then the packing blocks were taken out of the magnet-box, and the wooden cylinder having been removed from the stirrup, the collimator magnet was put in its place, and left free to assume its proper direction. The magnet-box was next levelled. For that purpose the suspension fibres were used as a plumb line, and the box was assumed to be level when they were seen to hang in the axis of the suspension tube throughout its whole length. Finally, the magnet was made to hang nearly level by moving it a little endwise in its stirrup; its scale was placed horizontal, with the figures erect; it was shaded from the direct rays of the sun by covering the glass top of the box; the mirror was screwed to the back of the box and adjusted so as to illuminate the magnet scale properly; and a thermometer was placed inside the magnet-box. The theodolite was next placed in its proper position on the other end of the table and levelled; particular care being taken that the horizontal axis of the telescope was truly level—especially if the altitude of the sun was considerable. The telescope having been turned towards the magnet and adjusted so as to obtain distinct vision of its scale, the horizontal circle was firmly clamped in such a position that the vertical wire in the field of the telescope cut the magnet scale as nearly as possible at the magnetic axis. By means of the vertical circle the optical axis of the telescope was then placed truly level, and the final adjustment of the magnet for horizontality was made by shifting it endwise in its stirrup till the scale was seen in the field of the telescope parallel to, and just in contact with, the horizontal wire.

When making my first observations considerable difficulty was experienced in getting a proper illumination of the magnet scale, but after some practice the following perfectly satisfactory plan was adopted. In cloudy weather the light of a white cloud was reflected into the magnet by means of the concave mirror. In clear weather the light of the blue sky, reflected from the mirror, was not sufficient, and it would not do to throw in the direct rays of the sun because of their heating power, which would certainly have led to the use of a wrong value of the magnetic moment; because the magnet would have been at a higher temperature than that shown by the thermometer in the box. Under these circumstances, in place of the mirror a piece of perfectly white paper was substituted, and the direct rays of the sun being allowed to fall upon it, it afforded a beautiful illumination of the magnet scale.

The copper damper, provided to slip into the magnet-box for the purpose of quieting the vibrations of the magnet, was never used. As the observations were all made in the open air, and as there was frequently wind enough to cause the instruments to vibrate perceptibly, the magnets seldom or never came to a state of absolute rest. Hence, the plan adopted to secure accurate readings of the scales was as follows. A screw-driver was slightly magnetized, and by approaching its south pole for an instant towards the south pole of the vibrating magnet, at a time when the magnet was moving towards the screw-driver, the arc of vibration was readily made quite small. Then, placing my eye to the telescope, I read off, and called out to my assistant, the scale reading at the instant the magnet attained the limit of its excursion in the eastern direction, and again when it attained the limit in a western direction—in other words, the greatest and least readings of the scale were noted. Five complete vibrations were generally observed, thus giving three eastern and three western readings, and the mean of the six was assumed to be the reading which would have been obtained if the magnet had been in a state of perfect rest.

In order to preserve the magnetism of the collimator magnets, they were always packed in a vertical position, with that pole downwards which would be lowest in a dipping needle.

Absolute Declinations were observed as follows: The instruments having been set up and adjusted in the manner already explained, the long magnet, C. 32, was suspended in the magnet-box, the telescope pointed nearly to its magnetic axis, and the horizontal circle of the theodolite firmly clamped. Then, 1°. The horizontal limb of the theodolite was read. 2°. The magnet scale being erect—that is, the figures upon it being right side up—the point upon it cut by the vertical wire of the telescope was observed. 3°. The telescope remaining as before, the magnet scale was inverted—that is, the magnet was turned on its axis through 180°, so that the figures upon its scale were seen inverted—and the point upon it cut by the vertical wire was again noted. 4°. The horizontal circle was unclamped, a colored glass placed upon the eye-piece, and the telescope pointed so that its vertical wire was just in advance of the first limb of the sun. Then the horizontal circle was clamped, the time of transit of the sun's first limb over the vertical wire noted, and the horizontal circle read. 5°. If the observation was made at a time of day when the sun's azimuth was changing tolerably rapidly, the telescope was not moved in azimuth at all, but, the reading of the horizontal circle remaining precisely as before, the sun was followed by moving the telescope in altitude, and the transit of its second limb was waited for and noted. If, however, the sun was changing its altitude much more rapidly than its azimuth then, in order to save time, the horizontal circle was unclamped, the telescope moved till its vertical wire was just in advance of the sun's second limb, the horizontal circle clamped, the time of transit of the sun's second limb over the vertical wire noted, and the horizontal circle read. 6°. The telescope of the theodolite was reversed in its Y's. 7°. The transit of the sun's first limb over the vertical wire was observed, and the horizontal circle read. 8°. The transit of the sun's second limb over the vertical wire was observed, and the horizontal circle read. 9°. The colored glass was removed from the eye-piece of the telescope, and a reading of the magnet scale (which was still inverted) was taken. 10°. The magnet was revolved on its axis through 180°, so as to place the scale erect, and another reading of the scale was taken. 11°. The horizontal circle was read.

Immediately before, and immediately after, going through with the operations just described, the telescope should be pointed to some well-defined distant object, and the reading of the horizontal circle noted. By so doing a check is afforded against any accidental shift of the horizontal circle; and if the same station is occupied at another time, absolute declinations may be determined without again referring to the sun, thus rendering it possible to observe during cloudy weather.

In the instruments under consideration the reading of the horizontal circle of the theodolite increases from left to right; and in both the magnets, C. 32 and S. 8, when the scale is erect an increase of scale reading indicates a motion of the north end of the magnet towards the east.

Let

ρ = reading of magnet, scale erect.

ρ' = reading of magnet, scale inverted.

R' = reading of horizontal circle of theodolite at the time the readings ρ and ρ' were observed.

d = value, in minutes of arc, of one division of the magnet scale.

R'' = reading of horizontal circle of the theodolite at the time of transit of sun's first limb over the vertical wire.

R''' = reading of horizontal circle of the theodolite at the time of transit of sun's second limb over the vertical wire.

α = observed chronometer time of transit of sun's first limb over the vertical wire.

α' = observed chronometer time of transit of sun's second limb over the vertical wire.

dt = correction of chronometer to reduce the reading of its face to local mean time.

τ = equation of time.

t = the sun's hour angle at the pole.
ϕ = latitude of the place of observation; positive when north of the equator.
A = azimuth of sun's centre at the time of its transit over the vertical wire: the azimuth being counted from the south around by the west.
δ = sun's declination; positive when north.

Then we have

$$t = \frac{\alpha + \alpha'}{2} + dt + \tau$$

$$\tan M = \frac{\tan \delta}{\cos t}$$

$$\tan A = \frac{\tan t \cos M}{\sin(\phi - M)}$$

where A is to be taken greater or less than 180° according as t is greater or less than 180°.

$$\text{Magnetic declination} = R' + \frac{d}{2}(\rho - \rho') + A - 180^\circ - \frac{R'' + R'''}{2}$$

in which the declination is east if its sign is positive; west if its sign is negative.

The reading of the magnetic axis of the magnet is

$$\tfrac{1}{2}(\rho + \rho')$$

which we will designate by c. It should be constant. Then, if at any station the magnet has only been observed with its scale erect, if c is known the observation may be reduced by the formula

$$\text{Magnetic declination} = R' + d(\rho - c) + A - 180^\circ - \frac{R'' + R'''}{2}$$

The following example shows fully the form employed in recording and reducing the observations.

Magnetic Declination.

Station, Acapulco, Mexico. *Date,* May 30, 1866. Portable Declinometer, D. 22. Magnet C. 32.
Observer, WM. HARKNESS.

	Circle readings.		Reading of magnet.	
Telescope direct.	Vernier . .	12° 23′ 30″	(1) Scale erect (2) Scale inverted	$78^{d}.0$ 80.3
			(1) — (2) = Δ	— 2.3
			Transit of sun's	
	Vernier . .	75° 25′ 30″	1st limb	$8^{h}\ 14^{m}\ 28^{s}$
	Vernier . .	74 55 30	2d limb	15 28
	Mean . . .	75 10 30	Mean	8 14 58.0

	Circle readings.		Transit of sun's	
Telescope reversed.	Vernier . .	75° 36′ 0″	1st limb	8^h 17^m 29^s
	Vernier . .	75 6 30	2d limb	18 38
	Mean . . .	75 21 15	Mean	8 18 3.5
			Reading of magnet.	
	Vernier . .	12° 28′ 0″	(1) Scale inverted	$81^d.3$
			(2) Scale erect	77.2
			(2) — (1) = Δ	— 4.1

Value of one division of magnet scale = 2′.349.

The telescope is direct when the vertical circle is on the left-hand side.

These observations were made *before* noon, and time was noted by chronometer *Fletcher*, 906, which was 1^h 41^m $22^s.2$ *fast* of local mean time.

At the time the azimuth was observed, the reading of the horizontal circle, telescope direct, to distant referring mark was 10° 23′ 30″.

	Telescope direct.	Telescope reversed.
Equation of time	0^h 2^m $47^s.1$	0^h 2^m $47^s.1$
t (in time)	— 5 23 37.1	— 5 20 31.6
t (in arc)	—80° 54′ 16″	—80° 7′ 54″
δ	+ 21 47 18	+ 21 47 19
Tan δ	9.60177	9.60178
Sec *t*	0.80111	0.76602
Tan *M*	0.40288	0.36780
φ	+ 16° 50′ 3″	+ 16° 50′ 3″
M	+ 68 25 21	+ 66 47 35
(φ — *M*)	—51 35 18	—49 57 32
Tan *t*	0.79562	0.75955
Cos *M*	9.56557	9.59556
Cosec (φ — *M*)	0.10592	0.11600
Tan *A*	0.46711	0.47111
Circle reading to magnet . .	12° 23′.5	12° 28.′0
Δ × ½ scale division . . .	— 2.7	— 4.8
Sun's azimuth	251 9.9	251 19.6
Sum	263 30.7	263 42.8
180° + circle reading to sun	255 10.5	255 21.3
Magnetic declination . . .	8 20.2 E.	8 21.5 E.

Observations of Vibrations were made as follows: The instrument having been set up and adjusted in the manner already explained, the long magnet, C. 32, was suspended in the magnet-box; and the telescope having been pointed so that its vertical wire cut the magnet scale approximately at the magnetic axis, the horizontal limb of the theodolite was firmly clamped. Then, 1°. By quickly approaching and withdrawing the magnetised screw-driver the magnet was caused to vibrate horizontally through an arc extending to about twenty scale divisions on each side of the magnetic axis—that is, through a total arc of about 1° 34′. The semi-arc of vibration being only 47′, no correction to the observed time of vibration was ever required on that account. 2°. My assistant having taken the chronometer, I placed my eye to the telescope, and at the instant the 80th division of the scale (which was very near the magnetic axis) crossed the vertical wire I cried "time," and my assistant noted the minute, second, and fraction of a second indicated by the chronometer. Still keeping my eye at the telescope, I counted the transits of the 80th division over the wire, calling the one at which time was noted 0, the next 1, the next 2, and so on up to the 10th, when I again cried "time," and my assistant once more noted the minute, second, and fraction of a second indicated by the chronometer. The difference of these two chronometer times gave a value for the time of ten vibrations of the magnet which was correct within about half a second. However, to guard against mistakes, the process was always repeated a second or third time. 3°. The temperature indicated by the thermometer in the magnet-box was noted; and then putting my eye to the telescope, I read the scale at the instant the magnet attained the eastern extremity, and again when it attained the western extremity, of its arc of vibration. These were the "extreme scale readings." 4°. The chronometer employed was a pocket one, beating five times in two seconds. Taking it in my hand, I commenced counting its beats at some multiple of ten seconds. Then, holding it to my ear and still mentally counting the beats, I put my eye to the telescope and noted the beat, and fraction of a beat, at which the 80th scale division crossed the vertical wire. For example, suppose the beat was taken up at the instant the chronometer indicated $10^h\ 2^m\ 10^s$, and counting the first succeeding beat 1, the next 2, and so on, suppose that the 80th division crossed the wire exactly at the 14th beat. Then, as 14.0 beats are equal to 5.6 seconds, the time of transit of the 80th scale division was $10^h\ 2^m\ 15^s.6$. The time of transit thus obtained was recorded as the 0 vibration. Adding to it the time of making ten vibrations—before determined—the approximate time when the 10th vibration would be completed became known. Taking up the beat of the chronometer at the nearest even ten seconds *before* that time, I put my eye to the telescope and observed the time of transit of the 80th division at the completion of the 10th vibration. In the same manner the time of completing the 20th, 30th, 40th, 50th, 100th, 150th, 160th, 170th, 180th, 190th, and 200th vibration was observed. Subtracting the time of completing the 0 vibration from the 150th, the 10th from the 160th, &c., there result six values of the time of making one hundred and fifty vibrations, from the mean of which a very accurate value of the time of making one vibration is obtained. It will not escape notice that when observing in the manner just described there is no risk of making a mistake of one vibration, because the magnet must, at all subsequent transits, be moving in the same direction as at the first transit, while in order to make a mistake of one vibration it would be necessary that it should be moving in the opposite direction. 5°. The extreme scale readings attained by the magnet at the eastern and western extremities of its arc of vibration were again observed; and then the thermometer in the magnet-box was read. 6°. The necessary observations for determining the coefficient of torsion of the suspension fibres were made. When the instrument was properly adjusted for observation the torsion circle always read 300°. With it remaining at that reading the arc of vibration of the magnet was reduced to four or five scale divisions (by means of the magnetized screw-driver) and then the scale was read. Next the torsion circle was turned *backward* one-quarter of a revolution, so as to make it indicate 210°, and the scale was again read. After that, the torsion circle was turned *forward* half a revolution (passing through the point 300°), so as to make it indicate 30°, and the scale was read. Finally, the torsion circle was turned *backward* one-quarter of a revolution, so as to make it indicate 300°, and the scale was once more read. Subtracting the second scale reading from the first, the second from the third, and the fourth from the third, gave three differences, which were added together and divided by four. The result was the number of scale divisions through which the magnet was deflected by a twist of ninety degrees in the suspension fibres.

Observations of Deflections were made as follows: The instruments having been set up and adjusted in the manner already explained, the short magnet, S. 8, was suspended in the magnet-box, and the telescope having been pointed so that its vertical wire cut the magnet scale approximately at its central division (not necessarily the magnetic axis) the horizontal limb of the theodolite was clamped firmly. Then, 1°. The time was noted. 2°. The thermometer inside the magnet-box was read. 3°. The long magnet C. 32 (which we will now call the deflecting magnet) was placed on the deflecting bar support, with its axis east and west, its centre on a level with and at a distance of two feet to the west of the suspended magnet, and its north end west; the vibrations of the suspended magnet were reduced to four or five scale divisions, by means of the magnetised screw-driver, and then its scale was read. 4°. The deflecting magnet (remaining in the same place on the deflecting bar support as before) was reversed end for end, so as to bring its north end east, and the scale of the suspended magnet was read. 5°. The reversals were repeated twice more, so as to give in all two scale readings with the north end of the deflecting magnet to the west, and two scale readings with it to the east. The mean of the two scale readings obtained with the north end of the deflecting magnet west, were subtracted from the mean of the two scale readings obtained with its north end east. The difference was twice the value of the angle of deflection, as resulting from observations made with the deflecting magnet west of the suspended magnet. 6°. The deflecting magnet was lifted from the deflecting bar support to the west, and placed on that to the east, of the suspended magnet; its distance from the suspended magnet being still two feet, and its north end being to the east, the scale of the suspended magnet, was read. 7°. The deflecting magnet (remaining in the same place on the eastern deflecting bar support) was reversed end for end, so as to bring its north end west, and the scale of the suspended magnet was read. 8°. The reversals were repeated twice more, so to give in all two scale readings with the north end of the deflecting magnet to the east, and two scale readings with it to the west. From the mean of the two scale readings obtained with the north end of the deflecting magnet east, the mean of the two scale readings obtained with its north end west were subtracted. The difference was twice the value of the angle of deflection, as resulting from observations made with the deflecting magnet east of the suspended magnet. The mean between this result and that obtained from the observations with the deflecting magnet west of the suspended magnet, was adopted as the true value of twice the angle of deflection, with the deflecting magnet at a distance of two feet from the suspended magnet. 9°. The thermometer inside the magnet-box was read. 10°. The time was noted. 11°. All the observations just described were repeated with the deflecting magnet at a distance of two and a half feet from the suspended magnet. 12°. The torsion of the suspension fibres was determined, precisely as described under the head of "observations of vibrations."

Horizontal Force was calculated from the observations of vibrations and deflections by the following formulæ:

T_0 = observed time of one vibration of the magnet.

T' = time of vibration, corrected for rate of chronometer and arc of vibration.

T = time of vibration, corrected for rate of chronometer, arc of vibration, torsion force of the suspending thread, temperature, and induction.

s = daily rate of chronometer, + when gaining, — when losing.

a, a' = semiarc of vibration, at the beginning and end of the observation, expressed in parts of radius.

$\frac{H}{F}$ = ratio of the force of torsion of the suspending thread to the magnetic directive force.

q = coefficient of the decrease of the magnetic moment of the magnet produced by an increase of temperature of 1° Fah. (This is not constant for all temperatures, and the correction is more exactly expressed by a formula of the form — correction to $t' = q(t' - t) + q'(t' - t)^2$, where t' is the observed temperature, and t an adopted standard temperature.)

K = moment of inertia of the magnet, including its suspending stirrup and other appendages. (This is constant for the same magnet and suspension, but varies slightly with the temperature, owing to the expansion of the materials.)

π = ratio of the circumference of a circle to its diameter = 3.14159.

μ = coefficient of increase in the magnetic moment of the magnet produced by the inducing action of a magnetic force equal to unity of the English system of absolute measurement.

r_0 = apparent distance between the centres of the deflecting and suspended magnets in the observations of deflections.

r = the same distance corrected for error of graduation and temperature. ($r = r_0 [1 + 0.00001(t' - 62°)]$ + correction for scale error.)

d = value, in minutes of arc, of one division of the magnet scale.

u_0 = observed angle of deflection, in scale divisions.

$u =$ angle of deflection, corrected for torsion force of the suspending thread.

$P =$ a constant depending upon the distribution of magnetism in the deflecting and suspended magnets.

$m =$ magnetic moment of the deflecting or vibrating magnet.

$X =$ horizontal component of the earth's magnetic force.

$\frac{m'}{X'} =$ value of $\frac{m}{X}$ before the application of the correction $\left(1 - \frac{P}{r^2}\right)$

$$\left(1 + \frac{H}{F}\right) = \frac{5400 + v}{5400}$$

where $v =$ the angle, expressed in minutes of arc, through which the suspended magnet is deflected by a twist of 90° in the suspension thread.

$$T' = T_0\left(1 - \frac{s}{86400}\right)\left(1 - \frac{\alpha\alpha'}{16}\right)$$

$$T^2 = T'^2 \left\{1 + \frac{H}{F}\right\} \left\{1 - (t' - t)q\right\} \left\{1 + \mu \frac{X'}{m'}\right\}$$

$$mX = \frac{\pi^2 K}{T^2}$$

$$u = du_0\left(1 + \frac{H}{F}\right)$$

$$\frac{m'}{X'} = \tfrac{1}{2} r^3 \tan u$$

$$\frac{m}{X} = \frac{m'}{X'}\left(1 - \frac{P}{r^2}\right)$$

$$m = \sqrt{mX \frac{m}{X}}$$

$$X = \frac{mX}{m}$$

In order to facilitate the finding of log. tan u, in the reduction of observations of deflection, the following table has been prepared. With the argument log. u (u being expressed in minutes of arc) it gives the quantity (log. tan u — log. u), or, in other words, the quantity which it is necessary to add to log. u in order to obtain log. tan u. The arrangement of the table is such that the quantity (log. tan u — log. u) is to be added to the log. u on the same line with it, or to any other log. u less than the one on the line next below. For example, if it were required to find log. tan u corresponding to any log. u from 8.0000 to 1.4340, it would only be necessary to add 6.46373 to the given log. u.

Log. *u*.	Log. tan *u* — Log. *u*.	Log. *u*.	Log. tan *u* — Log. *u*.
8.0000	6.46373	2.1159	6.46394
1.4341	6.46374	2.1261	6.46395
1.5957	6.46375	2.1358	6.46396
1.6874	6.46376	2.1452	6.46397
1.7517	6.46377	2.1541	6.46398
1.8014	6.46378	2.1626	6.46399
1.8414	6.46379	2.1708	6.46400
1.8756	6.46380	2.1787	6.46401
1.9047	6.46381	2.1864	6.46402
1.9310	6.46382	2.1937	6.46403
1.9538	6.46383	2.2008	6.46404
1.9750	6.46384	2.2079	6.46405
1.9934	6.46385	2.2146	6.46406
2.0111	6.46386	2.2209	6.46407
2.0274	6.46387	2.2271	6.46408
2.0426	6.46388	2.2332	6.46409
2.0565	6.46389	2.2393	6.46410
2.0700	6.46390	2.2453	6.46411
2.0824	6.46391	2.2509	6.46412
2.0941	6.46392	2.2565	6.46413
2.1055	6.46393		

The following are specimens of the forms employed in recording and reducing the observations of vibrations and deflections.

HORIZONTAL INTENSITY.

Observations of Vibrations.

Station, Acapulco, Mexico. *Date,* May 30th, 1866. Magnet C. 32. Inertia ring No.
Chron. Fletcher 906, rate, $1^s.38$ losing on mean time.

Number of vibrations.	Time.	Temp. *t'*	Extreme scale readings.		Time of 150 vibrations.
0	8^h 32^m $3^s.8$	87°	$57^d.8$	$102^d.2$	
10	8 32 57.0				
20	8 33 50.6				
30	8 34 43.9				
40	8 35 37.0				
50	8 36 30.6				
100	8 40 57.2				
150	8 45 23.4				13^m $19^s.6$
160	8 46 17.2				13 20.2
170	8 47 10.2				13 19.6
180	8 48 3.7				13 19.8
190	8 48 57.0				13 20.0
200	8 49 50.5	91	65.2	95.0	13 19.9
	Means,	89.0			13 19.85

Coefficient of torsion. Value of one scale div. = 2'.349

Tor. cir.	Scale.	Diff's.
300°	$80^d.1$	$3^d.4$
30	83.5	6.8
210	76.7	3.4
300	80.1	

Mean = v = 3.40

	Log's.
v = 8'.0	
5400' + v'	3.73304
5400 (ar. co.)	6.26761
$1 + \frac{H}{F}$	0.00065

HORIZONTAL INTENSITY.

Calculation.

$$T^2 = T'^2 \left(1 + \frac{H}{F}\right) \left(1 - (t' - t)\, q\right)$$

Observed time of 150 vibrations = $799^s.85$
Time of one vibration = 5.332
Correction for rate = .000
T' = 5.332

			Log's.
q		T'	0.72689
$t' - t$	+ 4.3	T'^2	1.45378
$(t' - t)\, q$		$1 + \frac{H}{F}$	65
$1 - (t' - t)q$		$1 - (t' - t)\, q$	9.99962
$mX = \frac{\pi^2 K}{T^2}$		T^2	1.45405
		$\pi^2 K$	2.17768
		mX	0.72363
		m	9.83487
		7.740 = X	0.88876

* Ob's of defl'n. *Date.* May 30th, 1866.

$t = 84^\circ.7$

$\frac{{}^{*}m}{X}$	8.94854
mX	0.72363
m^2	9.67217
m	9.83608

The chronometer used in this observation was $1^h\ 41^m\ 22^s.2$ fast of local mean time.

HORIZONTAL INTENSITY.

Observations of Deflections.

Station, Acapulco, Mexico. *Date,* May 30th, 1866. Mag. C. 32 deflecting. Mag. S. 8 suspended.
Observer, WM. HARKNESS.

Magnet.	North	Time. A. M. h. m.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	7 22	86°	$53^d.9$			r = 2.0 ft. log. = 0.30103
	E.			107.0	$53^d.9$	$53^d.1$	
	W.			53.9	107.0		
	E.			107.0			
East.	E.			107.5			
	W.			53.5	107.6	54.0	
	E.			107.7	53.6		
	W.	7 32	84	53.8			
Means,			85.0		$2u^d$	53.53	

Tors. cir.	Scale.	Diff's.
300°	$80^d.4$	
30	83.6	$3^d.2$
210	76.7	6.9
300	80.4	3.7
Mean = v = 3.45		

	Log's
v = 9'.8	
5400' + v'	3.73318
5400 (ar.co.)	6.26761
$1 + \frac{H}{F}$	0.00079

	Log's.
$2u^d$	1.72876
$\frac{1}{2}^d = 1'4175$	0.15152
$1 + \frac{H}{F}$	79
Sum	1.88107
$\frac{\text{Tan u}}{u'}$	6.46380
Tan u	8.34487
r^3	0.90309
$\frac{1}{2}$	9.69897
$\frac{m'}{X'}$	8.94693
$\frac{m}{X}$	8.94861

HORIZONTAL INTENSITY.

Observations of Deflections.

Station, Acapulco, Mexico. *Date,* May 30th, 1866. Mag. C. 32 deflecting. Mag. S. 8 suspended. Observer, WM. HARKNESS.

Magnet.	North end.	Time. A. M. h. m.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	7 32	84°	$66^d.9$	$66^d.9$	$27^d.3$	r = 2.5 ft. log. = 0.39794
	E.			94.1	94.2		
	W.			66.9			
	E.			94.2			
East.	E.			94.4			
	W.			66.8	94.4	27.6	
	E.			94.4	66.8		
	W.	7 40	85	66.8			
Means,			84.5		$2u^d$	27.45	

	Log's.
$2u^d$	1.43854
$\frac{1}{2}^d = 1'.4175$	0.15152
$1 + \frac{H}{F}$	79
Sum	1.59085
$\frac{\text{Tan u}}{u'}$	6.46374
Tan u	8.05459
r^3	1.19382
$\frac{1}{2}$	9.69897
$\frac{m'}{X'}$	8.94738
$\frac{m}{X}$	8.94846

The constants, peculiar to the portable declinometer D 22, were obtained as follows:

The Temperature Coefficients of the magnets were furnished by Mr. Chas. A. Schott, of the U. S. Coast Survey. They had been used with the instrument for some years, and I had no opportunity to redetermine them. They are as follows:

For the magnet C 32 $q = 0.00020$
" " " S 8 $q = 0.00027$

In reducing the observations a correction was always applied to the magnetic moment of the magnet C 32 to reduce it to what it would have been if C 32 had had the same temperature as S 8. Hence, the temperature coefficient of C 32 was the only one used, and in order to facilitate its application the following table was computed which furnishes the value of log. $[1 - (t' - t)\, q\,]$ with the argument $(t' - t)$.

Correction of Magnet C. 32 for Temperature

$(t'-t)$	Log. $[1-(t'-t)\,q]$	$(t'-t)$	Log. $[1-(t'-t)\,q]$
+ 1°	9·99991	— 1°	0.00009
+ 2	9·99983	— 2	0.00017
+ 3	9·99974	— 3	0.00026
+ 4	9·99965	— 4	0.00035
+ 5	9·99957	— 5	0.00043
+ 6	9·99948	— 6	0.00052
+ 7	9·99939	— 7	0.00061
+ 8	9·99930	— 8	0.00069
+ 9	9·99922	— 9	0.00078
+10	9·99913	—10	0.00087

P. P.

0.1	1
0.2	2
0.3	3
0.4	4
0.5	4
0.6	5
0.7	6
0.8	7
0.9	8

The Value of One Division of the Magnet Scale was determined for each magnet in the following manner: The instruments having been set up and adjusted as usual, the magnet was suspended in the magnet-box, and the packing blocks (before described as being used to prevent the suspension fibres from being twisted when the instrument was packed for travelling) were inserted in such a manner as to hold it perfectly steady. Then, the magnet scale being horizontal, the vertical wire of the theodolite telescope was made to coincide with any convenient scale division, and the horizontal circle of the theodolite was read. Next, the vertical wire was made to coincide with some other scale division, and the circle was again read. The difference of the two circle readings, divided by the difference of the two scale readings, gave the angular value of one scale division.

The following are the observations in detail for each magnet:

Magnet C. 32.

Date.	Circle Readings.	Differences.	Scale Readings.	Diff's.	Value of 1 Scale Division.
Nov. 16, 1865	4° 5′ 15″	3° 53′ 30″	$50^{d}.0$	$100^{d}.0$	2′.335
Nov. 16, 1865	0 11 45		150.0		
Nov. 16, 1865	4 6 45	3 55 0	50.0	100.0	2.350
Nov. 16, 1865	0 11 45		150.0		
Nov. 16, 1865	3 7 45	1 57 30	75.0	50.0	2.350
Nov. 16, 1865	1 10 15		125.0		
Nov. 16, 1865	3 7 45	1 57 30	75.0	50.0	2.350
Nov. 16, 1865	1 10 15		125.0		
Jan. 18, 1866	5 36 15	3 55 45	50.0	100.0	2.357
Jan. 18, 1866	1 40 30		150.0		
Jan. 18, 1866	4 37 0	1 57 30	75.0	50.0	2.350
Jan. 18, 1866	2 39 30		125.0		

Hence for the magnet C 32, we have
1 scale division = 2′.349 ± 0′.0020.

Magnet S. 8.

Date.	Circle Readings.	Differences.	Scale Readings.	Diff's.	Value of 1 Scale Division.
Nov. 16, 1865	4° 9′ 45″	4° 43′ 15′	$50^{d}.0$	$100^{d}.0$	2′.833
Nov. 16, 1865	359 26 30		150.0		
Nov. 16, 1865	4 9 45	4 43 15	50.0	100.0	2.832
Nov. 16, 1865	359 26 30		150.0		
Nov. 16, 1865	2 58 45	2 21 45	75.0	50.0	2.835
Nov. 16, 1865	0 37 0		125.0		
Nov. 16, 1865	2 59 0	2 21 30	75.0	50.0	2.830
Nov. 16, 1865	0 37 30		125.0		
Jan. 18, 1866	5 36 30	4 44 15	50.0	100.0	2.842
Jan. 18, 1866	0 52 15		150.0		
Jan. 18, 1866	4 25 30	2 22 0	75.0	50.0	2.840
Jan. 18, 1866	2 3 30		125.0		

Hence, for the magnet S 8, we have
1 scale division = 2′.835 ± 0′.0013.

The Moment of Inertia, and its Temperature Coefficient, of the Magnet C 32, was determined as follows: Let,

K_τ = moment of inertia of the magnet, including its suspending stirrup and other appendages, at the temperature τ.

ΔK = change in the value of K corresponding to a change of temperature of 1° Fah. in the magnet.

K'_τ = moment of inertia of the inertia ring, at the temperature τ.

d_i = internal diameter of the inertia ring, expressed in feet, at the temperature τ_0.

d_e = external diameter of the inertia ring, expressed in feet, at the temperature τ_0.

ε = coefficient of expansion for a change of temperature of 1° Fah. in the metal composing the inertia ring.

W = weight of the inertia ring expressed in grains.

t = time in which the magnet makes one vibration at the temperature τ_0 (corrected for chronometer rate, arc of vibration, and torsion.)

t' = time in which the magnet, loaded with the inertia ring, makes one vibration at the temperature τ_0 (corrected for chronometer rate, arc of vibration, and torsion)

Then

$$K'_\tau = W[1 + 2\varepsilon(\tau - \tau_0)] \left\{ \frac{d_i^2 + d_e^2}{8} \right\}$$

$$K_\tau = K'_{\tau_0} \left(\frac{t^2}{t'^2 - t^2} \right) + \Delta K (\tau - \tau_0)$$

The inertia ring used in making my observations was of bronze. Mr. Joseph Saxton, Assistant Superintendent of the Office of Weights and Measures, very obligingly measured and weighed it, with the following result:

Internal diameter = 2.385 inches = 0.19875 foot
External diameter = 2.947 inches = 0.24558 foot
Weight = 798.72 grains

the temperature of the ring being 74° Fah.

Hence, assuming the coefficient of expansion for an increase of temperature of 1° Fah. in the metal of this ring to be 0.0000105, we find by the formula given above

$$K'_\tau = 9.9601 + (\tau - 50^\circ)\ 0.000209$$

or

$$\text{Log. } K'_\tau = 0.99827 + (\tau - 50^\circ)\ 0.0000091$$

The following table contains all the times of vibration which were observed for the purpose of determining the moment of inertia of the magnet, together with the computation of the corresponding values of log. K from them. The value of t' was always observed either immediately before, or immediately after, the corresponding value of t which was to be used with it. This was done in order to have the temperature in both cases as nearly as possible the same, so that the correction necessary to reduce t' to the same temperature as t was always very small. Then having a sufficient number of values of K, obtained from observations made at widely different temperatures, the value of ΔK was easily found.

Date.	τ	Log. t'^2	Log. t^2	Log. $(t'^2 - t^2)$	Log. $\left(\frac{t^2}{t'^2 - t^2}\right)$	Log. K'_τ	Log. K_τ
Oct. 28, 1865	° 73.0	1.88210	1.66424	1.47811	0.18613	0.99849	1.18462
Nov. 16, 1865	87.7	1.72767	1.50891	1.32504	0.18385	0.99862	1.18247
Nov. 28, 1865	90.0	1.72835	1.51108	1.32345	0.18763	0.99864	1.18627
Dec. 13, 1865	89.5	1.74459	1.52673	1.34060	0.18613	0.99864	1.18477
Dec. 27, 1865	98.0	1.76681	1.54810	1.36412	0.18398	0.99872	1.18270
Jan. 18, 1866	87.2	1.77770	1.55921	1.37467	0.18458	0.99861	1.18315
March 19, 1866	76.2	1.75849	1.54101	1.35391	0.18710	0.99851	1.18561
April 11, 1866	74.0	1.75824	1.54019	1.35454	0.18565	0.99850	1.18415
May 30, 1866	84.7	1.67351	1.45405	1.27196	0.18209	0.99859	1.18068
Nov. 2, 1866	70.0	1.90424	1.68479	1.50268	0.18211	0.99846	1.18057
Nov. 2, 1866	70.0	1.90391	1.68450	1.50229	0.18221	0.99846	1.18067
Nov. 2, 1866	53.5	1.92843	1.70989	1.52548	0.18441	0.99830	1.18271
	79.5						1.18320

Let K_0 represent the mean of all the logarithms of K in the above table; then

$$K_0 = 1.18320$$

at a temperature of 79°.5. Now, assuming

$$\text{Log. } K_\tau = K_0 + (\tau - 79^\circ.5)\,\Delta K$$

we have

$$0 = K_0 - \text{log. } K_\tau + (\tau - 79^\circ.5)\,\Delta K$$

and each value of log. K_τ, given in the table above, will furnish one equation of condition for the determination of ΔK, as follows: the absolute terms being in units of the fifth place of decimals.

$$\begin{array}{l|l}
0 = -142 - 6.5\,\Delta K & 0 = -241 - 3.3\,\Delta K \\
0 = +73 + 8.2\,\Delta K & 0 = -95 - 5.5\,\Delta K \\
0 = -307 + 10.5\,\Delta K & 0 = +252 + 5.2\,\Delta K \\
0 = -157 + 10.0\,\Delta K & 0 = +263 - 9.5\,\Delta K \\
0 = +50 + 18.5\,\Delta K & 0 = +253 - 9.5\,\Delta K \\
0 = +5 + 7.7\,\Delta K & 0 = +49 - 26.0\,\Delta K
\end{array}$$

From these equations of condition we obtain, by the method of least squares, the normal equation

$$0 = -5856.2 + 1646.0\,\Delta K$$

whence

$$\text{Log. } \Delta K = 0.55119$$

$$\Delta K = +3.56$$

and finally

$$\text{Log. } K_\tau = 1.18320 + (\tau - 79^\circ.5)\,0.0000356 \pm 0.000368$$

or

$$K_\tau = 15.248 + (\tau - 79^\circ.5)\,0.00125 \pm 0.0129$$

Hence we have

$$\pi^2 K_\tau = 150.49 + (\tau - 79^\circ.5)\,0.01234$$

or

$$\text{Log. } \pi^2 K_\tau = 2.17750 + (\tau - 79^\circ.5)\,0.0000356$$

In order to facilitate the reduction of the observations of vibrations, the following table has been computed from the formula last given. It furnishes the value of log. $\pi^2 K_\tau$ to the argument τ.

τ	Log. $\pi^2 K_\tau$	P. P.	
50°	2.17645	1°	4
		2	7
60	2.17681	3	11
		4	14
70	2.17716	5	18
		6	21
80	2.17752	7	25
		8	28
90	2.17787	9	32
100	2.17823		

The Constant P, depending upon the distribution of the magnetism in the magnets C 32 and S 8, was determined by means of the formula

$$P = \frac{A - A'}{\dfrac{A}{r^2} - \dfrac{A'}{r'^2}}$$

where

A = value of $\frac{m'}{X'}$ determined from an observation of deflection with the deflecting magnet at the distance r from the suspended magnet.

A' = value of $\frac{m}{X'}$ determined from an observation of deflection with the deflecting magnet at the distance r' from the suspended magnet.

The following table contains all the observed values of A and A', together with the computation of the corresponding values of P. The values of A were obtained from deflections at a distance of 2.0 feet: those of A' from deflections at a distance of 2.5 feet.

Date.	Log. A	Log. A'	Log. $(A—A')$	Log. $\frac{A}{r^2}$	Log. $\frac{A'}{r'^2}$	Log. $\left(\frac{A}{r^2}-\frac{A'}{r'}\right)$	Log. P	P
October 30, 1865	9.1660	9.1669	6.4829*n*	8.5640	8.3711	8.1187	8.3643*n*	—0.0231
November 13, 1865	9.0084	9.0094	6.3881*n*	8.4063	8.2135	7.9608	8.4274*n*	0.0268
November 16, 1865	9.0087	9.0088	5.1491*n*	8.4067	8.2129	7.9629	7.1863*n*	0.0015
November 28, 1865	9.0068	9.0078	6.3989*n*	8.4047	8.2120	7.9591	8.4398*n*	—0.0275
December 13, 1865	9.0234	9.0175	7.1527	8.4213	8.2216	7.9879	9.1649	+0.1462
December 23, 1865	9.0295	9.0317	6.7332*n*	8.4274	8.2358	7.9798	8.7534*n*	—0.0567
December 27, 1865	9.0421	9.0413	6.3230	8.4400	8.2454	7.9978	8.3252	+0.0211
January 6, 1866	9.0628	9.0633	6.0587*n*	8.4608	8.2674	8.0163	8.0424*n*	—0.0110
January 18, 1866	9.0531	9.0536	6.1399*n*	8.4511	8.2578	8.0064	8.1335*n*	0.0136
February 7, 1866	9.0486	9.0495	6.3751*n*	8.4465	8.2536	8.0012	8.3739*n*	0.0237
March 2, 1866	9.0328	9.0339	6.4250*n*	8.4308	8.2380	7.9852	8.4398*n*	—0.0275
March 19, 1866	9.0350	9.0342	6.3106	8.4330	8.2383	7.9907	8.3199	+0.0209
March 29, 1866	9.0347	9 0347	4.8740	8.4326	8.2388	7.9890	6.8850	+0.0008
April 7, 1866	9.0367	9.0373	6.1551*n*	8.4346	8.2414	7.9899	8.1652*n*	—0.0146
April 11, 1866	9.0356	9.0360	5.9295*n*	8.4336	8.2401	7.9893	7.9402*n*	0.0087
April 13, 1866	9.0343	9.0368	6.7852*n*	8.4323	8.2409	7.9842	8.8010*n*	—0.0632
April 26, 1866	8.9902	8.9896	6.1515	8.3882	8.1937	7.9456	8.2059	+0.0161
May 7, 1866	8.9680	8.9704	6.7188*n*	8.3659	8.1745	7.9178	8.8010*n*	—0.0632
May 14, 1866	8.9468	8.9544	7.1930*n*	8.3447	8.1585	7.8872	9.3058*n*	0.2022
May 30, 1866	8.9468	8.9472	5.8890*n*	8.3448	8.1513	7.9004	7.9886*n*	0.0097
June 9, 1866	8.9775	8.9817	6.9669*n*	8.3754	8.1858	7.9241	9.0427*n*	—0.1103
June 15, 1866	9.0376	9.0346	6.8666	8.4355	8.2387	7.9970	8.8697	+0.0741
June 26, 1866	9.0810	9.0826	6.6509*n*	8.4790	8.2868	8.0324	8.6185*n*	—0.0415
November 1, 1866	9.1991	9.1972	6.8414	8.5971	8.4014	8.1568	8.6847	+0.0484

The indiscriminate mean of all the observations gives

$$P = -0.0166 \pm 0.0088$$

But Peirce's criterion for the rejection of doubtful observations throws out those of December 13 and May 14. Accordingly, excluding them, and taking the mean of all the others, there results

$$P = -0.0155 \pm 0.0057$$

and that value I have adopted. Hence, for $r = 2.0$ feet, we have

$$\text{Log.}\left(1 - \frac{P}{r^2}\right) = 0.00168$$

and for $r = 2.5$ feet

$$\text{Log.}\left(1 - \frac{P}{r^2}\right) = 0.00108$$

The Magnetic Moment of the Magnet C 32 was computed as follows: Observations of deflection were always taken at two different distances, viz., at 2.0 feet and at 2.5 feet. In general, the two values of $\frac{m}{X}$ thus obtained differed slightly from each other, and the mean of the two was assumed to be correct. This mean was combined with the value of mX, obtained from a set of vibrations observed on the *same day*, and thus m was determined. In no case was more than one set of observations of deflections taken on any single day, but in a few instances several sets of observations of vibrations were made. Under such circumstances, the mean of all the observed values of mX was combined with the mean of the two values of $\frac{m}{X}$, and thus a single value of m was deduced.

Let

$m_\tau =$ observed value of the magnetic moment at the temperature τ.

$m =$ value of m_τ after being multiplied by $[\,1 + (\tau - 75^\circ.8)\,q\,]$, or, in other words, after being reduced to the temperature 75°.8 Fah.

$m_0 =$ mean of all the observed values of m.

$a =$ daily decrease in the value of log. m, expressed in units of the fifth decimal place.

$d =$ time in days at which m is taken; d being counted from March 7th, 1866.

The following table contains all the observed values of log. m_τ, together with the computation from them of the final values of the same quantity. The column headed "days" gives the time in days counted from October 24th, 1865.

Date.	τ	Log. m_τ	Log. $[1+(\tau-75^\circ.8)q]$	Log. m	Days.	Concluded Log. m	Concluded Log. m_τ
	°						
October 24, 1865	57.5	9.84148	9.99841	9.83989	0	9.83990	9.84149
October 30, 1865	58.7	9.84139	9.99851	9.83990	6	9.83979	9.84128
November 13, 1865	85.5	9.83908	0.00082	9.83990	20	9.83951	9.83869
November 16, 1865	87.7	9.83951	0.00104	9.84055	23	9.83945	9.83841
November 28, 1865	90.0	9.83773	0.00121	9.83894	35	9.83922	9.83801
December 13, 1865	89.5	9.83645	0.00117	9.83762	50	9.83893	9.83776
December 23, 1865	87.2	9.83768	0.00100	9.83868	60	9.83873	9.83773
December 27, 1865	98.0	9.83655	0.00191	9.83846	64	9.83865	9.83674
January 6, 1866	74.2	9.83915	9.99986	9.83901	74	9.83846	9.83860
January 18, 1866	87.2	9.83666	0.00100	9.83766	86	9.83823	9.83723
February 7, 1866	69.5	9.83783	9.99945	9.83728	106	9.83784	9.83839
March 2, 1866	69.7	9.83831	9.99947	9.83778	129	9.83739	9.83792
March 19, 1866	76.2	9.83618	0.00004	9.83622	146	9.83706	9.83702
March 29, 1866	68.2	9.83780	9.99934	9.83714	156	9.83686	9.83752
April 7, 1866	67.0	9.83861	9.99923	9.83784	165	9.83669	9.83746
April 11, 1866	74.0	9.83716	9.99984	9.83700	169	9.83661	9.83677
April 13, 1866	65.7	9.83711	9.99912	9.83623	171	9.83657	9.83745
April 26, 1866	79.2	9.83626	0.00030	9.83656	184	9.83632	9.83602
May 7, 1866	77.0	9.83670	0.00009	9.83679	195	9.83610	9.83601
May 14, 1866	82.2	9.83448	0.00056	9.83504	202	9.83596	9.83540
May 30, 1866	84.7	9.83602	0.00078	9.83680	218	9.83565	9.83487
June 9, 1866	65.0	9.83662	9.99906	9.83568	228	9.83546	9.83640
June 15, 1866	71.0	9.83493	9.99958	9.83451	234	9.83534	9.85576
June 26, 1866	63.0	9.83548	9.99889	9.83437	245	9.83513	9.83624
November 1, 1866	66.2	9.83326	9.99916	9.83242	373	9.83263	9.83347
Means	75.8			9.83729	154		

The mean of the quantities in the column headed τ is 75°.8. Accordingly, adding log. $[1 + (\tau - 75°.8)q]$ to each log. m_τ, we obtain the values of log. m given in the table. Taking the mean of these values, and also the mean of the numbers in the column "days," we find that at 134 days, which corresponds to March 7th, 1866, the value of log. m was $9.83729 = \log.\ m_0$. Then, assuming

$$\text{Log. } m = \log.\ m_0 - \alpha d$$

we have

$$0 = 9.83729 - \log.\ m - \alpha d$$

and each value of log. m furnishes an equation of condition for the determination of α, as follows.

$$\begin{aligned}
0 &= -260 + 134\,\alpha \\
0 &= -261 + 128\,\alpha \\
0 &= -261 + 114\,\alpha \\
0 &= -326 + 111\,\alpha \\
0 &= -165 + 99\,\alpha \\
0 &= -33 + 84\,\alpha \\
0 &= -139 + 74\,\alpha \\
0 &= -117 + 70\,\alpha \\
0 &= -172 + 60\,\alpha \\
0 &= -37 + 48\,\alpha \\
0 &= +1 + 28\,\alpha \\
0 &= -49 + 5\,\alpha \\
0 &= +107 - 12\,\alpha
\end{aligned}$$

$$\begin{aligned}
0 &= +15 - 22\,\alpha \\
0 &= -55 - 31\,\alpha \\
0 &= +29 - 35\,\alpha \\
0 &= +106 - 37\,\alpha \\
0 &= +73 - 50\,\alpha \\
0 &= +50 - 61\,\alpha \\
0 &= +225 - 68\,\alpha \\
0 &= +49 - 84\,\alpha \\
0 &= +161 - 94\,\alpha \\
0 &= +278 - 100\,\alpha \\
0 &= +292 - 111\,\alpha \\
0 &= +487 - 239\,\alpha
\end{aligned}$$

By the method of least squares we obtain the normal equation

$$0 = -397497 + 203965\,\alpha$$

Solving, we get

$$\alpha = +1.9488$$

Hence

$$\text{Log. } m = 9.83729 - 0.0000195\,d \pm 0.000090$$

or

$$m = 0.68753 - 0.0000310\,d \pm 0.000144$$

From the first of these expressions the quantities in the column "concluded log. m" were computed.

If, in the expression for log. m, given above, we introduce the correction for temperature, we obtain

$$\text{Log. } m_\tau = 9.83729 - 0.0000195\,d - 0.000087\,(\tau - 75°.8)$$

by means of which the quantities in the column "concluded log. m_τ" were computed.

The probable error of a single observed value of log. m is $\pm$ 0.000452, and of a single observed value of m it is $\pm$ 0.000719.

Observations of Inclination were all made with a dip circle by Henry Barrow & Co., of London. It was provided with two needles, marked A 1 and A 2, each 3.5 inches long, and having axles 0.016 of an inch in diameter. The distance between the agate planes on which they rested was 0.74 of an inch. By means of two microscopes, one opposite each end of the needle—each of which, assuming distinct vision to be obtained at a distance of ten inches, magnified 18 diameters—the inclination of the needle was referred to, and read off upon a vertical circle six inches in diameter, divided to half degrees, and reading by means of two verniers to single minutes. The pointing of the microscopes to the ends of the needle was effected by means of a clamp and tangent screw. The horizontal circle of the instrument was four inches in diameter, divided to half degrees, and reading by means of one vernier to single minutes. It was provided with a clamp, but no tangent screw.

Readings of the position of the dipping needle were made as follows: In the field of view of each microscope was a plate of glass upon which was engraved three fine parallel lines, the middle one being intended to represent one of the two extremities of a diameter passing through a vertical circle described about the prolongation of the axle of the needle. The north microscope having been turned till the centre line in its field of view coincided with the north end of the needle, the vernier belonging to that microscope was read off, and recorded as the reading of the north end of the needle. Then the south microscope was turned till the centre line in its field of view coincided with the south end of the needle, and the vernier belonging to that microscope was read off, and recorded as the reading of the south end of the needle. In order to distinguish between the two microscopes the letter N was scratched upon one of them, and that one was always, in all positions of the instrument, used to read the north end of the needle.

The instrument having been set up and levelled, before beginning to observe it was necessary to place the plane of the vertical circle in the magnetic meridian. At a few of the earlier stations this was accomplished as follows: The needle was placed on the agate planes, with the side on which the letters were marked facing the microscopes. Then 1°. The microscopes having been turned till they were nearly in a vertical line, the vernier of the lower one was set to 90° 0′, and the vertical circle was moved in azimuth—so that its face (by which is meant the side on which the microscopes were) was south—till the lower end of the needle was bisected by the middle line in the lower microscope; the Y's were raised and lowered gently, and if the bisection of the needle was altered, it was corrected by turning the circle in azimuth. Then the horizontal circle was clamped and read off; and this reading was called A. 2°. The vernier of the upper microscope was set to 90° 0′, and the horizontal circle having been unclamped, the vertical circle was moved in azimuth—its face still remaining south—till the upper end of the needle was bisected by the middle line in the upper microscope; the Y's were raised and lowered gently, and if the bisection of the needle was altered, it was corrected by turning the circle in azimuth. Then the horizontal circle was clamped and read off, and this reading was called B. 3°. The horizontal circle was unclamped, and turned in azimuth 180°, so as to bring the face of the instrument to the north, and then the 1° and 2° processes just described were repeated; thus giving two more readings of the horizontal circle, which were called C and D. Then

$$\frac{A+B+C+D}{4}=E$$

where E is the division of the horizontal circle at which it was necessary to set the vernier in order that the plane of the vertical circle might be *at right angles* to the magnetic meridian. Therefore the vernier was set at $90° + E$, and the plane of the vertical circle coincided with the magnetic meridian. However, it soon became evident that this process consumed too much time, and the following, which is quite as accurate and much more expeditious, was adopted: A fine line was marked permanently upon the top of the instrument parallel to the plane of the vertical circle; then, after the instrument had been levelled, but before the dipping needle had been placed upon the agate planes, a pocket compass, with a needle about one and a half inches long, was placed with its centre upon the fine line, and the vertical circle was turned in azimuth till the compass needle and line were parallel to each other. That being the case, the plane of the vertical circle was known to be in the magnetic meridian, and the horizontal circle was clamped and read off.

The following is the method which was adopted in making observations of dip: 1°. The agate planes, and those parts of the axle of the needle which would rest upon them, were carefully wiped with a piece of chamois leather (I have since seen reason to believe that a piece of cork would have answered the purpose better), and then the instrument was set up, levelled, and the plane of the vertical circle placed in the magnetic meridian by the process before described. 2°. The needle was secured upon a block, provided for the purpose, and magnetised by means of a pair of eight-inch bar magnets, in such a manner that its marked end acquired north polarity. It was considered to be saturated with magnetism when the bar magnets had been drawn from its centre to its extremities six times, the process being performed upon both of its sides, and then it was removed from the block and placed in position upon the agate planes, with its face (by which is meant that side upon which the letters were marked) towards the east. 3°. The plane of the vertical circle being in the magnetic meridian, with the face of the instrument towards the east, and the needle in position upon the agate planes, with its face also towards the east, the north and south ends of the needle were read. Let these readings be designated respectively as ϕ' and ϕ''. 4°. The needle was reversed upon the agate planes, so as to bring its face towards the west, and its north and south ends were read. Let these readings be designated respectively ϕ''' and ϕ^{IV}. 5°. The horizontal circle was unclamped, the vertical circle turned in azimuth 180°, so as to bring its face towards the west, and the horizontal circle again clamped. The face of the needle now being towards the east, its north and south ends were read. Let these readings be designated respectively as ϕ^{V} and ϕ^{VI}. 6°. The needle was reversed upon the agate planes, so as to bring its face towards the west, and its north and south ends were read. Let these readings be designated respectively as ϕ^{VII} and ϕ^{VIII}. 7°. The time was noted, and then the needle, having been removed from the agate planes, was placed upon the block provided for the purpose, and remagnetised in such a manner that its marked end acquired south polarity; after which it was again placed in position upon the agate planes, with its face towards the west, and its north and south ends were read. Let these readings be designated respectively as ψ' and ψ''. 8°. The needle was reversed upon the agate planes, so as to bring its face towards the east, and its north and south ends were read. Let these readings be designated respectively as ψ''' and ψ^{IV}. 9°. The horizontal circle was unclamped, the vertical circle turned in azimuth 180°, so as to bring its face to the east, and the horizontal circle again clamped. The face of the needle now being towards the west, its north and south ends were read. Let these readings be designated respectively as ψ^{V} and ψ^{VI}. 10°. The needle was reversed upon the agate planes, so as to bring its face towards the east, and its north and south ends were read. Let these readings be designated respectively as ψ^{VII} and ψ^{VIII}.

At the first few stations each of the readings ϕ', ϕ'', ϕ''' .... ϕ^{VIII}, ψ', ψ'', ψ''' .... ψ^{VIII}, was repeated three times, the Y's being raised and lowered again between each repetition; but after some experience I became convinced that the increase of accuracy obtained by three repetitions, over that obtained by a single careful reading, was not sufficient to warrant the greatly increased expenditure of time, and accordingly the repetitions were abandoned.

The needle A 2 proved to be well balanced, and the observations made with it were therefore reduced by the usual formula, namely

$$\frac{\phi' + \phi'' + \phi''' + \phi^{IV} + \phi^{V} + \phi^{VI} + \phi^{VII} + \phi^{VIII}}{8} = \alpha$$

$$\frac{\psi' + \psi'' + \psi''' + \psi^{IV} + \psi^{V} + \psi^{VI} + \psi^{VII} + \psi^{VIII}}{8} = \beta$$

$$\theta = \frac{\alpha + \beta}{2}$$

where θ is the magnetic inclination or dip.

The needle A 1 proved not to be well balanced, which was shown by the great difference between the values of α and β obtained with it in low magnetic latitudes; although they agreed well enough at places where the dip was large. An examination of all the observations showed that in every case

$$\frac{\phi' + \phi'' + \phi^{V} + \phi^{VI}}{4} = \frac{\phi''' + \phi^{IV} + \phi^{VII} + \phi^{VIII}}{4}$$

and

$$\frac{\psi' + \psi'' + \psi^{V} + \psi^{VI}}{4} = \frac{\psi''' + \psi^{IV} + \psi^{VII} + \psi^{VIII}}{4}$$

at least within about one degree. It therefore followed that, although the centre of gravity of the needle did not lie in its axle, it did lie somewhere in the line joining the two extremities of the needle and passing through its axle. In such cases we have

$$\tan \theta = \frac{\tan \alpha + \tan \beta}{2}$$

and by that formula all the observations made with this needle were reduced.

At St. Thomas some observations of dip were made with the plane of the vertical circle out of the magnetic meridian. They were reduced by the formula

$$\tan \theta = \tan \theta' \cos \alpha$$

where θ is the true dip, and θ' the dip observed with the vertical circle in a plane whose azimuth, measured from the magnetic meridian, was α.

The values of the Vertical and Total Force have been computed from the horizontal force and inclination by the formulæ

$$Z = X \tan \theta$$
$$R = X \sec \theta$$

where

$X =$ horizontal component of the earth's magnetic force.
$Z =$ vertical component of the earth's magnetic force.
$R =$ total magnetic intensity.
$\theta =$ magnetic inclination.

All values of force are expressed in English units; namely, in terms of grains, feet, and seconds. If it is desired to have them in metric units, expressed in terms of milligrams, millimeters, and seconds, they must be multiplied by 0.46108.

The observations of magnetic declination, inclination, and force are given in full at the end of this section, but for convenience of reference the following abstract of them is inserted here.

Station.	Date.	Declination.	Inclination.		Log. $\frac{m}{X}$	Log. mX	Temp.	$X =$ Hor. Force
			Needle A. 1.	Needle A. 2.				
Philadelphia, Pa.	Oct. 24, 1865	......	......	... ..	9.22363	0.45934	57.5	4.148
Gosport, Va.	Oct. 28, 1865	......	......	......	......	0.51303	73.0	4.709
Gosport, Va.	Oct. 30, 1865	2° 37′.8 W.	+69° 21′	+69° 54′	9.16787	0.51492	58.7	4.717
St. Thomas,	Nov. 13, 1865	......	+49 36	+49 32	9.01026	0.66791	85.5	6.749
St. Thomas,	Nov. 16, 1865	0 39.6 E.	+49 39	+49 44	9.01014	0.66888	87.7	6.768
Salute Islands,	Nov. 28, 1865	0 3.8 W.	+34 27	+34 42	9.00868	0.66679	90.0	6.742
Ceara,	Dec. 13, 1865	8 28.8 W.	+21 26	+21 20	9.02178	0.65112	89.5	6.507
Pernambuco,	Dec. 23, 1865	10 59.6 W.	+12 6	+12 10	9.03195	0.64340	87.2	6.392
Bahia,	Dec. 27, 1865	7 56.6 W.	+ 4 31	+ 4 17	9.04305	0.63005	98.0	6.213
Rio Janeiro,	Jan. 6, 1866	......	—11 48	—11 46	9.06444	0.61386	74.2	5.960
Rio Janeiro,	Jan. 9, 1866	2 41.8 W.	......	......	......	0.61205	80.5	5.944
Monte Video,	Jan. 18, 1866	9 16.6 E.	—31 11	—30 58	......	0.61892	87.2	6.049
Monte Video,	Jan. 18, 1866	......	......	—31 8	9.05476	0.61822	87.2	6.039
Monte Video,	Jan. 19, 1866	9 25.0 E.	......	......	......	0.61754	89.5	6.033
Sandy Point,	Feb. 7, 1866	21 52.0 E.	—54 52	—55 2	9.05044	0.62523	69.5	6.121
Valparaiso,	March 2, 1866	15 54.3 E.	—34 50	—35 7	9.03474	0.64188	69.7	6.367
Valparaiso,	March 19, 1866	15 36.6 E.	—35 28	—35 28	9.03599	0.63637	76.2	6.300
Valparaiso,	March 29, 1866	15 54.8 E.	—35 34	—35 27	......	0.64126	68.2	6.364
Valparaiso,	March 29, 1866	......	......	......	9.03607	0.63782	68.2	6.314
Valparaiso,	April 7, 1866	15 49.4 E.	—35 26	—35 23	9.03837	0.63885	67.0	6.330
Valparaiso,	April 11, 1866	15 57.6 E.	—35 29	—35 36	......	0.63697	74.0	6.312
Valparaiso,	April 11, 1866	......	......	......	9.03720	0.63725	74.0	6.317
Valparaiso,	April 13, 1866	15 53.9 E.	—35 40	—35 12	9.03692	0.63730	65.7	6.307
Callao,	April 26, 1866	10 29.6 E.	— 6 28	— 6 29	8.99132	0.68120	79.2	7.001
Payta,	May 7, 1866	8 53.0 E.	+ 5 9	+ 4 47	8.97055	0.70285	77.0	7.359
Panama Bay,	May 14, 1866	5 55.8 E.	+32 5	+31 47	8.95196	0.71700	82.2	7.614
Acapulco,	May 30, 1866	8 20.8 E.	+39 49	+39 58	8.94841	0.72363	84.7	7.740
Acapulco,	May 30, 1866	8 23.6 E.	......	......	......	.....	......	......
Magdalena Bay,	June 9, 1866	10 40.5 E.	+48 41	+48 22	......	0.69240	65.0	7.178
Magdalena Bay,	June 9, 1866	......	......	......	8.98098	0.69211	65.0	7.173
San Diego Bay,	June 15, 1866	13 9.4 E.	+57 51	+57 56	9.03746	0.63241	71.0	6.261
San Francisco Bay,	June 26, 1866	16 25.5 E.	+62 13	+62 31	9.08320	0.58777	63.0	5.643
Washington, D. C.	Nov. 1, 1866	2 44.2 W.	+71 51	+72 13	9.19956	0.46695	66.2	4.300
Washington, D. C.	May 6, 1867	......	+71 55	+72 5	......	......	......	......

Taking the means we obtain the final values of the magnetic elements at each station, as follows:

Station.	Latitude.	Longitude West.	Date.	Declination.	No. of Obs.	Inclination.	No. of Obs.	Horizontal Force.	No. of Obs.	Vertical Force.	Total Force.
Philadelphia, Pa. . .	39° 56′ N.	75° 7′	Oct. 24, 1865	° ′		° ′		4.148	1		
Gosport	36 49 N.	76 17	Oct. 29, 1865	2 37.8 W.	1	+69 38	2	4.713	2	12.696	13.542
St. Thomas	18 20 N.	64 55	Nov. 14, 1865	0 39.6 E.	1	+49 38	4	6.758	2	7.950	10.434
Salute Islands	5 17 N.	52 33	Nov. 28, 1865	0 3.8 W.	1	+34 35	2	6.742	1	4.648	8.189
Ceara	3 44 S.	38 31	Dec. 13, 1865	8 28.8 W.	1	+21 23	2	6.507	1	2.548	6.988
Pernambuco	8 4 S.	34 52	Dec. 23, 1865	10 59.6 W.	1	+12 8	2	6.392	1	1.374	6.538
Bahia	12 57 S.	38 30	Dec. 27, 1865	7 56.6 W.	1	+ 4 24	2	6.213	1	0.478	6.231
Rio Janeiro	22 54 S.	43 8	Jan. 8, 1866	2 41.8 W.	1	—11 47	2	5.952	2	1.242	6.080
Monte Video	34 53 S.	56 13	Jan. 18, 1866	9 20.8 E.	2	—31 6	3	6.040	3	3.644	7.054
Sandy Point	53 10 S.	70 54	Feb. 7, 1866	21 52.0 E.	1	—54 57	2	6.121	1	8.725	10.658
Valparaiso	33 2 S.	71 41	March 29, 1866	15 51.1 E.	6	—35 23	12	6.326	8	4.493	7.759
Callao	12 5 S.	77 17	April 26, 1866	10 29.6 E.	1	— 6 28	2	7.001	1	0.794	7.046
Payta	5 6 S.	81 6	May 7, 1866	8 53.0 E.	1	+ 4 58	2	7.359	1	0.640	7.387
Panama Bay	8 54 N.	79 30	May 14, 1866	5 55.8 E.	1	+31 56	2	7.614	1	4.745	8.972
Acapulco	16 50 N.	99 52	May 30, 1866	8 22.2 E.	2	+39 54	2	7.740	1	6.472	10.089
Magdalena Bay . . .	24 40 N.	112 7	June 9, 1866	10 40.5 E.	1	+48 32	2	7.176	2	8.120	10.837
San Diego Bay . . .	32 42 N.	117 13	June 15, 1866	13 9.4 E.	1	+57 54	2	6.261	1	9.981	11.782
San Francisco	37 49 N.	122 21	June 26, 1866	16 25.5 E.	1	+62 22	2	5.643	1	10.779	12.167
Washington	38 54 N.	77 3	Nov. 1 1866	2 44.2 W.	1	+72 2	2	4.300	1	13.260	13.940

OBSERVATIONS OF MAGNETIC DECLINATION.

MAGNETIC DECLINATION.

Gosport, Va. October 30, 1865.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	359° 59′ 15″	(1) Scale erect . . . (2) Scale inverted .	$81^{d}.7$ 76.5
			(1) — (2) = Δ . . .	+ 5.2
			Transit of Sun's	
	Vernier . . . . . Vernier		1st limb . . . 2d limb . . .	10^{h} 40^{m} $6^{s}.2$ 42 27.0
	Mean	162 12 45	Mean	10 41 16.6
Telescope Reversed.	Vernier . . . . . Vernier		1st limb . . . 2d limb . . .	10^{h} 44^{m} $48^{s}.0$ 47 8.8
	Mean	163° 34′ 45″	Mean	10 45 58.4
			Reading of Magnet.	
	Vernier		(1) Scale inverted . (2) Scale erect . . .	$64^{d}.2$ 93.5
			(2) — (1) = Δ . . .	+29.3

	Telescope Direct.	Telescope Reversed.
Equation of time	16^{m} $13^{s}.7$	
t	—16° 47′ 28″	
δ	—13 56 36	
Circle reading to magnet	359° 59′.2	
$\Delta \times \frac{1}{2}$ scale division	+ 6.1	
Sun's azimuth	339 29.6	
Sum	339 34.9	
180° + circle reading to sun . . .	342 12.7	
Magnetic declination	2 37.8 W.	

These observations were made before noon.

Chronometer 0^{h} 4^{m} $40^{s}.2$ fast of local mean time.

MAGNETIC DECLINATION.

St. Thomas. November 16, 1865.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	359° 59′ 0″	(1) Scale erect . . . . . . (2) Scale inverted	$80^d.3$ 78.2
			(1) — (2) = Δ	+ 2.1
			Transit of Sun's	
	Vernier . . . . . . Vernier		1st limb . . . . . . 2d limb	$9^h\ 10^m\ 35^s.0$ 13 31.0
	Mean	141 24 0	Mean	9 12 3.0
Telescope Reversed.	Vernier . . . . . . Vernier		1st limb . . . . . . 2d limb	$9^h\ 16^m\ 45^s.0$ 19 37.5
	Mean	143° 0′ 45″	Mean	9 18 11.2
			Reading of Magnet.	
	Vernier	359 58 45	(1) Scale inverted . . . . (2) Scale erect	$76^d.0$ 82.3
			(2) — (1) = Δ	+ 6.3

	Telescope Direct.	Telescope Reversed.
Equation of time	$15^m\ 0^s.1$	$15^m\ 0^s.0$
t	— 28° 2′ 53″	— 26° 30′ 51″
δ	— 18 51 11	— 18 51 15
Circle reading to magnet	359° 59′.0	359° 58′.7
Δ × ½ scale division	+ 2.5	+ 7.4
Sun's azimuth	321 59.9	323 36.5
Sum	322 1.4	323 42.6
180° + circle reading to sun	321 24.0	323 0.7
Magnetic declination	0 37.4 E.	0 41.9 E.

These observations were made before noon.

Chronometer $0^h\ 40^m\ 45^s.4$ slow of local mean time.

MAGNETIC DECLINATION.

Salute Islands. November 28, 1865.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	0° 11′ 0″	(1) Scale erect . . . . . . (2) Scale inverted	$79^d.2$ 79.3
			(1) — (2) = Δ	— 0.1
			Transit of Sun's	
	Vernier . . . . . . Vernier		1st limb . . . . . . 2d limb	$12^h\ 21^m\ 44^s.0$ 25 37.5
	Mean	228 16 15	Mean	12 23 40.7
Telescope Reversed.	Vernier . . . . . . Vernier		1st limb . . . . . . 2d limb	$12^h\ 29^m\ 11^s.5$ 33 14.0
	Mean	229° 48′ 15″	Mean	12 31 12.7
			Reading of Magnet.	
	Vernier	0 14 30	(1) Scale inverted . . . . (2) Scale erect	$81^d.2$ 77.3
			(2) — (1) = Δ	— 3.9

	Telescope Direct.	Telescope Reversed.
Equation of time	$11^m\ 40^s.8$	$11^m\ 40^s.6$
t	+ 31° 25′ 13″	+ 33° 18′ 10″
δ	— 21 25 2	— 21 25 6
Circle reading to magnet	0° 11′.0	0° 14′.5
Δ × ½ scale division	— 0.1	— 4.6
Sun's azimuth	48 0.8	49 35.1
Sum	48 11.7	49 45.0
180° + circle reading to sun	48 16.2	49 48.2
Magnetic declination	0 4.5 W.	0 3.2 W.

These observations were made after noon.

Chronometer $1^h\ 30^m\ 19^s.4$ slow of local mean time.

MAGNETIC DECLINATION.
Ceara, December 13, 1865.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	1° 10′ 30″	(1) Scale erect	$79^d.6$
			(2) Scale inverted	78.5
			(1) — (2) = Δ	+ 1.1
			Transit of Sun's	
	Vernier	255 56 45	1st limb	$1^h\ 42^m\ 0^s$
	Vernier	25 15	2d limb	44 0
	Mean	255 41 0	Mean	1 43 0.0
Telescope Reversed.	Vernier	255° 27′ 0″	1st limb	$1^h\ 47^m\ 0^s$
	Vernier	256 5 15	2d limb	48 0
	Mean	255 46 8	Mean	1 47 30.0
			Reading of Magnet.	
	Vernier	1 15 30	(1) Scale inverted	$82^d.2$
			(2) Scale erect	76.1
			(2) — (1) = Δ	— 6.1

	Telescope Direct.	Telescope Reversed.
Equation of time	$5^m\ 10^s.3$	$5^m\ 10^s.2$
t	+ 63° 40′ 36″	+ 64° 48′ 4″
δ	— 23 12 12	— 23 12 12
Circle reading to magnet	1° 10′.5	1° 15′.5
Δ × ½ scale division	+ 1.3	— 7.2
Sun's azimuth	66 0.4	66 8.9
Sun	67 12.2	67 17.2
180° + circle reading to sun	75 41.0	75 46.1
Magnetic declination	8 28.8 W.	8 28.9 W.

These observations were made after noon.

Chronometer $2^h\ 26^m\ 32^s.1$ slow of local mean time.

MAGNETIC DECLINATION.
Pernambuco, December 23, 1865.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	2° 37′ 0″	(1) Scale erect	$80^d.8$
			(2) Magnetic axis	79.11
			(1) — (2) = Δ	+ 1.69
			Transit of Sun's	
	Vernier	135 15 30	1st limb	$7^h\ 19^m\ 35^s$
	Vernier	134 28 45	2d limb	20 55
	Mean	134 52 7	Mean	7 20 15.0
Telescope Reversed.	Vernier		1st limb	
	Vernier		2d limb	
	Mean		Mean	
			Reading of Magnet.	
	Vernier		(1) Scale inverted	
			(2) Scale erect	
			(2) — (1) = Δ	

	Telescope Direct.	Telescope Reversed.
Equation of time	$0^m\ 31^s.5$	
t	— 30° 39′ 40″	
δ	— 23 26 32	
Circle reading to magnet	2° 37′.0	
Δ × 1 scale division	+ 4.0	
Sun's azimuth	301 11.5	
Sum	303 52.5	
180° + circle reading to sun	314 52.1	
Magnetic declination	10 59.6 W.	

These observations were made before noon, and prior to beginning them the collimation was adjusted.

Chronometer $2^h\ 36^m\ 34^s.8$ slow of local mean time.

MAGNETIC DECLINATION.

Bahia, December 27, 1865.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	3° 32′ 45″	(1) Scale erect (2) Scale inverted	$77^d.5$ 80.7
			(1) — (2) = Δ	— 3.2
			Transit of Sun's	
	Vernier Vernier	121 48 45 6 15	1st limb 2d limb	$6^h\ 28^m\ 19^s$ 30 28
	Mean	121 27 30	Mean	6 29 23.5
Telescope Reversed.	Vernier Vernier	122° 2′ 30″ 121 17 30	1st limb 2d limb	$6^h\ 36^m\ 38^s$ 37 37
	Mean	121 40 0	Mean	6 37 7.5
			Reading of Magnet.	
	Vernier	3 32 0	(1) Scale inverted (2) Scale erect	$80^d.8$ 77.5
			(2) — (1) = Δ	— 3.3

	Telescope Direct.	Telescope Reversed.
Equation of time	$1^m\ 26^s.8$	$1^m\ 26^s.9$
t	—47° 29′ 0″	—45° 33′ 9″
δ	—23 19 36	—23 19 36
Circle reading to magnet	3° 32′.7	3° 32′.0
$\Delta \times \frac{1}{2}$ scale division	— 3.8	— 3.9
Sun's azimuth	290 2.3	290 14.9
Sum	293 31.2	293 43.0
180° + circle reading to sun	301 27.5	301 40.0
Magnetic declination	7 56.3 W.	7 57.0 W.

These observations were made before noon.
Chronometer $2^h\ 22^m\ 6^s.8$ slow of local mean time.

MAGNETIC DECLINATION.

Rio Janeiro, January 9, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	2° 36′ 45″	(1) Scale erect (2) Scale inverted	$79^d.8$ 78.2
			(1) — (2) = Δ	+ 1.6
			Transit of Sun's	
	Vernier Vernier	111 42 30 112 4 15	1st limb 2d limb	$4^h\ 52^m\ 10^s$ 55 8
	Mean	111 53 23	Mean	4 53 39.0
Telescope Reversed.	Vernier Vernier	111° 56′ 30″ 18 0	1st limb 2d limb	$4^h\ 56^m\ 50^s$ 57 50
	Mean	111 37 15	Mean	4 57 20.0
			Reading of Magnet.	
	Vernier	2 37 0	(1) Scale inverted (2) Scale erect	$78^d.3$ 79.8
			(2) — (1) = Δ	+ 1.5

	Telescope Direct.	Telescope Reversed.
Equation of time	$7^m\ 23^s.4$	$7^m\ 23^s.4$
t	—77° 31′ 30″	—76° 36′ 15″
δ	—22 6 32	—22 6 31
Circle reading to magnet	2° 36′.7	2° 37′.0
$\Delta \times \frac{1}{2}$ scale division	+ 1.9	+ 1.8
Sun's azimuth	286 33.1	286 16.6
Sum	289 11.7	288 55.4
180° + circle reading to sun	291 53.4	291 37.2
Magnetic declination	2 41.7 W.	2 41.8 W.

These observations were made before noon.
Chronometer $2^h\ 3^m\ 38^s.4$ slow of local mean time.

MAGNETIC DECLINATION.

Monte Video, January 18, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	2° 10′ 45″	(1) Scale erect (2) Scale inverted	79^{d}.1 79.0
			(1) — (2) = Δ	+ 0.1
			Transit of Sun's	
	Vernier Vernier		1st limb 2d limb	4^{h} 19^{m} 15^{s} 23 44
	Mean	250 49 30	Mean	4 21 29.5
Telescope Reversed.	Vernier Vernier		1st limb 2d limb	4^{h} 26^{m} 3^{s} 30 30
	Mean	249° 55′ 15″	Mean	4 28 16.5
			Reading of Magnet.	
	Vernier	2 10 45	(1) Scale inverted (2) Scale erect	78^{d}.5 79.6
			(2) — (1) = Δ	+ 1.1

	Telescope Direct.	Telescope Reversed.
Equation of time t δ	10^{m} 51^{s}.7 + 80° 31′ 12″ — 20 26 47	10^{m} 51^{s}.8 + 82° 12′ 55″ — 20 26 44
Circle reading to magnet Δ × ½ scale division Sun's azimuth	2° 10′.7 + 0.1 77 53.6	2° 10′.7 + 1.3 77 1.5
Sum 180° + circle reading to sun	80 4.4 70 49.5	79 13.5 69 55.2
Magnetic declination	9 14.9 E.	9 18.3 E.

These observations were made after noon.
Chronometer 1^{h} 11^{m} 27^{s}.0 slow of local mean time.

MAGNETIC DECLINATION.

Monte Video, January 19, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	2° 34′ 52″	(1) Scale erect (2) Scale inverted	77^{d}.5 80.2
			(1) — (2) = Δ	- 2.7
			Transit of Sun's	
	Vernier Vernier		1st limb 2d limb	3^{h} 38^{m} 8^{s} 42 51
	Mean	256 30 30	Mean	3 40 29.5
Telescope Reversed.	Vernier Vernier		1st limb 2d limb	3^{h} 44^{m} 40^{s} 49 19
	Mean	255° 36′ 0″	Mean	3 46 59.5
			Reading of Magnet.	
	Vernier	2 34 30	(1) Scale inverted (2) Scale erect	81^{d}.6 76.7
			(2) — (1) = Δ	— 4 9

	Telescope Direct.	Telescope Reversed.
Equation of time t δ	11^{m} 9^{s}.5 + 70° 13′ 30″ — 20 14 31	11^{m} 9^{s}.6 + 71° 50′ 58″ — 20 14 28
Circle reading to magnet Δ × ½ scale division Sun's azimuth	2° 34′.9 — 3.2 83 23.3	2° 34′.5 — 5.8 82 32.9
Sum 180° + circle reading to sun	85 55.0 76 30.5	85 1.6 75 36.0
Magnetic declination	9 24.5 E.	9 25.6 E.

These observations were made after noon.
Chronometer 1^{h} 11^{m} 34^{s}.0 slow of local mean time.

MAGNETIC DECLINATION.
Sandy Point, February 7, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	2° 54′ 45″	(1) Scale erect	$79^d.8$
			(2) Scale inverted	78.5
			(1) — (2) = Δ	+ 1.3
			Transit of Sun's	
	Vernier		1st limb	$10^h\ 53^m\ 10^s$
	Vernier		2d limb	55 31
	Mean	6 44 15	Mean	10 54 20.5
Telescope Reversed.	Vernier		1st limb	$10^h\ 58^m\ 53^s$
	Vernier		2d limb	11 1 12
	Mean	4° 38′ 0″	Mean	11 0 2.5
			Reading of Magnet.	
	Vernier	2 54 15	(1) Scale inverted	$77^d.9$
			(2) Scale erect	80.9
			(2) — (1) = Δ	+ 3.0

	Telescope Direct.	Telescope Reversed.
Equation of time	$14^m\ 25^s.6$	$14^m\ 25^s.6$
t	— 16° 49′ 15″	— 15° 23′ 45″
δ	— 15 13 36	— 15 13 31
Circle reading to magnet	2° 54′.7	2° 54′.2
Δ × ½ scale division	+ 1.5	+ 3.5
Sun's azimuth	205 38.2	203 34.1
Sum	208 34.4	206 31.8
180° + circle reading to sun	186 44.2	184 38.0
Magnetic declination	21 50.2 E.	21 53.8 E.

These observations were made before noon.
Chronometer $0^h\ 12^m\ 48^s.1$ slow of local mean time.
Magnet rendered quite unsteady by the wind.

MAGNETIC DECLINATION.
Valparaiso, March 2, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	4° 13′ 0″	(1) Scale erect	$71^d.1$
			(2) Scale inverted	87.3
			(1) — (2) = Δ	— 16.2
			Transit of Sun's	
	Vernier		1st limb	$4^h\ 28^m\ 50^s$
	Vernier		2d limb	32 51.5
	Mean	264 44 0	Mean	4 30 50.7
Telescope Reversed.	Vernier		1st limb	$4^h\ 35^m\ 0^s.5$
	Vernier		2d limb	39 9.0
	Mean	263° 47′ 30″	Mean	4 37 4.7
			Reading of Magnet.	
	Vernier	4 5 30	(1) Scale inverted	$85^d.3$
			(2) Scale erect	73.4
			(2) — (1) = Δ	— 11.9

	Telescope Direct.	Telescope Reversed.
Equation of time	$12^m\ 17^s.4$	$12^m\ 17^s.4$
t	+ 67° 4′ 55″	+ 68° 38′ 25″
δ	— 7 1 15	— 7 1 10
Circle reading to magnet	4° 13′.0	4° 5′.5
Δ × ½ scale division	— 19.0	— 14.0
Sun's azimuth	96 44.8	95 49.9
Sum	100 38.8	99 41.4
180° + circle reading to sun	84 44.0	83 47.5
Magnetic declination	15 54.8 E.	15 53.9 E.

These observations were made after noon.

Chronometer $0^h\ 9^m\ 46^s.4$ slow of local mean time.

MAGNETIC DECLINATION.

Valparaiso, March 19, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	12° 49′ 15″	(1) Scale erect	$82^d.4$
			(2) Scale inverted	76.2
			(1) — (2) = Δ	+ 6.2
			Transit of Sun's	
	Vernier		1st limb	$3^h\ 20^m\ 49^s$
	Vernier		2d limb	24 14.5
	Mean	290 45 36	Mean	3 22 31.7
Telescope Reversed.	Vernier		1st limb	
	Vernier		2d limb	
	Mean		Mean	
			Reading of Magnet.	
	Vernier		(1) Scale inverted	
			(2) Scale erect	
			(2) — (1) = Δ	

	Telescope Direct.	Telescope Reversed.
Equation of time	$7^m\ 50^s.3$	
t	+ 51° 2′ 55″	
δ	— 0 23 16	
Circle reading to magnet	12° 49′.2	
Δ × ½ scale division	+ 7.3	
Sun's azimuth	113 25.7	
Sum	126 22.2	
180° + circle reading to sun	110 45.6	
Magnetic declination	15 36.6 E.	

These observations were made after noon, and have been corrected for error of collimation.
Chronometer $0^h\ 9^m\ 30^s.3$ slow of local mean time.

MAGNETIC DECLINATION.

Valparaiso, March 29, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	15° 11′ 30″	(1) Scale erect	$80^d.2$
			(2) Scale inverted	78.1
			(1) — (2) = Δ	+ 2.1
			Transit of Sun's	
	Vernier		1st limb	$2^h\ 10^m\ 58^s$
	Vernier		2d limb	13 46
	Mean	311 0 30	Mean	2 12 22.0
Telescope Reversed.	Vernier		1st limb	$2^h\ 16^m\ 13^s$
	Vernier		2d limb	19 0
	Mean	309° 58′ 30″	Mean	2 17 36.5
			Reading of Magnet.	
	Vernier	15 42 30	(1) Scale inverted	$85^d.8$
			(2) Scale erect	72.3
			(2) — (1) = Δ	— 13.5

	Telescope Direct.	Telescope Reversed.
Equation of time	$4^m\ 47^s.3$	$4^m\ 47^s.3$
t	+ 34° 15′ 22″	+ 35° 34′ 0″
δ	+ 3 31 11	+ 3 31 17
Circle reading to magnet . .	15° 11′.5	15° 42′.5
Δ × ½ scale division . . .	+ 2.5	— 15.9
Sun's azimuth	131 44.0	130 23.9
Sum	146 58.0	145 50.5
180° + circle reading to sun	131 0.5	129 58.5
Magnetic declination	15 57.5 E.	15 52.0 E.

These observations were made after noon.
Chronometer $0^h\ 9^m\ 26^s.8$ slow of local mean time.

MAGNETIC DECLINATION.
Valparaiso, April 7, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	20° 11′ 30″	(1) Scale erect	$79^d.4$
			(2) Scale inverted	79.9
			(1) — (2) = Δ	— 0.5
			Transit of Sun's	
	Vernier		1st limb	$8^h\ 16^m\ 21^s$
	Vernier		2d limb	19 35
	Mean	66 36 0	Mean	8 17 58.0
Telescope Reversed.	Vernier		1st limb	$8^h\ 21^m\ 38^s$
	Vernier		2d limb	24 51
	Mean	65° 36′ 0″	Mean	8 23 14.5
			Reading of Magnet.	
	Vernier	20 12 30	(1) Scale inverted	$81^d.8$
			(2) Scale erect	76.5
			(2) — (1) = Δ	— 5.3

	Telescope Direct.	Telescope Reversed.
Equation of time	$2^m\ 9^s.9$	$2^m\ 9^s.8$
t	—53° 42′ 4″	—52° 22′ 55″
δ	+ 6 52 13	+ 6 52 18
Circle reading to magnet	20° 11′.5	20° 12′.5
Δ × ½ scale division	— 0.6	— 6.2
Sun's azimuth	242 16.0	241 17.7
Sum	262 26.9	261 24.0
180° + circle reading to sun	246 36.0	245 36.0
Magnetic declination	15 50.9 E.	15 48.0 E.

These observations were made before noon.

Chronometer $0^h\ 9^m\ 23^s.6$ slow of local mean time.

MAGNETIC DECLINATION.
Valparaiso, April 11, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	20° 45′ 0″	(1) Scale erect	$76^d.5$
			(2) Scale inverted	81.8
			(1) — (2) = Δ	— 5.3
			Transit of Sun's	
	Vernier		1st limb	$2^h\ 28^m\ 53^s$
	Vernier		2d limb	31 42
	Mean	315 7 30	Mean	2 30 17.5
Telescope Reversed.	Vernier		1st limb	$2^h\ 33^m\ 38^s$
	Vernier		2d limb	36 29
	Mean	314° 3′ 30″	Mean	2 35 3.5
			Reading of Magnet.	
	Vernier	20 44 30	(1) Scale inverted	$81^d.8$
			(2) Scale erect	76.6
			(2) — (1) = Δ	— 5.2

	Telescope Direct.	Telescope Reversed.
Equation of time	$0^m\ 59^s.0$	$0^m\ 59^s.0$
t.	+ 39° 40′ 6″	+ 40° 51′ 36″
δ.	+ 8 27 2	+ 8 27 7
Circle reading to magnet	20° 45′.0	20° 44′.5
Δ × ½ scale division	— 6.2	— 6.1
Sun's azimuth	130 26.7	129 22.3
Sum	151 5.5	150 0.7
180° + circle reading to sun	135 7.5	134 3.5
Magnetic declination	15 58.0 E.	15 57.2 E.

These observations were made after noon, and prior to taking them the telescope was adjusted for collimation.

Chronometer $0^h\ 9^m\ 21^s.9$ slow of local mean time.

MAGNETIC DECLINATION.
Valparaiso, April 13, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	20° 37′ 0″	(1) Scale erect	$80^{d}.4$
			(2) Scale inverted	77.9
			(1) — (2) = Δ	+ 2.5
			Transit of Sun's	
	Vernier	315 6 30	1st limb	$2^{h}\ 31^{m}\ 18^{s}$
	Vernier	314 56 0	2d limb	34 58
	Mean	315 1 15	Mean	2 33 8.0
Telescope Reversed.	Vernier		1st limb	
	Vernier		2d limb	
	Mean		Mean	
			Reading of Magnet.	
	Vernier		(1) Scale inverted	
			(2) Scale erect	
			(2) — (1) = Δ	

	Telescope Direct.	Telescope Reversed.
Equation of time	$0^{m}\ 27^{s}.6$	
t	+ 40° 30′ 27″	
δ	+ 9 10 46	
Circle reading to magnet	20° 37′.0	
Δ × ½ scale division	+ 2.9	
Sun's azimuth	130 15.2	
Sum	150 55.1	
180° + circle reading to sun	135 1.2	
Magnetic declination	15 53.9 E.	

These observations were made after noon, through clouds; collimation correct.
Chronometer $0^{h}\ 9^{m}\ 21^{s}.4$ slow of local mean time.

MAGNETIC DECLINATION.
San Lorenzo Island, April 26, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	23° 13′ 30″	(1) Scale erect	$80^{d}.7$
			(2) Scale inverted	77.3
			(1) — (2) = Δ	+ 3.4
			Transit of Sun's	
	Vernier		1st limb	$1^{h}\ 37^{m}\ 26^{s}$
	Vernier		2d limb	40 23
	Mean	331 9 0	Mean	1 38 54.5
Telescope Reversed.	Vernier		1st limb	$1^{h}\ 42^{m}\ 10^{s}$
	Vernier		2d limb	45 11
	Mean	329° 38′ 30″	Mean	1 43 40.5
			Reading of Magnet.	
	Vernier	22 26 0	(1) Scale inverted	$57^{d}.0$
			(2) Scale erect	100.5
			(2) — (1) = Δ	+ 43.5

	Telescope Direct.	Telescope Reversed.
Equation of time	$2^{m}\ 19^{s}.8$	$2^{m}\ 19^{s}.9$
t	+ 22° 30′ 12″	+ 23° 41′ 43″
δ	+ 13 37 9	+ 13 37 12
Circle reading to magnet	23° 13′.5	22° 26′.0
Δ × ½ scale division	+ 4.0	+ 51.1
Sun's azimuth	138 21.1	136 50.9
Sum	161 38.6	160 8.0
180° + circle reading to sun	151 9.0	149 38.5
Magnetic declination	10 29.6 E.	10 29.5 E.

These observations were made after noon.
Chronometer $0^{h}\ 11^{m}\ 13^{s}.5$ fast of local mean time.

MAGNETIC DECLINATION.

Payta, May 7, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	12° 49′ 0″	(1) Scale erect	$79^{d}.6$
			(2) Scale inverted	78.9
			(1) − (2) = Δ	+ 0.7
			Transit of Sun's	
	Vernier	74 35 30	1st limb	7^{h} 35^{m} 58^{s}
	Vernier	75 5 0	2d limb	37 12
	Mean	74 50 15	Mean	7 36 35.0
Telescope Reversed.	Vernier	74° 25′ 30″	1st limb	7^{h} 39^{m} 10^{s}
	Vernier	51 30	2d limb	40 6
	Mean	74 38 30	Mean	7 39 38.0
			Reading of Magnet.	
	Vernier	12 52 30	(1) Scale inverted	$80^{d}.1$
			(2) Scale erect	78.1
			(2) − (1) = Δ	− 2.0

	Telescope Direct.	Telescope Reversed.
Equation of time	3^{m} $37^{s}.9$	3^{m} $37^{s}.9$
t	−71° 37′ 15″	−70° 51′ 30″
δ	+16 50 1	+16 50 3
Circle reading to magnet	12° 49′.0	12° 52′.5
Δ × ½ scale division	+ 0.8	− 2.3
Sun's azimuth	250 51.6	250 43.1
Sum	263 41.4	263 33.3
180° + circle reading to sun	254 50.2	254 38.5
Magnetic declination	8 51.2 E.	8 54.8 E.

These observations were made before noon.
Chronometer 0^{h} 26^{m} $41^{s}.9$ fast of local mean time.

MAGNETIC DECLINATION.

Flamenco Island, Panama Bay, May 14, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	11° 25′ 30″	(1) Scale erect	$78^{d}.4$
			(2) Scale inverted	79.8
			(1) − (2) = Δ	− 1.4
			Transit of Sun's	
	Vernier	79 18 0	1st limb	7^{h} 58^{m} 1^{s}
	Vernier	78 42 0	2d limb	58 54
	Mean	79 0 0	Mean	7 58 27.5
Telescope Reversed.	Vernier	79° 19′ 0″	1st limb	8^{h} 0^{m} 55^{s}
	Vernier	78 43 0	2d limb	1 58
	Mean	79 1 0	Mean	8 1 26.5
			Reading of Magnet.	
	Vernier	11 33 0	(1) Scale inverted	$82^{d}.8$
			(2) Scale erect	75.2
			(2) − (1) = Δ	− 7.6

	Telescope Direct.	Telescope Reversed.
Equation of time	3^{m} $53^{s}.1$	3^{m} $53^{s}.1$
t	−64° 29′ 4″	−63° 44′ 19″
δ	+18 38 56	+18 38 58
Circle reading to magnet	11° 25′.5	11° 33′.0
Δ × ½ scale division	− 1.6	− 8.9
Sun's azimuth	253 32.1	253 32.6
Sum	264 56.0	264 56.7
180° + circle reading to sun	259 0.0	259 1.0
Magnetic declination	5 56.0 E.	5 55.7 E.

These observations were made before noon.
Chronometer 0^{h} 20^{m} $16^{s}.9$ fast of local mean time.

MAGNETIC DECLINATION.

Acapulco, May 30, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	12° 23′ 30″	(1) Scale erect . . . . . . (2) Scale inverted	$78^d.0$ 80.3
			(1) — (2) = Δ	— 2.3
			Transit of Sun's	
	Vernier . . . . . . Vernier	75 25 30 74 55 30	1st limb . . . . . . 2d limb	$8^h\ 14^m\ 28^s$ 15 28
	Mean	75 10 30	Mean	8 14 58.0
Telescope Reversed.	Vernier . . . . . . Vernier	75° 36′ 0″ 6 30	1st limb . . . . . . 2d limb	$8^h\ 17^m\ 29^s$ 18 38
	Mean	75 21 15	Mean	8 18 3.5
			Reading of Magnet.	
	Vernier	12 28 0	(1) Scale inverted . . . . (2) Scale erect	$81^d.3$ 77.2
			(2) — (1) = Δ	— 4.1

	Telescope Direct.	Telescope Reversed.
Equation of time	$2^m\ 47^s.1$	$2^m\ 47^s.1$
t	— 80° 54′ 16″	— 80° 7′ 54″
δ	+ 21 47 18	+ 21 47 19
Circle reading to magnet	12° 23′.5	12° 28′.0
Δ × ½ scale division	— 2.7	— 4.8
Sun's azimuth	251 9.9	251 19.6
Sum	263 30.7	263 42.8
180° + circle reading to sun	255 10.5	255 21.2
Magnetic declination	8 20.2 E.	8 21.6 E.

These observations were made before noon.
Chronometer $1^h\ 41^m\ 22^s.2$ fast of local mean time.
Circle reading to distant referring mark 10° 23′ 0″.

MAGNETIC DECLINATION.

Acapulco, May 30, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	12° 27′ 30″	(1) Scale erect . . . . . . (2) Magnetic axis	$78^d.0$ 79.11
			(1) — (2) = Δ	— 1.11
			Transit of Sun's	
	Vernier . . . . . . Vernier		1st limb . . . . . . 2d limb	
	Mean		Mean	
Telescope Reversed.	Vernier . . . . . . Vernier		1st limb . . . . . . 2d limb	
	Mean		Mean	
			Reading of Magnet.	
	Vernier	12 27 30	(1) Magnetic axis . . . . (2) Scale erect	$79^d.11$ 78.0
			(2) — (1) = Δ	— 1.11

	Telescope Direct.	Telescope Reversed.
Circle reading to magnet	12° 27′.5	12° 27′.5
Δ × 1 scale division	— 2.6	— 2.6
Azimuth of mark.	186 22.4	186 21.4
Sum	198 47.3	198 46.3
180° + circle reading to mark . . .	190 23.0	190 23.0
Magnetic declination	8 24.3 E.	8 23.3 E.

These observations were made at $9^h\ 19^m$ A.M., local mean time.

MAGNETIC DECLINATION.
Magdalena Bay, June 9, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	13° 4′ 0″	(1) Scale erect . . . . . . (2) Magnetic axis	$78^d.10$ 79.11
			(1) — (2) = Δ	— 1.01
			Transit of Sun's	
	Vernier . . . . . . Vernier	278 39 0 277 50 0	1st limb . . . . . . 2d limb	$5^h\ 9^m\ 10^s$ 10 18
	Mean	278 14 30	Mean	5 9 44.0
Telescope Reversed.	Vernier . . . . . . Vernier		1st limb . . . . . . 2d limb	
	Mean		Mean	
			Reading of Magnet.	
	Vernier		(1) Scale inverted . . . . (2) Scale erect	
			(2) — (1) = Δ	

	Telescope Direct.	Telescope Reversed.
Equation of time	$1^m\ 3^s.0$	
t	+ 40° 10′ 39″	
δ	+ 22 58 41	
Circle reading to magnet	13° 4′.0	
Δ × 1 scale division	— 2.4	
Sun's azimuth	95 53.4	
Sum	108 55.0	
180° + circle reading to sun	98 14.5	
Magnetic declination	10 40.5 E.	

These observations were made after noon. Collimation error zero.
Chronometer $2^h\ 30^m\ 4^s.4$ fast of local mean time.

MAGNETIC DECLINATION.
San Diego Bay, June 15, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	16° 9′ 30″	(1) Scale erect . . . . . . (2) Scale inverted	$79^d.4$ 78.7
			(1) — (2) = Δ	+ 0.7
			Transit of Sun's	
	Vernier . . . . . . Vernier	277 48 30 278 52 30	1st limb . . . . . . 2d limb	$6^h\ 42^m\ 20^s$ 45 36
	Mean	278 20 30	Mean	6 43 58.0
Telescope Reversed.	Vernier . . . . . . Vernier	279° 2′ 0″ 278 28 30	1st limb . . . . . . 2d limb	$6^h\ 46^m\ 45^s$ 47 43
	Mean	278 45 15	Mean	6 47 14.0
			Reading of Magnet.	
	Vernier	16 33 30	(1) Scale inverted . . . . (2) Scale erect	$88^d.2$ 69.7
			(2) — (1) = Δ	— 18.5

	Telescope Direct.	Telescope Reversed.
Equation of time	$0^m\ 12^s.0$	$0^m\ 12^s.1$
t	+ 58° 18′ 22″	+ 59° 7′ 21″
δ	+ 23 20 30	+ 23 20 31
Circle reading to magnet	16° 9′.5	16° 33′.5
Δ × ½ scale division	+ 0.8	— 21.7
Sun's azimuth	95 19.5	95 43.0
Sum	111 29.8	111 54.8
180° + circle reading to sun . . .	98 20.5	98 45.2
Magnetic declination	13 9.3 E.	13 9.6 E.

These observations were made after noon.
Chronometer $2^h\ 50^m\ 32^s.5$ fast of local mean time.

MAGNETIC DECLINATION.

San Francisco Bay, June 26, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	20° 9′ 30″	(1) Scale erect (2) Scale inverted	$79^d.3$ 78.8
			(1) — (2) = Δ	+ 0.5
			Transit of Sun's	
	Vernier Vernier	88 40 0 12 30	1st limb 2d limb	$3^h\ 54^m\ 2^s$ 55 18
	Mean	88 26 15	Mean	3 54 40.0
Telescope Reversed.	Vernier Vernier	88° 58′ 0″ 28 0	1st limb 2d limb	$3^h\ 57^m\ 12^s$ 58 9
	Mean	88 43 0	Mean	3 57 40.5
			Reading of Magnet.	
	Vernier	20 28 30	(1) Scale inverted (2) Scale erect	$89^d.6$ 68.1
			(2) — (1) = Δ	—21.5

	Telescope Direct.	Telescope Reversed.
Equation of time	$2^m\ 29^s.4$	$2^m\ 29^s.4$
t	—65° 14′ 24″	—64° 29′ 17″
δ	+ 23 22 9	+ 23 22 9
Circle reading to magnet	20° 9′.5	20° 28′.5
Δ × ½ scale division	+ 0.6	— 25.3
Sun's azimuth	264 40.7	265 6.2
Sum	284 50.8	285 9.4
180° + circle reading to sun	268 26.2	268 43.0
Magnetic declination	16 24.6 E.	16 26.4 E.

These observations were made before noon.
Chronometer $8^h\ 13^m\ 8^s.2$ fast of local mean time.

MAGNETIC DECLINATION.

U. S. Naval Observatory, Washington, November 1, 1866.

	Circle Readings.		Reading of Magnet.	
Telescope Direct.	Vernier	0° 25′ 0″	(1) Scale erect (2) Scale inverted	$87^d.5$ 70.5
			(1) — (2) = Δ	+ 17.0
			Transit of Sun's	
	Vernier Vernier		1st limb 2d limb	$7^h\ 9^m\ 6^s.5$ 11 42.2
	Mean	222 51 0	Mean	7 10 24.4
Telescope Reversed.	Vernier Vernier		1st limb 2d limb	$7^h\ 16^m\ 7^s.5$ 18 44.0
	Mean	224° 30′ 0″	Mean	7 17 25.8
			Reading of Magnet.	
	Vernier	0 43 30	(1) Scale inverted (2) Scale erect	$78^d.0$ 79.9
			(2) — (1) = Δ	+ 1.9

	Telescope Direct.	Telescope Reversed.
Equation of time	$16^m\ 18^s.5$	$16^m\ 18^s.5$
t	+35° 43′ 47″	+ 37° 29′ 8″
δ	— 14 32 51	— 14 32 55
Circle reading to magnet	0° 25′.0	0° 43′.5
Δ × ½ scale division	+ 20.0	+ 2.2
Sun's azimuth	39 22.2	40 59.7
Sum	40 7.2	41 45.4
180° + circle reading to sun	42 51.0	44 30.0
Magnetic declination	2 43.8 W.	2 44.6 W.

These observations were made after noon, and the readings of the magnet scale were taken two hours before the transits of the sun.
Chronometer $5^h\ 3^m\ 47^s.8$ fast of local mean time.

OBSERVATIONS OF MAGNETIC INCLINATION.

Magnetic Dip.
Gosport, October 30, 1865. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
70° 39′	70° 22′	71° 3′	70° 44′	109° 58′	109° 55′	109° 25′	109° 46′
70 49	70 30	71 4	70 44	110 10	110 25	109 19	109 37
70 45	70 27	71 5	70 47	110 15	110 30	109 33	109 50
70 44	70 26	71 4	70 45	110 8	110 17	109 26	109 44
70 35		70 55		110 12		109 35	
70 45				109 54			
70 25							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
111° 52′	112° 4′	112° 13′	112° 29′	68° 49′	68° 24′	68° 45′	68° 26′
111 55	112 8	112 9	112 26	68 47	68 27	68 30	68 13
112 2	112 17	112 9	112 25	68 37	68 17	68 41	68 20
111 56	112 10	112 10	112 27	68 44	68 23	68 39	68 20
112 3		112 18		68 34		68 30	
112 10				68 32			
68 11							

Resulting Dip: + 69° 21′

Magnetic Dip.
Gosport, October 30, 1865. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
71° 47′	71° 41′	70° 4′	69° 48′	109° 17′	109° 41′	111° 8′	111° 30′
72 5	71 51	70 6	69 52	109 13	109 34	111 8	111 24
71 59	71 46	70 14	69 60	109 0	109 21	110 59	111 18
71 57	71 46	70 8	69 56	109 10	109 32	111 5	111 24
71 51		70 2		109 21		111 15	
70 56				110 18			
70 19							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
110° 29′	110° 40′	110° 39′	110° 59′	69° 57′	69° 37′	70° 0′	69° 37′
110 33	110 54	110 57	111 12	69 41	69 20	70 7	69 42
110 41	110 23	110 54	111 11	69 40	69 18	70 10	69 45
110 34	110 39	110 50	111 7	69 46	69 25	70 6	69 41
110 36		110 58		69 36		69 54	
110 47				69 45			
69 29							

Resulting Dip: + 69° 54′

NOTE.—It will be observed that at some stations only one end of the needle was read. In such cases the other end of the needle was hidden by the cross-bar which supports the agate planes.

MAGNETIC DIP.

St. Thomas, November 13, 1865, Needle A. 2.

POLARITY OF MARKED END NORTH.							
CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
53° 37′ 53 55 53 55	53° 18′ 53 35 53 35	52° 54′ 53 0 53 5	52° 30′ 52 34 52 35	127° 23′ 127 30 127 26	127° 37′ 127 43 127 40	128° 17′ 128 15 128 8	128° 36′ 128 35 128 31
53 49	53 29	53 0	52 33	127 26	127 40	128 13	128 34
53 39		52 46		127 33		128 24	
53 12				127 58			
52 37							

POLARITY OF MARKED END SOUTH.							
CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
127° 11′ 127 13 127 16	127° 30′ 127 32 127 33	127° 59′ 127 61 127 54	128° 17′ 128 18 128 12	53° 24′ 53 35 53 26	53° 13′ 53 15 53 7	52° 35′ 52 39 52 30	52° 8′ 52 11 52 4
127 13	127 32	127 58	128 16	53 28	53 12	52 35	52 8
127 23		128 7		53 20		52 22	
127 45				52 51			
52 33							

Resulting Dip: + 49° 32′

Azimuth of Dip Circle 26° 16′

MAGNETIC DIP.

St. Thomas, November 13, 1865, Needle A. 1.

POLARITY OF MARKED END SOUTH.							
CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
50° 2′ 50 35 50 50	49° 44′ 50 15 50 24	50° 12′ 50 15 50 16	49° 52′ 49 45 49 53	130° 11′ 130 15 130 11	130° 30′ 130 30 130 24	130° 12′ 130 6 130 11	130° 28′ 130 24 130 26
50 29	50 8	50 14	49 50	130 12	130 28	130 10	130 26
50 18		50 2		130 20		130 18	
50 10				130 19			
49 55							

POLARITY OF MARKED END NORTH.							
CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
124° 41′ 124 22 124 35	125° 0′ 124 37 124 52	125° 36′ 125 38 125 37	125° 50′ 125 51 125 56	55° 31′ 55 49 56 0	55° 11′ 55 24 55 28	55° 28′ 55 21 55 20	55° 25′ 54 50 54 54
124 33	124 50	125 37	125 52	55 47	55 21	55 23	55 3
124 42		125 45		55 34		55 13	
125 14				55 24			
55 5							

Resulting Dip: + 49° 36′

Azimuth of Dip Circle 26° 16′

Magnetic Dip.

St. Thomas, November 13, 1865. Needle A. 2.

POLARITY OF MARKED END SOUTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
49° 42′ 49 44 40 53	49° 21′ 49 20 49 25	50° 10′ 51 5 50 47	49° 55′ 50 42 50 19	130° 50′ 130 40 130 46	131° 15′ 131 3 131 11	130° 56′ 130 37 130 41	130° 47′ 130 57 130 66
49 46	49 22	50 40	50 18	130 45	131 10	130 45	130 57
49 34		50 29		130 57		130 51	
50 1				130 54			
49 34							

POLARITY OF MARKED END NORTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
	N.	S.	N.	S.	N.	S.	N.
129° 32′ 129 47 129 55	129° 59′ 130 11 130 20	130° 4′ 130 22 130 8	130° 30′ 130 47 130 35	49° 4′ 49 25 49 20	49° 1′ 49 30 49 28	50° 26′ 50 36 50 31	50° 29′ 50 45 50 32
129 45	130 10	130 11	130 37	49 16	49 20	50 31	50 35
129 58		130 24		49 18		50 33	
130 11				49 56			
49 53							

Resulting Dip: + 49° 44′

Magnetic Dip.

St. Thomas, November 16, 1865. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
52° 16′ 52 26 52 40	51° 57′ 52 3 52 8	53° 0′ 53 9 53 7	52° 40′ 52 47 52 45	128° 36′ 128 28 128 30	128° 54′ 128 44 128 42	127° 44′ 127 45 127 52	128° 5′ 128 1 128 7
52 27	52 3	53 5	52 44	128 31	128 47	127 47	128 4
52 15		52 55		128 39		127 55	
52 35				128 17			
52 9							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
133° 43′ 133 47 133 36	134° 0′ 134 0 133 50	133° 12′ 133 16 133 24	133° 28′ 133 31 133 43	47° 34′ 47 28 47 21	47° 14′ 46 51 46 53	47° 50′ 47 38 47 34	47° 30′ 47 20 47 8
133 42	133 57	133 17	133 34	47 28	46 59	47 41	47 19
133 50		133 25		47 14		47 30	
133 37				47 22			
46 52							

Resulting Dip: + 49° 39′

MAGNETIC DIP.

Salute Islands, November 28, 1865. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
35° 28′	35° 5′	34° 37′	34° 10′	145° 17′	145° 35′	145° 15′	145° 48′
35 59	35 38	34 45	34 15	145 5	145 28	145 12	145 44
35 45	35 16	34 30	33 53	145 17	145 16	145 45	146 18
35 44	35 20	34 37	34 6	145 13	145 26	145 24	145 57
35 32		34 22		145 20		145 40	
34 57				145 30			
34 44							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
145° 28′	145° 45′	145° 25′	145° 45′	35° 45′	35° 15′	35° 15′	34° 44′
145 35	145 58	145 24	145 55	35 40	35 12	34 45	34 21
145 40	146 6	145 25	145 55	35 41	35 15	34 40	34 9
145 34	145 56	145 25	145 52	35 42	35 14	34 53	34 25
145 45		145 39		35 28		34 39	
145 42				35 3			
34 40							

Resulting Dip: + 34° 42′

MAGNETIC DIP.

Salute Islands, Nov. 28, 1865. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
38° 57′	38° 35′	38° 50′	38° 15′	142° 5′	142° 23′	141° 40′	142° 2′
39 0	38 25	39 25	38 50	142 26	142 45	141 31	141 53
38 58	38 14	39 16	38 50	142 7	142 26	141 30	141 53
38 58	38 25	39 10	38 38	142 13	142 31	141 34	141 56
38 42		38 54		142 22		141 45	
38 48				142 4			
38 22							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
150° 55′		149° 0′	149° 23′	30° 6′	29° 39′	31° 5′	30° 34′
150 50		149 12	149 33	30 0	29 34	31 10	30 39
150 45		149 18	149 37	30 10	29 45	31 29	30 55
150 50	(151 22)	149 10	149 31	30 5	29 39	31 15	30 43
151 4		149 20		29 52		30 59	
150 12				30 25			
30 7							

Resulting Dip: + 34° 27′

Magnetic Dip.

Ceara, December 13, 1865. Needle A. 2.

POLARITY OF MARKED END SOUTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N	S.	N	S.	N.	S.	N.
20° 30′ 20 17 20 30		21° 30′ 21 2 21 15		159° 56′ 160 37 160 30		156° 35′ 157 0 157 0	
20 26		21 16		160 21		156 52	
20 51				158 36			
21 7							

POLARITY OF MARKED END NORTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
159° 4′ 158 45 158 40		160° 20′ 160 5 159 23		22° 55′ 22 32 22 28		22° 20′ 22 8 22 26	
158 50		159 56		22° 38′		22 18	
159 23				22 28			
21 33							

Resulting Dip: + 21° 20′

Magnetic Dip.

Ceara, December 13, 1865. Needle A. 1.

POLARITY OF MARKED END SOUTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
17° 30′ 17 31 17 45		16° 5′ 15 52 15 52		163° 20′ 163 20 163 6		166° 50′ 165 30 166 0	
17 35		15 56		163 15		166 7	
16 45				164 41			
16 2							

POLARITY OF MARKED END NORTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
154° 0′ 154 18 154 5		153° 55′ 154 20 154 40		27° 10′ 27 10 27 0		27° 10′ 27 0 27 20	
154 8		154 18		27 7		27 10	
154 13				27 9			
26 28							

Resulting Dip: + 21° 26′

MAGNETIC DIP.

Pernambuco, Dec. 23, 1865. Needle A. 2.

POLARITY OF MARKED END NORTH.							
CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N	S.	N.
12° 20′		12° 30′		169° 45′		167° 5′	
12 15		12 10		170 10		167 10	
12 35		12 10		170 40		167 5	
12 23		12 17		170 12		167 7	
12 20				168 40			
		11 50					

POLARITY OF MARKED END SOUTH.							
CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
168° 30′		168° 10′		14° 45′		12° 5′	
168 25		168 30		14 30		12 30	
169 20		167 35		14 20		12 25	
168 45		168 5		14 32		12 20	
168 25				13 26			
		12 30					

Resulting Dip: + 12° 10′

MAGNETIC DIP.

Pernambuco, Dec. 23, 1865. Needle A. 1.

POLARITY OF MARKED END NORTH.							
CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
18° 30′		18° 0′		162° 10′		163° 5′	
18 35		18 0		162 40		163 20	
18 55		18 0		162 40		162 30	
18 40		18 0		162 30		162 58	
18 20				162 44			
		17 48					

POLARITY OF MARKED END SOUTH.							
CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
174° 20′		173° 35′		5° 30′		7° 25′	
175 20		173 30		5 30		7 40	
175 30		173 50		5 50		7 40	
175 3		173 38		5 37		7 35	
174 20				6 36			
		6 8					

Resulting Dip: + 12° 6′

Magnetic Dip.

Bahia, December 27, 1865. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
3° 35′ 3 45 3 30	3° 15′ 3 30 3 35	4° 40′ 5 10 5 50	4° 15′ 4 45 5 20	176° 30′ 176 45 176 45	176° 30′ 176 40 176 40	176° 10′ 176 5 176 45	176° 10′ 176 5 175 50
3 37	3 27	5 13	4 47	176 40	176 37	176 20	176 2
3 32		5 0		176 38		176 11	
4 16				176 24			
3 56							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
174° 45′ 174 45 174 40	174° 50′ 174 40 174 50	176° 30′ 177 15 176 0	176° 30′ 177 15 176 0	4° 30′ 5 5 5 0	4° 10′ 4 45 4 40	5° 25′ 5 30 5 30	5° 0′ 5 5 5 0
174 43	174 47	176 35	176 35	4 52	4 32	5 28	5 2
174 45		176 35		4 42		5 15	
175 40				4 58			
4 39							

Resulting Dip: + 4° 17′

Magnetic Dip.

Bahia, December 27, 1865. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
11° 30′ 11 30 12 0		11° 30′ 11 10 11 10		168° 55′ 169 10 169 10		170° 20′ 169 55 170 25	
11 40		11 17		169 5		170 13	
11 28				169 39			
10 54							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
3° 15′ 3 35 3 5		1° 50′ 1 55 1 55		177° 25′ 178 20 178 5		179° 20′ 179 10 179 10	
3 18		1 53		177 57		179 13	
—2 35				—178 35			
—2 0							

Resulting Dip: + 4° 31′

MAGNETIC DIP.

Rio Janeiro, January 6, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	167° 0′		168° 30′		11° 20′		11° 35′
	166 45		169 0		12 30		11 35
	167 10		169 15		12 30		11 30
	166 58		168 55		12 7		11 33
	167 56				11 50		
			11 57				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	10° 15′		12° 5′		168° 55′		167° 45′
	11 15		12 30		169 0		168 5
	11 35		12 50		169 35		168 10
	11 2		12 28		169 10		168 0
	11 45				168 35		
			11 35				

Resulting Dip: —11° 46′

MAGNETIC DIP.

Rio Janeiro, January 6, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	175° 15′		174° 20′		4° 50′		7° 10′
	175 50		174 15		5 35		7 0
	175 45		174 0		5 0		6 35
	175 37		174 12		5 8		6 55
	174 55				6 2		
			5 34				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	18° 5′		18° 10′		162° 10′		162° 55′
	18 15		18 5		162 15		163 15
	18 25		18 15		161 45		163 35
	18 15		18 10		162 3		163 15
	18 12				162 39		
			17 46				

Resulting Dip: —11° 48′

Magnetic Dip.

Monte Video, January 18, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	155° 15′ 155 10 155 15		153° 30′ 153 40 153 20		25° 40′ 25 10 25 40		26° 20′ 27 0 26 40
	155 13		153 30		25 30		26 40
154 22				26 5			
25 52							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	36° 0′ 36 10 36 10		36° 20′ 36 20 36 30		144° 20′ 144 20 144 20		144° 10′ 144 20 144 30
	36 7		36 23		144 20		144 20
36 15				144 20			
35 57							

Resulting Dip: —31° 11′

Magnetic Dip.

Monte Video, January 18, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	149° 10′ 148 50 149 20		149° 20′ 149 30 150 10		32° 10′ 31 20 32 0		31° 0′ 31 0 31 20
	149 7		149 40		31 50		31 7
149 23				31 29			
31 3							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	31° 40′ 32 10 31 40		30° 50′ 31 0 30 50		149° 30′ 149 10 149 50		149° 40′ 150 0 149 20
	31 50		30 53		149 30		149 40
31 22				149 35			
30 54							

Resulting Dip: —30° 58′

Magnetic Dip.

Monte Video, January 18, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	148° 50′ 149 0 149 30		149° 20′ 148 50 149 0		31° 0′ 31 10 31 20		31° 0′ 31 40 31 40
	149 7		149 3		31 10		31 27
149 5				31 19			
31 7							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	32° 0′ 32 0 31 50		31° 0′ 31 20 31 40		149° 10′ 149 10 149 20		149° 10′ 149 30 149 50
	31 57		31 20		149 13		149 30
31 39				149 22			
31 8							

Resulting Dip: —31° 8′

MAGNETIC DIP.

Sandy Point, February 7, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
128° 10′	128° 0′	128° 15′	128° 10′	52° 35′	52° 30′	52° 45′	52° 45′
128 0	127 45	127 30	127 15	52 45	52 40	52 45	52 50
128 10	128 0	128 20	128 10	52 45	52 40	52 55	52 45
128 7	127 55	128 2	127 52	52 42	52 37	52 48	52 47
128 1		127 57		52 40		52 48	
127 59				52 44			
52 22							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
57° 5′	57° 0′	57° 40′	57° 35′	123° 10′	123° 15′	123° 0′	122° 55′
57 15	57 5	57 40	57 35	123 20	123 10	123 10	123 0
57 15	57 5	57 45	57 40	123 45	123 20	123 10	123 0
57 12	57 3	57 42	57 37	123 25	123 15	123 7	122 58
57 7		57 40		123 20		123 3	
57 24				123 12			
57 6							

Resulting Dip: —54° 52′

MAGNETIC DIP.

Sandy Point, February 7, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West	
S.	N.	S.	N.	S.	N.	S.	N.
124° 45′	124° 45′	126° 30′	126° 10′	55° 30′	56° 0′	55° 0′	54° 50′
124 55	124 45	125 45	125 30	55 10	55 5	54 45	55 10
125 15	124 45	125 45	125 40	55 30	56 0	55 0	54 0
124 58	124 45	126 0	125 47	55 23	55 42	54 55	54 40
124 52		125 53		55 33		54 47	
125 22				55 10			
54 54							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
56° 15′	56° 10′	54° 35′	54° 30′	124° 35′	125° 0′	126° 0′	125° 30′
56 15	56 45	54 25	54 40	124 40	124 30	126 15	125 35
56 20	56 15	54 35	54 45	123 55	123 45	125 50	125 45
56 17	56 23	54 32	54 38	124 23	124 25	126 2	125 37
56 20		54 35		124 24		125 50	
55 27				125 7			
55 10							

Resulting Dip: —55° 2′

MAGNETIC DIP.

Valparaiso, March 2, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	150° 45′ 150 40 150 45		148° 30′ 149 15 149 10		30° 45′ 30 30 29 55		31° 15′ 31 10 31 35
	150 43		148 58		30 23		31 20
	149 50				30 52		
			30 31				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	38° 30′ 38 45 38 50		39° 15′ 39 0 39 30		141° 35′ 142 20 140 55		141° 5′ 141 45 141 15
	38 42		39 15		141 37		141 22
	38 58				141 30		
			38 44				

Resulting Dip: —34° 50′

MAGNETIC DIP.

Valparaiso, March 2, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	145° 15′ 145 25 145 15		145° 30′ 144 40 145 15		35° 20′ 35 35 35 40		35° 0′ 35 0 34 45
	145 18		145 8		35 32		34 55
	145 13				35 14		
			35 0				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	36° 10′ 35 45 36 5		34° 50′ 34 50 35 5		145° 0′ 145 0 144 20		145° 15′ 145 10 145 0
	36 0		34 55		144 47		145 8
	35 27				144 58		
			35 14				

Resulting Dip: —35° 7′

MAGNETIC DIP.

Valparaiso, March 19, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	144° 50′ 145 0 144. 55		144° 15′ 144 30 144 20		35° 50′ 36 40 36 15		34° 45′ 35 5 35 30
	144 55		144 22		36 15		35 7
	144 39				35 41		
			35 31				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	37° 0′ 37 10 37 20		34° 45′ 34 40 34 20		145° 10′ 144 45 144 30		145° 15′ 145 20 145 10
	37 10		34 35		144 48		145 15
	35 52				145 1		
			35 25				

Resulting Dip: —35° 28′

MAGNETIC DIP.

Valparaiso, March 19, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	149° 50′ 150 10 149 45		148° 50′ 148 30 148 20		30° 15′ 30 30 30 30		31° 30′ 31 50 31 20
	149 55		148 33		30 25		31 33
	149 14				30 59		
			30 52				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	39° 20′ 39 50 39 30		40° 5′ 40 15 40 20		140° 55′ 141 10 140 55		140° 0′ 140 30 140 45
	39 33		40 13		141 0		140 25
	39 53				140 43		
			39 35				

Resulting Dip: —35° 28′

MAGNETIC DIP.

Valparaiso, March 29, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	146° 10′		145° 15′		35° 45′		35° 20′
	145 10		145 30		35 40		35 30
	144 50		145 15		35 50		35 30
	145 23		145 20		35 45		35 27
	145 22				35 36		
			35 7				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	36° 40′		35° 30′		144° 15′		144° 40′
	36 40		35 45		145 0		145 15
	37 20		35 45		144 20		145 0
	36 53		35 40		144 32		144 58
	36 17				144 45		
			35 46				

Resulting Dip: —35° 27′

MAGNETIC DIP.

Valparaiso, March 29, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	149° 30′		149° 15′		30° 10′		31° 45′
	150 0		148 40		30 20		31 50
	150 15		148 40		30 40		31 40
	149 55		148 52		30 23		31 45
	149 24				31 4		
			30 50				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	40° 40′		40° 20′		140° 40′		140° 15′
	40 15		40 20		141 10		140 40
	40 10		40 20		141 10		140 30
	40 22		40 20		141 0		140 28
	40 21				140 44		
			39 48				

Resulting Dip: —35° 34′

MAGNETIC DIP.

Valparaiso, April 7, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	144° 30′		144° 30′		36° 40′		35° 10′
	145 0		145 30		36 15		35 10
	144 30		145 10		35 40		34 40
	144 40		145 3		36 12		35 0
	144 51				35 36		
			35 22				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	36° 20′		34° 40′		145° 15′		145° 40′
	36 15		35 0		144 15		144 45
	36 40		35 0		144 0		145 15
	36 25		34 53		144 30		145 13
	35 39				144 52		
			35 24				

Resulting Dip: —35° 23′

MAGNETIC DIP.

Valparaiso, April 7, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	150° 30′		149° 20′		30° 20′		32° 0′
	150 40		149 15		30 25		32 15
	150 0		149 0		31 30		32 10
	150 23		149 12		30 45		32 8
	149 47				31 27		
			30 50				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	39° 50′		40° 15′		140° 40′		140° 20′
	39 30		40 15		141 45		140 30
	39 40		40 0		141 0		140 30
	39 40		40 10		141 8		140 27
	39 55				140 47		
			39 34				

Resulting Dip: —35° 26′

Magnetic Dip.

Valparaiso, April 11, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	144° 20′ 144 40 144 50		145° 20′ 145 0 144 50		36° 10′ 36 0 35 45		35° 40′ 35 40 35 40
	144 37		145 3		35 58		35 40
	144 50				35 49		
			35 30				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	36° 50′ 36 50 36 50		35° 20′ 36 0 35 10		144° 20′ 144 30 144 35		145° 10′ 145 10 145 0
	36 50		35 30		144 28		145 7
	36 10				144 47		
			35 42				

Resulting Dip: —35° 36′

Magnetic Dip.

Valparaiso, April 11, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	149° 40′ 150 0 150 20		150° 10′ 148 50 149 0		30° 40′ 30 20 30 10		31° 50′ 31 40 31 40
	150 0		149 20		30 23		31 43
	149 40				31 3		
			30 42				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	39° 30′ 39 30 39 40		41° 20′ 40 25 40 0		140° 50′ 141 10 140 40		140° 30′ 140 10 140 10
	39 33		40 35		140 53		140 17
	40 4				140 35		
			39 45				

Resulting Dip: —35° 29′

MAGNETIC DIP.

Valparaiso, April 13, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	145° 45′		145° 20′		35° 0′		35° 20′
	145 45		145 0		35 20		35 30
	145 45		145 0		35 30		35 20
	145 45		145 7		35 17		35 23
145 26				35 20			
34 57							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	36° 10′		34° 50′		144° 30′		144° 30′
	36 0		34 50		144 30		144 30
	36 0		34 50		144 50		144 30
	36 3		34 50		144 37		144 30
35 26				144 34			
35 26							

Resulting Dip: —35° 12′

MAGNETIC DIP.

Valparaiso, April 13, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	150° 15′		148° 50′		30° 15′		31° 50′
	150 10		148 50				
	150 10		148 50				
	150 12		148 50				
149 31				31 2			
30 46							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	40° 5′		40° 30′		140° 40′		139° 50′
40 18				140 15			
40 2							

Resulting Dip: —35° 40′

MAGNETIC DIP.

San Lorenzo Island, April 26, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	172° 20′		175° 35′		8° 10′		6° 20′
	173 57				7 15		
			6 39				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	6° 15′		7° 40′		175° 10′		173° 30′
	6 58				174 20		
			6 19				

Resulting Dip: —6° 29′

MAGNETIC DIP.

San Lorenzo Island, April 26, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	0° 0′		+1° 15′		0° 35′		1° 50′
	+0 37				—1 13		
			—0 18				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
	13° 10′		12° 40′		167° 30′		168° 20
	12 55				167 55		
			—12 30				

Resulting Dip: —6° 28′

MAGNETIC DIP.

Payta, May 7, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.							
CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
	4° 30′		4° 20′		176° 45′		175° 0′
4 25				175 52			
4 17							
POLARITY OF MARKED END SOUTH.							
CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S,	N.	S.	N.	S.	N.	S.	N.
	174° 0′		175° 35′		6° 5′		4° 40′
174 48				5 22			
5 17							

Resulting Dip: + 4° 47′

MAGNETIC DIP.

Payta, May 7, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.							
CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
11° 15′		10° 30′		169° 45′		169° 50′	
10 52				169 48			
+10 32							
POLARITY OF MARKED END SOUTH.							
CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
1° 10′		0° 10′		179° 20′		0° 45′	
—0 40				+0 2			
—0 19							

Resulting Dip: + 5° 9′

Magnetic Dip.

Flamenco Island, Panama Bay, May 14, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
32° 40′	32° 10′	31° 35′	31° 0′	148° 50′	148° 40′	148° 15′	148° 10′
32 25		31 18		148 45		148 12	
31 52				148 28			
31 42							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
148° 45′	148° 40′	148° 30′	148° 20′	32° 45′	32° 10′	32° 30′	32° 0′
148 42		148 25		32 28		32 15	
148 34				32 22			
31 54							

Resulting Dip: + 31° 48′

Magnetic Dip.

Flamenco Island, Panama Bay, May 14, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
36° 20′		36° 40′		144° 25′		144° 25′	
36 30				144 25			
36 2							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
153° 15′		152° 10′		27° 40′		28° 50′	
152 43				28 15			
27 46							

Resulting Dip: + 32° 5′

MAGNETIC DIP.

Acapulco, May 30, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
41° 15′	40° 45′	40° 10′	39° 30′	139° 40′	139° 45′	140° 10′	140° 10′
41 0		39 50		139 42		140 10	
40 25				139 56			
40 15							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
139° 50′	139° 45′	140° 35′	140° 20′	40° 20′	39° 50′	39° 0′	38° 40′
139 47		140 28		40 5		38 50	
140 7				39 28			
39 40							

Resulting Dip: + 39° 58′

MAGNETIC DIP.

Acapulco, May 30, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
43° 10′	42° 40′	43° 40′	43° 15′	137° 40′	137° 35′	137° 30′	137° 20′
42 55		43 28		137 37		137 25	
43 12				137 31			
42 50							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
144° 15′	144° 10′	143° 20′	143° 15′	36° 45′	36° 15′	37° 20′	36° 50′
144 12		143 18		36 30		37 5	
143 45				36 47			
36 31							

Resulting Dip: + 39° 49′

MAGNETIC DIP.

Magdalena Bay, June 9, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
50° 30′	50° 0′	49° 0′	48° 30′	130° 40′	130° 45′	132° 15′	132° 15′
50 15		48 45		130 42		132 15	
49 30				131 29			
49 0							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East	
S.	N.	S.	N.	S.	N.	S.	N.
131° 0′	131° 0′	132° 0′	132° 10′	45° 30′	45° 0′	48° 50′	48° 30′
131 0		132 5		45 15		48 40	
131 32				46 58			
47 43							

Resulting Dip: + 48° 22′

MAGNETIC DIP.

Magdalena Bay, June 9, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
51° 40′	51° 10′	52° 15′	51° 45′	129° 15′	129° 10′	128° 45′	128° 45′
51 25		52 0		129 12		128 45	
51 43				128 58			
51 23							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
135° 0′	134° 50′	134° 30′	134° 30′	46° 0′	45° 40′	46° 30′	46° 0′
134 55		134 30		45 50		46 15	
134 43				46 2			
45 39							

Resulting Dip: + 48° 41′

MAGNETIC DIP.

San Diego Bay, June 15, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.							
CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
59° 25′	59° 0′	58° 15′	57° 45′	122° 0′	121° 55′	122° 40′	122° 40′
59 12		58 0		121 57		122 40	
58 36				122 18			
58 9							

POLARITY OF MARKED END SOUTH.							
CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
122° 30′	122° 20′	123° 0′	123° 0′	58° 30′	58° 10′	58° 15′	57° 40′
122 25		123 0		58 20		57 57	
122 42				58 8			
57 43							

Resulting Dip: + 57° 56′

MAGNETIC DIP.

San Diego Bay, June 15, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.							
CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
60° 10′	59° 45′	60° 30′	60° 0′	121° 0′	120° 45′	120° 20′	120° 0′
59 58		60 15		120 52		120 20	
60 6				120 36			
59 45							

POLARITY OF MARKED END SOUTH.							
CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
124° 50′	124° 45′	124° 30′	124° 30′	56° 20′	55° 50′	56° 20′	56° 0′
124 47		124 30		56 5		56 10	
124 38				56 7			
55 44							

Resulting Dip: + 57° 51′

Magnetic Dip.

San Francisco Bay, June 26, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
63° 30′	63° 10′	62° 50′	62° 20′	117° 20′	117° 10′	117° 40′	117° 30′
63 20		62 35		117 15		117 35	
62 57				117 25			
62 46							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
118° 20′	118° 20′	117° 50′	117° 30′	62° 30′	62° 0′	63° 0′	62° 40′
118 20		117 40		62 15		62 50	
118 0				62 32			
62 16							

Resulting Dip: + 62° 31′

Magnetic Dip.

San Francisco Bay, June 26, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
63° 0′	63° 40′	64° 40′	64° 15′	116° 40′	116° 30′	116° 20′	116° 10′
63 20		64 27		116 35		116 15	
63 54				116 25			
63 45							

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
120° 0′	119° 45′	120° 0′	120° 0′	61° 10′	60° 45′	61° 10′	60° 40′
119 52		120 0		60 57		60 55	
119 56				60 56			
60 30							

Resulting Dip: + 62° 13′

MAGNETIC DIP.

U. S. Naval Observatory, Washington, Nov. 1, 1866. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
72° 45′	72° 45′	73° 15′	73° 5′	107° 45′	107° 30′	107° 25′	107° 0′
72 45		73 10		107 37		107 13	
	72 57				107 25		
			72 46				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
109° 25′	109° 0′	109° 45′	109° 20′	71° 20′	71° 0′	71° 5′	70° 45′
109 12		109 33		71 10		70 55	
	109 23				71 2		
			70 50				

Resulting Dip: + 71° 51′

MAGNETIC DIP.

U. S. Naval Observatory, Washington, Nov. 1, 1866. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
73° 30′	73° 15′	71° 30′	71° 15′	107° 20′	107° 0′	108° 5′	107° 45′
73 22		71 23		107 10		107 55	
	72 22				107 33		
			72 24				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
107° 35′	107° 5′	108° 50′	108° 40′	72° 25′	72° 20′	72° 0′	71° 45′
107 20		108 45		72 22		71 53	
	108 2				72 8		
			72 3				

Resulting Dip: + 72° 13′

Magnetic Dip.

U. S. Naval Observatory, Washington, May 6, 1867. Needle A. 1.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
73° 0′	72° 50′	73° 35′	73° 15′	107° 45′	107° 15′	107° 10′	106° 50′
72 55		73 25		107 30		107 0	
	73 10				107 15		
			72 58				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
110° 0′	109° 30′	109° 40′	109° 15′	71° 25′	71° 10′	71° 10′	70° 50′
109 45		109 28		71 18		71 0	
	109 36				71 9		
			70 46				

Resulting Dip: + 71° 55′

Magnetic Dip.

U. S. Naval Observatory, Washington, May 6, 1867. Needle A. 2.

POLARITY OF MARKED END NORTH.

CIRCLE EAST.				CIRCLE WEST.			
Face East.		Face West.		Face East.		Face West.	
S.	N.	S.	N.	S.	N.	S.	N.
73° 45′	73° 30′	72° 20′	71° 50′	107° 40′	107° 15′	108° 50′	108° 40′
73 38		72 5		107 28		108 45	
	72 52				108 6		
			72 23				

POLARITY OF MARKED END SOUTH.

CIRCLE WEST.				CIRCLE EAST.			
Face West.		Face East.		Face West.		Face East.	
S.	N.	S.	N.	S.	N.	S.	N.
108° 30′	108° 0′	109° 0′	108° 30′	72° 30′	72° 0′	72° 0′	71° 40′
108 15		108 45		72 15		71 50	
	108 30				72 2		
			71 46				

Resulting Dip: + 72° 4′

HORIZONTAL INTENSITY. OBSERVATIONS OF VIBRATIONS.

Philadelphia, October 24, 1865.

No.	Time P. M.	No.	Time P. M.	Time of 156 vibrations.
0	$3^{h}\ 27^{m}\ 5^{s}.6$	156	$3^{h}\ 45^{m}\ 50^{s}.8$	$18^{m}\ 45^{s}.2$
10	3 28 17.2	166	3 47 2.0	18 44.8
20	3 29 29.6	176	3 48 15.2	18 45.6
30	3 30 42.0	186	3 49 27.2	18 45.2
40	3 31 54.4	196	3 50 39.2	18 44.8
50	3 33 6.4	206	3 51 51.6	18 45.2
			Mean . . .	18 45.13

Extreme scale readings,
At beginning . . . . . 5.0 — 150.0
At end . . . . . . 23.0 — 86.0
Coefficient of torsion $v = 8.12$ div.
Temperature . . . . . 60°.7
Time of one vibration . $7^{s}.212$

Gosport, October 28, 1865.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$3^{h}\ 43^{m}\ 6^{s}.4$	150	$4^{h}\ 0^{m}\ 3^{s}.6$	$16^{m}\ 57^{s}.2$
10	3 44 14.4	160	4 1 11.6	16 57.2
20	3 45 22.0	170	4 2 19.5	16 57.5
30	3 46 29.6	180	4 3 27.2	16 57.6
40	3 47 37.2	190	4 4 34.9	16 57.7
50	3 48 45.6	200	4 5 42.8	16 57.2
			Mean . . .	16 57.40

Extreme scale readings,
At beginning . . . . . . 69.2 — 88.8
At end . . . . 72.1 — 85.2
Coefficient of torsion, $v = 7.35$ div.
Temperature . . . . . 73°.0
Time of one vibration . $6^{s}.783$

Gosport, October 28, 1865.

Inertia ring on magnet.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$4^{h}\ 39^{m}\ 7^{s}.9$	150	$5^{h}\ 0^{m}\ 55^{s}.0$	$21^{m}\ 47^{s}.1$
10	4 40 35.1	160	5 2 21.7	21 46.6
20	4 42 2.3	170	5 3 48.8	21 46.5
30	4 43 29.3	180	5 5 16.0	21 46.7
40	4 44 56.4	190	5 6 43.2	21 46.8
50	4 46 23.7	200	5 8 10.1	21 46.4
			Mean . . .	21 46.68

Extreme scale readings,
At beginning . . . . . . 91.0 — 66.5
At end . . . . 88.0 — 69.0
Coefficient of torsion, $v = 8.97$ div.
Temperature . . . . . 70°.0
Time of one vibration . $8^{s}.711$

Gosport, October 30, 1865.

No.	Time.	No.	Time.	Time of 150 vibrations.
0	$12^{h}\ 17^{m}\ 5^{s}.1$	150	$12^{h}\ 33^{m}\ 58^{s}.8$	$16^{m}\ 53^{s}.7$
10	12 18 12.8	160	12 35 7.8	16 55.0
20	12 19 20.7	170	12 36 16.4	16 55.7
30	12 20 28.5	180	12 37 24.0	16 55.5
40	12 21 36.1	190	12 38 29.6	16 53.5
50	12 22 44.0	200	12 39 39.2	16 55.2
			Mean . . .	16 54.77

Extreme scale readings,
At beginning . . . . . . 70.0 — 88.3
At end . . . . 77.0 — 82.0
Temperature . . . . . 60°.0
Time of one vibration . $6^{s}.765$

St. Thomas, November 13, 1865.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$2^{h}\ 23^{m}\ 6^{s}.2$	150	$2^{h}\ 37^{m}\ 18^{s}.6$	$14^{m}\ 12^{s}.4$
10	2 24 3.2	160	2 38 15.4	14 12.2
20	2 24 59.8	170	2 39 12.2	14 12.4
30	2 25 56.9	180	2 40 8.4	14 11.5
40	2 26	190	2 41 5.7	14
50	2 27 49.0	200	2 42 2.8	14 13.8
			Mean . . .	14 12.46

Extreme scale readings,
At beginning . . . . . . 62.2 — 98.0
At end . . . . 69.8 — 90.2
Coefficient of torsion, $v = 4.10$ div.
Temperature . . . . . 87°.0
Time of one vibration . $5^{s}.683$

St. Thomas, November 16, 1865.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$12^{h}\ 13^{m}\ 3^{s}.4$	150	$12^{h}\ 27^{m}\ 15^{s}.1$	$14^{m}\ 11^{s}.7$
10	12 14 0.4	160	12 28 12.0	14 11.6
20	12 14 57.2	170	12 29 8.5	14 11.3
30	12 15 54.3	180	12 30 5.4	14 11.1
40	12 16 50.6	190	12 31 2.2	14 11.6
50	12 17 47.8	200	12 31 59.0	14 11.2
			Mean . . .	14 11.42

Extreme scale readings,
At beginning . . . . . . 59.8 — 98.8
At end . . . . 67.2 — 89.5
Coefficient of torsion, $v = 4.25$ div.
Temperature . . . . . 87°.5
Time of one vibration . $5^{s}.676$

HORIZONTAL INTENSITY. OBSERVATIONS OF VIBRATIONS.

St. Thomas, November 16, 1865.

Inertia ring on magnet.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$1^h\ 0^m\ 6^s.4$	150	$1^h\ 18^m\ 20^s.5$	$18^m\ 14^s.1$
10	1 1 18.6	160	1 19 34.1	18 15.5
20	1 2 31.8	170	1 20 46.6	18 14.8
30	1 3 45.1	180	1 21 59.8	18 14.7
40	1 4 58.1	190	1 23 12.9	18 14.8
50	1 6 11.4	200	1 24 26.2	18 14.8
			Mean	18 14.78

Extreme scale readings,
At beginning . . . . . 61.8 — 98.0
At end . . . . 63.5 — 96.2
Coefficient of torsion . . $v = 5.22$ div.
Temperature . . . . . . 86°.0
Time of one vibration . . $7^s.299$

Salute Islands, November 28, 1865.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	$9^h\ 43^m\ 3^s.6$	150	$9^h\ 57^m\ 17^s.7$	$14^m\ 14^s.1$
10	9 44 0.4	160	9 58 14.2	14 13.8
20	9 44 57.4	170	9 59 11.4	14 14.0
30	9 45 54.2	180	10 0 8.6	14 14.4
40	9 46 51.3	190	10 1 5.6	14 14.3
50	9 47 48.3	200	10 2 2.5	14 14.2
			Mean	14 14.13

Extreme scale readings,
At beginning . . . . . 57.5 — 99.8
At end . . . . 71.4 — 86.0
Coefficient of torsion . . $v = 3.72$ div.
Temperature . . . . . . 95°.5
Time of one vibration . . $5^s.694$

Salute Islands, November 28, 1865.

Inertia ring on magnet.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$11^h\ 31^m\ 9^s.5$	150	$11^h\ 49^m\ 25^s.1$	$18^m\ 15^s.6$
10	11 32 22.5	160	11 50 38.6	18 16.1
20	11 33 35.6	170	11 51 51.6	18 16.0
30	11 34 48.7	180	11 53 4.7	18 16.0
40	11 36 1.4	190	11 54 17.8	18 16.4
50	11 37 14.8	200	11 55 30.3	18 15.5
			Mean	18 15.93

Extreme scale readings,
At beginning . . . . . 54.8 — 105.3
At end . . . . 65.4 — 94.0
Coefficient of torsion . . $v = 5.65$ div.
Temperature . . . . . . 91°.0
Time of one vibration . . $7^s.306$

Ceara, December 13, 1865.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$11^h\ 35^m\ 8^s.3$	150	$11^h\ 49^m\ 36^s.0$	$14^m\ 27^s.7$
10	11 36 6.2	160	11 50 34.2	14 28.0
20	11 37 4.2	170	11 51 33.4	14 29.2
30	11 38 1.0	180	11 52 31.2	14 30.2
40	11 38 59.1	190	11 53 28.2	14 29.1
50	11 39 57.0	200	11 54 25.6	14 28.6
			Mean	14 28.80

Extreme scale readings,
At beginning . . . . . 59.0 — 101.0
At end . . . . 45.5 — 115.0
Coefficient of torsion . . $v = 5.40$ div.
Temperature . . . . . . 89°.0
Time of one vibration . . $5^s.792$

A strong breeze blowing, which made the vibrations somewhat unsteady.

Ceara, December 13, 1865.

Inertia ring on magnet.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$12^h\ 23^m\ 14^s.1$	150	$12^h\ 41^m\ 51^s.5$	$18^m\ 37^s.4$
10	12 24 28.8	160	12 43 6.1	18 37.3
20	12 25 43.8	170	12 44 20.0	18 36.2
30	12 26 59.0	180	12 45 33.6	18 34.6
40	12 28 13.6	190	12 46 49.2	18 35.6
50	12 29 28.2	200	12 48 3.8	18 35.6
			Mean	18 36.12

Extreme scale readings,
At beginning . . . . . 104.8 — 58.8
At end . . . . 100.0 — 62.2
Coefficient of torsion . . $v = 7.00$ div.
Temperature . . . . . . 89°.5
Time of one vibration . . $7^s.441$

Pernambuco, December 23, 1865.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	$6^h\ 50^m\ 16^s.8$	150	$7^h\ 4^m\ 54^s.4$	$14^m\ 37^s.6$
10	6 51 15.7	160	7 5 52.6	14 36.9
20	6 52 14.0	170	7 6 51.1	14 37.1
30	6 53 12.6	180	7 7 49.6	14 37.0
40	6 54 10.9	190	7 8 48.0	14 37.1
50	6 55 9.6	200	7 9 46.4	14 36.8
			Mean	14 37.08

Extreme scale readings,
At beginning . . . . . 46.0 — 115.0
At end . . . . 62.0 — 99.0
Coefficient of torsion . . $v = 4.27$ div.
Temperature . . . . . . 90°.5
Time of one vibration . . $5^s.847$

Horizontal Intensity. Observations of Vibrations.

Bahia, December 27, 1865.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	7^h 14^m $5^s.6$	150	7^h 28^m $55^s.6$	14^m $50^s.0$
10	7 15 4.9	160	7 29 55.0	14 50.1
20	7 16 4.1	170	7 30 54.4	14 50.3
30	7 17 3.6	180	7 31 53.6	14 50.0
40	7 18 2.9	190	7 32 53.0	14 50.1
50	7 19 2.2	200	7 33 52.2	14 50.0
			Mean	14 50.08

Extreme scale readings,
At beginning . . . . 92.8 — 63.1
At end . . . . . . 86.8 — 68.3
Coefficient of torsion . . $v = 4.85$ div.
Temperature . . . . . 92°.5
Time of one vibration . . $5^s.934$

Bahia, December 27, 1865.

Inertia ring on magnet.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	8^h 3^m $4^s.2$	150	8^h 22^m $9^s.4$	19^m $5^s.2$
10	8 4 20.8	160	8 23 25.8	19 5.0
20	8 5 37.0	170	8 24 42.2	19 5.2
30	8 6 53.4	180	8 25 58.6	19 5.2
40	8 8 9.8	190	8 27 14.8	19 5.0
50	8 9 26.0	200	8 28 30.8	19 4.8
			Mean	19 5.07

Extreme scale readings,
At beginning . . . . 57.9 — 100.4
At end . . . . . . 67.9 — 89.2
Coefficient of torsion . . $v = 6.70$ div.
Temperature . . . . . 97°.5
Time of one vibration . . $7^s.634$

Rio Janeiro, January 6, 1866.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	3^h 21^m $6^s.8$	150	3^h 36^m $12^s.5$	15^m $5^s.7$
10	3 22 5.8	160	3 37 12.5	15 6.7
20	3 23 6.6	170	3 38 13.3	15 6.7
30	3 24 7.0	180	3 39 13.6	15 6.6
4	3 25 7.7	190	3 40 14.5	15 6.8
50	3 26 8.1	200	3 41 15.0	15 6.9
			Mean	15 6.57

Extreme scale readings,
At beginning . . . . 62.1 — 96.3
At end . . . . . . 70.0 — 89.2
Coefficient of torsion . . $v = 5.10$ div.
Temperature . . . . . 76°.0
Time of one vibration . . $6^s.044$

Rio Janeiro, January 9, 1866.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	5^h 30^m $11^s.8$	150	5^h 45^m $20^s.2$	15^m $8^s.4$
10	5 31 12.4	160	5 46 21.0	15 8.6
20	5 32 13.0	170	5 47 21.5	15 8.5
30	5 33 13.4	180	5 48 22.1	15 8.7
40	5 34 14.0	190	5 49 22.6	15 8.6
50	5 35 14.6	200	5 50 23.2	15 8.6
			Mean	15 8.57

Extreme scale readings,
At beginning . . . . 62.2 — 98.1
At end . . . . . . 69.2 — 91.2
Temperature . . . . . 80°.5
Time of one vibration . . $6^s.057$

Monte Video, January 18, 1866.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	1^h 27^m $8^s.2$	150	1^h 42^m $9^s.4$	15^m $1^s.2$
10	1 28 8.2	160	1 43 9.5	15 1.3
20	1 29 8.3	170	1 44 9.7	15 1.4
30	1 30 8.2	180	1 45 9.7	15 1.5
40	1 31 8.5	190	1 46 9.7	15 1.2
50	1 32 8.5	200	1 47 9.9	15 1.4
			Mean	15 1.33

Extreme scale readings,
At beginning . . . . 58.4 — 98.3
At end . . . . . . 66.8 — 90.2
Coefficient of torsion . . $v = 5.10$ div.
Temperature . . . . . 84°.0
Time of one vibration . . $6^s.009$

Monte Video, January 18, 1866.

Inertia ring on magnet.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	2^h 10^m $3^s.2$	150	2^h 29^m $22^s.9$	19^m $19^s.7$
10	2 11 20.5	160	2 30 40.1	19 19.6
20	2 12 37.8	170	2 31 57.3	19 19.5
30	2 13 55.1	180	2 33 14.6	19 19.5
40	2 15 12.4	190	2 34 31.8	19 19.4
50	2 16 29.8	200	2 35 49.3	19 19.5
			Mean	19 19.53

Extreme scale readings,
At beginning . . . . 56.9 — 101.0
At end . . . . . . 65.9 — 91.4
Coefficient of torsion . . $v = 6.25$ div.
Temperature . . . . . 84°.5
Time of one vibration . . $7^s.730$

HORIZONTAL INTENSITY. OBSERVATIONS OF VIBRATIONS.

Monte Video, January 18, 1866.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$2^{h}\ 55^{m}\ 9^{s}.3$	150	$3^{h}\ 10^{m}\ 11^{s}.4$	$15^{m}\ 2^{s}.1$
10	2 56 9.2	160	3 11 11.4	15 2.2
20	2 57 9.4	170	3 12 11.5	15 2 1
30	2 58 9.4	180	3 13 11.9	15 2.5
40	2 59 9.4	190	3 14 12.1	15 2.7
50	3 0 9.8	200	3 15 12.1	15 2.3
			Mean	15 2.32

Extreme scale readings,
At beginning . . . . . 58.0 — 100.2
At end . . . . 65.8 — 91.6
Temperature . . . . . . 86°.0
Time of one vibration . . $6^{s}.015$

Monte Video, January 19, 1866.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$3^{h}\ 3^{m}\ 8^{s}.8$	150	$3^{h}\ 18^{m}\ 11^{s}.8$	$15^{m}\ 3^{s}.0$
10	3 4 8.9	160	3 19 12.2	15 3.3
20	3 5 9.3	170	3 20 12.6	15 3.3
30	3 6 9.4	180	3 21 12.6	15 3.2
40	3 7 9.7	190	3 22 13.0	15 3.3
50	3 8 10.1	200	3 23 13.3	15 3.2
			Mean	15 3.22

Extreme scale readings,
At beginning . . . . . 56.0 — 102.0
At end . . . . 66.6 — 91.5
Temperature . . . . . . 89°.5
Time of one vibration . . $6^{s}.021$

Sandy Point, February 7, 1866.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	$11^{h}\ 37^{m}\ 4^{s}.5$	150	$11^{h}\ 51^{m}\ 58^{s}.4$	$14^{m}\ 53^{s}.9$
10	11 38 4.5	160	11 52 58.4	14 53.9
20	11 39 3.7	170	11 53 58.2	14 54.5
30	11 40 4.1	180	11 54 58.0	14 53.9
40	11 41 3.3	190	11 55 57.8	14 54.5
50	11 42 2.5	200	11 56 57.8	14 55.3
			Mean	14 54.33

Extreme scale readings,
At beginning . . . . . 61.0 — 100.0
At end . . . . 60.5 — 97.5
Coefficient of torsion . . $v = 6.85$ div.
Temperature . . . . . . 71°.5
Time of one vibration . . $5^{s}.962$
Magnet rendered quite unsteady by the high wind.

Valparaiso, March 2, 1866.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$5^{h}\ 0^{m}\ 3^{s}.4$	150	$5^{h}\ 14^{m}\ 41^{s}.0$	$14^{m}\ 37^{s}.6$
10	5 1 2.2	160	5 15 39.3	14 37.1
20	5 2 0.6	170	5 16 37.8	14 37.2
30	5 2 59.4	180	5 17 36.6	14 37.2
40	5 3 57.4	190	5 18 35.1	14 37.7
50	5 4 55.7	200	5 19 33.7	14 38.0
			Mean	14 37.47

Extreme scale readings,
At beginning . . . . . 99.8 — 56.8
At end . . . . 97.8 — 57.8
Coefficient of torsion . . $v = 6.17$ div.
Temperature . . . . . . 72°.5
Time of one vibration . . $5^{s}.850$

Valparaiso, March 19, 1866.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$1^{h}\ 42^{m}\ 6^{s}.6$	150	$1^{h}\ 56^{m}\ 50^{s}.2$	$14^{m}\ 43^{s}.6$
10	1 43 5.6	160	1 57 48.6	14 43.0
20	1 44 4.2	170	1 58 47.7	14 43.5
30	1 45 3.0	180	1 59 46.3	14 43.3
40	1 46 1.9	190	2 0 44.9	14 43.0
50	1 47 0.8	200	2 1 44.1	14 43.3
			Mean	14 43.28

Extreme scale readings,
At beginning . . . . . 65.0 — 95.8
At end . . . . 61.2 — 96.8
Coefficient of torsion . . $v = 4.75$ div.
Temperature . . . . . . 76°.0
Time of one vibration . . $5^{s}.889$

Valparaiso, March 19, 1866.

Inertia ring on magnet.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$2^{h}\ 32^{m}\ 5^{s}.4$	150	$2^{h}\ 51^{m}\ 0^{s}.4$	$18^{m}\ 55^{s}.0$
10	2 33 21.2	160	2 52 15.8	18 54.6
20	2 34 36.8	170	2 53 30.8	18 54.0
30	2 35 52.5	180	2 54 47.2	18 54.7
40	2 37 8.2	190	2 56 1.2	18 53.0
50	2 38 23.9	200	2 57 15.8	18 51.9
			Mean	18 53.87

Extreme scale readings,
At beginning . . . . . 61.6 — 98.9
At end . . . . 73.3 — 84.0
Coefficient of torsion . . $v = 6.82$ div.
Temperature . . . . . . 73°.0
Time of one vibration . . $7^{s}.559$

HORIZONTAL INTENSITY. OBSERVATIONS OF VIBRATIONS.

Valparaiso, March 29, 1860.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	12^h 37^m 9^s.0	150	12^h 51^m 47^s.4	14^m 38^s.4
10	12 38 7.4	160	12 52 45.8	14 38.4
20	12 39 5.7	170	12 53 46.2	14 40.5
30	12 40 4.3	180	12 54 44.2	14 39.9
40	12 41 3.4	190	12 55 40.4	14 37.0
50	12 42 2.0	200	12 56 —	14 —
			Mean	14 38.84

Extreme scale readings,
At beginning . . . . 61.3 — 97.2
Temperature . . . . . 76°.0
Time of one vibration . . 5^s.859

Magnet brought to rest by the vibrations of the instrument caused by the wind.

Valparaiso, March 29, 1866.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	1^h 28^m 7^s.2	150	1^h 42^m 49^s.0	14^m 41^s.8
10	1 29 5.2	160	1 43 48.0	14 42.8
20	1 30 6.8	170	1 44 46.9	14 40.1
30	1 31 2.4	180	1 45 45.2	14 42.8
40	1 32 0.6	190	1 46 43.8	14 43.2
50	1 32 58.6	200	1 47 43.0	14 44.4
			Mean	14 42.52

Extreme scale readings,
At beginning . . . . 63.0 — 98.8
At end . . . . . . 65.5 — 96.0
Coefficient of torsion . . $v = 3.80$ div.
Temperature . . . . . 75°.5
Time of one vibration . . 5^s.883

Vibrations irregular on account of the wind, which, at one time, almost brought the magnet to rest.

Valparaiso, April 7, 1866.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	10^h 2^m 15^s.6	150	10^h 16^m 55^s.0	14^m 39^s.4
10	10 3 14.2	160	10 17 54.2	14 40.0
20	10 4 13.2	170	10 18 53.6	14 40.4
30	10 5 11.8	180	10 19 53.0	14 41.2
40	10 6 11.2	190	10 20 52.4	14 41.2
50	10 7 9.6	200	10 21 51.2	14 41.6
			Mean	14 40.63

Extreme scale readings,
At beginning . . . . 59.8 — 102.8
At end . . . . . . 56.5 — 106.5
Coefficient of torsion . . $v = 3.92$ div.
Temperature . . . . . 66°.5
Time of one vibration . . 5^s.871

Valparaiso, April 11, 1866.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	12^h 15^m 14^s.0	150	12^h 29^m 56^s.6	14^m 42^s.6
10	12 16 13.0	160	12 30 55.4	14 42.4
20	12 17 11.8	170	12 31 54.2	14 42.4
30	12 18 10.4	180	12 32 53.2	14 42.8
40	12 19 9.0	190	12 33 52.0	14 43.0
50	12 20 7.8	200	12 34 51.0	14 43.2
			Mean	14 42.73

Extreme scale readings,
At beginning . . . . 56.0 — 103.0
At end . . . . . . 64.5 — 91.0
Temperature . . . . . 74°.5
Time of one vibration . . 5^s.885

Valparaiso, April 11, 1866.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	12^h 37^m 12^s.2	150	12^h 51^m 55^s.0	14^m 42^s.8
10	12 38 11.0	160	12 52 54.0	14 43.0
20	12 39 9.8	170	12 53 52.8	14 43.0
30	12 40 8.6	180	12 54 51.8	14 43.2
40	12 41 7.4	190	12 55 50.6	14 43.2
50	12 42 6.4	200	12 56 49.4	14 43.0
			Mean	14 43.03

Extreme scale readings,
At beginning . . . . 64.5 — 91.0
At end . . . . . . 70.0 — 85.0
Temperature . . . . . 81°.0
Time of one vibration . . 5^s.887

Valparaiso, April 11, 1866.

Inertia ring on magnet.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	1^h 8^m 6^s.6	150	1^h 27^m 2^s.4	18^m 55^s.8
10	1 9 22.2	160	1 28 18.1	18 55.9
20	1 10 37.8	170	1 29 33.8	18 56.0
30	1 11 53.7	180	1 30 49.4	18 55.7
40	1 13 9.4	190	1 32 5.2	18 55.8
50	1 14 25.0	200	1 33 21.0	18 56.0
			Mean	18 55.87

Extreme scale readings,
At beginning . . . . 58.8 — 101.6
At end . . . . . . 67.0 — 93.2
Coefficient of torsion . . $v = 5.50$ div.
Temperature . . . . . 88°.0
Time of one vibration . . 7^s.572

HORIZONTAL INTENSITY. OBSERVATIONS OF VIBRATIONS.

Valparaiso, April 13, 1866.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$2^h\ 45^m\ 23^s.6$	150	$3^h\ 0^m\ 6^s.2$	$14^m\ 42^s.6$
10	2 46 21.8	160	3 1 4.6	14 42.8
20	2 47 21.2	170	3 2 3.6	14 42.4
30	2 48 19.6	180	3 3 2.4	14 42.8
40	2 49 19.0	190	3 4 0.6	14 41.6
50	2 50 17.8	200	3 4 58.6	14 40.8
			Mean . . .	14 42.17

Extreme scale readings,
At beginning . . . 57.8 — 101.5
At end . . . . . 74.2 — 85.2
Temperature . . . . 66°.5
Time of one vibration . $5^s.881$

San Lorenzo Island, April 26, 1866.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	$12^h\ 40^m\ 6^s.9$	150	$12^h\ 54^m\ 7^s.4$	$14^m\ 0^s.5$
10	12 41 3.0	160	12 55 3.0	14 0.0
20	12 41 59.0	170	12 55 59.2	14 0.2
30	12 42 55.0	180	12 56 54.9	13 59.9
40	12 43 51.0	190	12 57 50.8	13 59.8
50	12 44 47.1	200	12 58 47.4	14 0.3
			Mean . . .	14 0.08

Extreme scale readings,
At beginning . . . . . 61.2 — 101.1
At end . . . . 71.0 — 89.0
Coefficient of torsion . . . $v = 3.10$ div.
Temperature. . . . . . 89°.0
Time of one vibration . . . $5^s.601$

Payta, May 7, 1866.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	$9^h\ 21^m\ 9^s.8$	150	$9^h\ 34^m\ 49^s.4$	$13^m\ 39^s.6$
10	9 22 4.4	160	9 35 44.0	13 39.6
20	9 22 59.2	170	9 36 38.6	13 39.4
30	9 23 53.6	180	9 37 33.2	13 39.6
40	9 24 48.2	190	9 38 27.6	13 39.4
50	9 25 42.8	200	9 39 22.3	13 39.5
			Mean . . .	13 39.52

Extreme scale readings,
At beginning . . . . . 58.2 — 101.8
At end . . . . 67.8 — 92.2
Coefficient of torsion . . . $v = 3.20$ div.
Temperature . . . . . 87°.5
Time of one vibration . . . $5^s.463$

Flamenco Island, Panama Bay, May 14, 1866.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	$8^h\ 50^m\ 11^s.4$	150	$9^h\ 3^m\ 37^s.8$	$13^m\ 26^s.4$
10	8 51 5.1	160	9 4 31.4	13 26.3
20	8 51 59.0	170	9 5 25.2	13 26.2
30	8 52 52.8	180	9 6 19.0	13 26.2
40	8 53 46.5	190	9 7 13.0	13 26.5
50	8 54 40.4	200	9 8 6.9	13 26.5
			Mean . . .	13 26.35

Extreme scale readings,
At beginning . . . . . 58.2 — 101.0
At end . . . . 66.6 — 92.9
Coefficient of torsion . . . $v = 2.78$ div.
Temperature. . . . . . 92°.0
Time of one vibration. . . $5^s.376$

Acapulco, May 30, 1866.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	$8^h\ 32^m\ 3^s.8$	150	$8^h\ 45^m\ 23^s.4$	$13^m\ 19^s.6$
10	8 32 57.0	160	8 46 17.2	13 20.2
20	8 33 50.6	170	8 47 10.2	13 19.6
30	8 34 43.9	180	8 48 3.7	13 19.8
40	8 35 37.0	190	8 48 57.0	13 20.0
50	8 36 30.6	200	8 49 50.5	13 19.9
			Mean . . .	13 19.85

Extreme scale readings,
At beginning . . . . . 57.8 — 102.2
At end . . . . 65.2 — 95.0
Coefficient of torsion . . . $v = 3.40$ div.
Temperature. . . . . . 89°.0
Time of one vibration. . . $5^s.332$

Acapulco, May 30, 1866.

Inertia ring on magnet.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	$9^h\ 46^m\ 9^s.2$	150	$10^h\ 3^m\ 19^s.5$	$17^m\ 10^s.3$
10	9 47 17.4	160	10 4 28.2	17 10.8
20	9 48 26.5	170	10 5 37.0	17 10.5
30	9 49 35.2	180	10 6 45.6	17 10.4
40	9 50 43.8	190	10 7 54.4	17 10.6
50	9 51 52.4	200	10 9 3.2	17 10.8
			Mean . . .	17 10.57

Extreme scale readings,
At beginning . . . . . 56.2 — 103.7
At end . . . . 65.1 — 94.8
Coefficient of torsion . . . $v = 4.55$ div.
Temperature . . . . . 99°.5
Time of one vibration . . $6^s.870$

HORIZONTAL INTENSITY. OBSERVATIONS OF VIBRATIONS.

Magdalena Bay, June 9, 1866.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	1^h 8^m 5^s.4	150	1^h 21^m 52^s.8	
10	1 8 59.4	160	1 22 49.0	
20	1 9 54.5	170	1 23 44.4	
30	1 10 49.0	180	1 24 40.2	
40	1 11 44.4	190	1 25 36.0	
50	1 12 39.8	200	1 26 30.8	
100	1 17 16.4			

Extreme scale readings,
At beginning . . . . . 55.0 — 101.0
At end . . . . 69.0 — 85.0
Temperature . . . . . . 79°.0
Time of one vibration . . 5^s.527

In this and the following observation the vibrations of the magnet were very irregular on account of a high wind which shook the instrument.

Magdalena Bay, June 9, 1866.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	1^h 41^m 12^s.2	150	1^h 55^m 4^s.8	
10	1 42 7.8	160	1 56 0.4	
20	1 43 3.0	170	1 56 56.0	
30	1 43 59.0	180	1 57 51.4	
40	1 44 54.0	190	1 58 46.4	
50	1 45 48.4	200	1 59 41.6	
100	1 50 25.4			

Extreme scale readings,
At beginning . . . . . 53.5 — 98.5
At end . . . .
Coefficient of torsion . . $v = 4.37$ div.
Temperature . . . . . . 86°.5
Time of one vibration . . 5^s.533

San Diego Bay, June 15, 1866.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	6^h 11^m 9^s.2	150	6^h 25^m 58^s.2	14^m 49^s.0
10	6 12 8.3	160	6 26 56.6	14 48.3
20	6 13 7.4	170	6 27 55.8	14 48.4
30	6 14 7.0	180	6 28 55.4	14 48.4
40	6 15 6.2	190	6 29 53.8	14 47.6
50	6 16 5.4	200	6 30 53.0	14 47.6
			Mean	14 48.22

Extreme scale readings,
At beginning . . . . . 94.9 — 108.9
At end . . . . 70.0 — 88.0
Coefficient of torsion . . $v = 3.60$ div.
Temperature . . . . . . 79°.0
Time of one vibration . . 5^s.921

San Francisco Bay, June 26, 1866.

No.	Time A. M.	No.	Time A. M.	Time of 150 vibrations.
0	3^h 21^m 22^s.7	150	3^h 36^m 57^s.7	15^m 35^s.0
10	3 22 24.7	160	3 38 0.0	15 35.3
20	3 23 27.2	170	3 39 2.5	15 35.3
30	3 24 30.2	180	3 40 4.7	15 34.5
40	3 25 32.0	190	3 41 7.2	15 35.2
50	3 26 34.7	200	3 42 10.0	15 35.3
			Mean	15 35.10

Extreme scale readings,
At beginning . . . . . 57.0 — 102.0
At end . . . . 68.0 — 90.5
Coefficient of torsion . . $v = 4.35$ div.
Temperature . . . . . . 77°.0
Time of one vibration . . 6^s.234

U. S. N. Observatory, Washington, Nov. 1, 1866.

No.	Time P. M.	No.	Time P. M.	Time of 150 vibrations.
0	5^h 19^m 52^s.7	150	5^h 37^m 46^s.5	17^m 53^s.8
10	5 21 5.0	160	5 38 58.0	17 53.0
20	5 22 16.0	170	5 40 9.2	17 53.2
30	5 23 27.5	180	5 41 20.7	17 53.2
40	5 24 39.0	190	5 42 31.8	17 52.8
50	5 25 50.7	200	5 43 43.0	17 52.3
			Mean	17 53.05

Extreme scale readings,
At beginning . . . . . 52.5 — 106.0
At end . . . . 66.6 — 95.2
Coefficient of torsion . . $v = 5.80$ div.
Temperature . . . . . . 67°.5
Time of one vibration . . 7^s.154

The following sets of observations of vibrations were made in the basement of the Observatory, where there is much iron, and are to be used only to determine the moment of inertia of the magnet.

Set 1. November 2, 1866.

No.	Time.	No.	Time.	Time of 150 vibrations.
0	5^h 37^m 31^s.7	150	5^h 54^m 53^s.8	17^m 22^s.1
10	5 38 41.2	160	5 56 3.2	17 22.0
20	5 39 50.7	170	5 57 12.7	17 22.0
30	5 41 0.2	180	5 58 21.5	17 21.3
40	5 42 9.7	190	5 59 31.2	17 21.5
50	5 43 19.2	200	6 0 40.7	17 21.5
			Mean	17 21.73

Extreme scale readings,
At beginning . . . . . 59.1 — 99.8
At end . . . . 66.9 — 92.2
Temperature . . . . . . 65°.5
Time of one vibration . . 6^s.945

Horizontal Intensity. Observations of Vibrations.

Set No. 2. November 2, 1866.

Inertia ring on magnet.

No.	Time.	No.	Time.	Time of 150 vibrations.
0	6^h 17^m $25^s.3$	150	6^h 39^m $46^s.8$	22^m $21^s.5$
10	6 18 55.2	160	6 41 16.2	22 21.0
20	6 20 24.2	170	6 42 45.7	22 21.5
30	6 21 54.0	180	6 44 14.8	22 20.8
40	6 23 23.7	190	6 45 44.2	22 20.5
50	6 24 53.0	200	6 47 13.7	22 20.7
			Mean	22 21.00

Extreme scale readings,
At beginning . . . . 58.9 — 100.8
At end . . . . 68.3 — 95.5
Coefficient of torsion . . $v = 7.58$ div.
Temperature . . . . . 68°.5
Time of one vibration . . $8^s.940$

Set No. 3. November 2, 1866.

No.	Time.	No.	Time.	Time of 150 vibrations.
0	6^h 57^m $41^s.3$	150	7^h 15^m $3^s.2$	17^m $21^s.9$
10	6 58 50.8	160	7 16 12.8	17 22.0
20	7 0 0.2	170	7 17 22.3	17 22.1
30	7 1 9.8	180	7 18 31.5	17 21.7
40	7 2 19.0	190	7 19 41.0	17 22.0
50	7 3 28.8	200	7 20 50.5	17 21.7
			Mean	17 21.90

Extreme scale readings,
At beginning . . . . 54.2 — 104.5
At end . . . . 63.2 — 94.9
Temperature . . . . . 69°.0
Time of one vibration . . $6^s.946$

Set No. 4. November 2, 1866.

Inertia ring on magnet.

No.	Time.	No.	Time.	Time of 150 vibrations.
0	7^h 26^m $18^s.3$	150	7^h 48^m $39^s.0$	22^m $20^s.7$
10	7 27 47.7	160	7 50 8.5	22 20.8
20	7 29 17.2	170	7 51 37.9	22 20.7
30	7 30 46.7	180	7 53 7.3	22 20.6
40	7 32 16.0	190	7 54 36.7	22 20.7
50	7 33 45.5	200	7 56 5.8	22 20.3
			Mean	22 20.63

Extreme scale readings,
At beginning . . . . 56.5 — 103.6
At end . . . . 65.1 — 96.3
Temperature . . . . . 70°.0
Time of one vibration . . $8^s.938$

Set No. 5. November 2, 1866.

No.	Time.	No.	Time.	Time of 150 vibrations.
0	8^h 7^m $22^s.7$	150	8^h 24^m $44^s.2$	17^m $21^s.5$
10	8 8 32.2	160	8 25 53.7	17 21.5
20	8 9 41.7	170	8 27 3.2	17 21.5
30	8 10 51.2	180	8 28 12.7	17 21.5
40	8 12 0.7	190	8 29 22.0	17 21.3
50	8 13 10.2	200	8 30 31.7	17 21.5
			Mean	17 21.47

Extreme scale readings,
At beginning . . . . 58.7 — 99.3
At end . . . . 66.5 — 91.2
Coefficient of torsion . . $v = 6.05$ div.
Temperature . . . . . 69°.5
Time of one vibration . . $6^s.943$

Set No. 6. November 2, 1866.

No.	Time.	No.	Time.	Time of 150 vibrations.
0	12^h 31^m $58^s.2$	150	12^h 49^m $51^s.2$	17^m $53^s.0$
10	12 33 9.2	160	12 51 2.5	17 53.3
20	12 34 21.0	170	12 52 14.2	17 53.2
30	12 35 32.7	180	12 53 25.7	17 53.0
40	12 36 44.0	190	12 54 37.2	17 53.2
50	12 37 55.7	200	12 55 48.7	17 53.0
			Mean	17 53.12

Extreme scale readings,
At beginning . . . . 59.5 — 99.0
At end . . . . 65.5 — 92.0
Temperature . . . . . 56°.0
Time of one vibration . . $7^s.154$

Set No. 7. November 2, 1866.

Inertia ring on magnet.

No.	Time.	No.	Time.	Time of 150 vibrations.
0	1^h 3^m $23^s.5$	150	1^h 26^m $22^s.7$	22^m $59^s.2$
10	1 4 55.2	160	1 27 54.2	22 59.0
20	1 6 27.5	170	1 29 26.7	22 59.2
30	1 7 59.2	180	1 30 58.5	22 59.3
40	1 9 31.3	190	1 32 30.2	22 58.9
50	1 11 3.2	200	1 34 2.5	22 59.3
			Mean	22 59.15

Extreme scale readings,
At beginning . . . . 58.2 — 101.0
At end . . . . 68.0 — 97.2
Temperature . . . . . 53°.5
Time of one vibration . . $9^s.194$

HORIZONTAL INTENSITY. OBSERVATIONS OF VIBRATIONS.

Set No. 8. November 2, 1866.

No.	Time.	No.	Time.	Time of 150 vibrations.
0	1^h 40^m $19^s.2$	150	1^h 58^m $11^s.5$	17^m $52^s.3$
10	1 41 30.7	160	1 59 23.0	17 52.3
20	1 42 42.2	170	2 0 34.5	17 52.3
30	1 43 53.7	180	2 1 46.0	17 52.3
40	1 45 5.2	190	2 2 57.5	17 52.3
50	1 46 16.7	200	2 4 9.0	17 52.3
			Mean	17 52.30

Extreme scale readings,
At beginning . . . . 60.0 — 101.0
At end . . . . 68.0 — 92.8
Temperature . . . . . . 52°.5
Time of one vibration . . $7^s.149$

HORIZONTAL INTENSITY. OBSERVATIONS OF DEFLECTIONS.

Philadelphia, October 24, 1865.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W. E. W. E.	$4^{h}\ 40^{m}$	59.°	$141^{d}.5$ 41.5 141.4 41.4	$141^{d}.5$ 41.5	$100^{d}.0$	$r = 2.0$ ft.
East.	E. W. E. W.	4 58	56.	40.5 141.8 40.5 141.6	40.5 141.7	101.2	
Means			57.5		$2u^{d}$	100.60	

Gosport, October 30, 1865.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W. E. W. E.	$11^{h}\ 6^{m}$	59°	$39^{d}.2$ 127.7 39.4 127.4	$39^{d}.3$ 127.5	$88^{d}.2$	$r = 2.0$ ft.
East.	E. W. E. W.	11 30	59	128.0 38.8 127.3 39.1	127.6 38.9	88.7	
Means			59.0		$2u^{d}$	88.45	

Coefficient of torsion, $v = 7.82$ div.

Gosport, October 30, 1865.

Magnet.	North end.	Time.	Temp. t	Scale dings.	Alternate Means.	Diff'
West.	W. E. W. E.	$11^{h}\ 30^{m}$	59°	$60^{d}.5$ 105.7 60.0 105.4	$60^{d}.2$ 105.5	$45^{d}.3$
East.	E. W. E. W.	11 48	58	105.9 60.4 105.9 60.3	105.9 60.4	45.5
Means			58.5		$2u^{d}$	'45.4

HORIZONTAL INTENSITY. OBSERVATIONS OF DEFLECTIONS.

St. Thomas, November 13, 1865.

Magnet	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$2^{h}\ 5^{m}$	87°.	$46^{d}.4$			$r = 2.0$ ft.
	E.			108.1	$46^{d}.4$	$61^{d}.7$	
	W.			46.4	108.1		
	E.			108.1			
East.	E.			108.3			
	W.			46.8	108.4	61.6	
	E.			108.5	46.8		
	W.	2 15	85.	46.9			
Means			86.0		$2u^{d}$	61.65	

Coefficient of torsion, $v = 4.80$ div.

St. Thomas, November 13, 1865.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$2^{h}\ 15^{m}$	85.°	$61^{d}.7$			$r = 2.5$ ft.
	E.			93.2	$61^{d}.6$	$31^{d}.6$	
	W.			61.6	93.2		
	E.			93.3			
East.	E.			93.2			
	W.			61.6	93.2	31.7	
	E.			93.3	61.5		
	W.	2 35	85.	61.5			
Means			85.0		$2u^{d}$	31.65	

St. Thomas, November 16, 1865.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$12^{h}\ 10^{m}$	90.°	$43^{d}.6$			$r = 2.0$ ft.
	E.			105.3	$43^{d}.6$	$61^{d}.7$	
	W.			43.7	105.3		
	E.			105.3			
East.	E.			105.6			
	W.			43.9	105.5	61.7	
	E.			105.5	43.8		
	W.	12 20	87.	43.8			
Means			88.5		$2u^{d}$	61.70	

Coefficient of torsion, $v = 4.55$ div.

St. Thomas, November 16, 1865.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$12^{h}\ 20^{m}$	87.°	$58^{d}.7$			$r = 2.5$ ft.
	E.			90.4	$58^{d}.6$	$31^{d}.8$	
	W.			58.6	90.4		
	E.			90.4			
East.	E.			90.4			
	W.			59.1	90.4	31.4	
	E.			90.5	59.0		
	W.	12 30	87.	58.9			
Means			87.0		$2u^{d}$	31.60	

Salute Islands, November 28, 1865.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$12^{h}\ 15^{m}$	91.°	$41^{d}.1$			$r = 2.0$ ft.
	E.			102.5	$41^{d}.1$	$61^{d}.4$	
	W.			41.1	102.5		
	E.			102.5			
East.	E.			102.8			
	W.			41.3	102.8	61.5	
	E.			102.9	41.3		
	W.	12 25	90.	41.3			
Means			90.5		$2u^{d}$	61.45	

Coefficient of torsion, $v = 4.02$ div.

Salute Islands, November 28, 1865.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$12^{h}\ 25^{m}$	90.°	$56^{d}.3$			$r = 2.5$ ft.
	E.			87.8	$56^{d}.3$	$31^{d}.5$	
	W.			56.3	87.8		
	E.			87.8			
East.	E			88.0			
	W.			56.4	88.0	31.6	
	E.			88.0	56.4		
	W.	12 35	89.	56.4			
Means			89.5		$2u^{d}$	31.55	

HORIZONTAL INTENSITY. OBSERVATIONS OF DEFLECTIONS.

Ceara, December 13, 1865.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$12^h\ 15^m$	89°	$46^d.7$			$r = 2.0$ ft.
	E.			110.5	$46^d.6$	$64^d.0$	
	W.			46.5	110.6		
	E.			110.6			
East.	E.			110.7			
	W.			47.2	110.8	63.5	
	E.			111.0	47.3		
	W.	12 26	90	47.4			
Means			89.5		$2u^d$	63.75	

Coefficient of torsion, $v = 6.72$ div.

Ceara, December 13, 1865.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$12^h\ 26^m$	90°	$62^d.7$			$r = 2.5$ ft.
	E.			95.6	$62^d.8$	$32^d.6$	
	W.			62.8	95.4		
	E.			95.2			
East.	E.			95.3			
	W.			63.4	95.5	31.8	
	E.			95.7	63.7		
	W.	12 40	89	64.1			
Means			89.5		$2u^d$	32.20	

Pernambuco, December 23, 1865.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$8^h\ 35^m$	85°	$48^d.4$			$r = 2.0$ ft.
	E.			113.3	$48^d.4$	$64^d.8$	
	W.			48.5	113.2		
	E.			113.2			
East.	E.			113.9			
	W.			49.5	114.2	64.6	
	E.			114.4	49.6		
	W.	8 50	88	49.7			
Means			86.5		$2u^d$	64.70	

Coefficient of torsion, $v = 5.10$ div.

Pernambuco, December 23, 1865.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$8^h\ 50^m$	88°	$64^d.6$			$r = 2.5$ ft.
	E.			98.0	$64^d.7$	$33^d.4$	
	W.			64.8	98.1		
	E.			98.1			
East.	E.			98.2			
	W.			64.9	98.2	33.2	
	E.			98.2	65.0		
	W.	9 0	88	65.0			
Means			88.0		$2u^d$	33.30	

Bahia, December 27, 1865.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$11^h\ 5^m$	98°	$46^d.5$			$r = 2.0$ ft.
	E.			112.2	$46^d.5$	$65^d.9$	
	W.			46.6	112.4		
	E.			112.7			
East.	E.			113.6			
	W.			46.4	113.7	67.3	
	E.			113.9	46.4		
	W.	11 12	98	46.4			
Means			98.0		$2u^d$	66.60	

Coefficient of torsion, $v = 5.27$ div.

Bahia, December 27, 1865.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternute Means.	Diff's.	Dist.
West.	W.	$11^h\ 12^m$	98°	$62^d.9$			$r = 2.5$ ft.
	E.			96.6	$62^d.8$	$33^d.8$	
	W.			62.8	96.6		
	E.			96.6			
East.	E.			96.9			
	W.			62.6	97.0	34.3	
	E.			97.1	62.7		
	W.	11 20	98	62.8			
Means			98.0		$2u^d$	34.05	

HORIZONTAL INTENSITY. OBSERVATIONS OF DEFLECTIONS.

Rio Janeiro, January 6, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$6^h\ 0^m$	75°	$39^d.1$			$r = 2.0$ ft.
	E.			109.0	$39^d.0$	$69^d.8$	
	W.			39.0	108.8		
	E.			108.6			
East.	E.			109.4			
	W.			39.4	109.3	69.9	
	E.			109.2	39.4		
	W.	6 10	74	39.3			
Means			74.5		$2u^d$	69.85	

Coefficient of torsion, $v = 5.77$ div.

Rio Janeiro, January 6, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$6^h\ 10^m$	74°	$56^d.2$			$r = 2.5$ ft.
	E.			92.0	$56^d.2$	$35^d.7$	
	W.			56.2	91.9		
	E.			91.8			
East.	E.			92.0			
	W.			56.2	92.1	35.9	
	E.			92.2	56.2		
	W.	6 20	74	56.2			
Means			74.0		$2u^d$	35.80	

Monte Video, January 18, 1866.

Magnet.	North end.	Time.	Temp.	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$4^h\ 35^m$	87°	$37^d.2$			$r = 2.0$ ft.
	E.			105.9	$37^d.3$	$68^d.7$	
	W.			37.4	106.0		
	E.			106.0			
East.	E.			106.0			
	W.			37.7	106.0	68.0	
	E.			105.9	38.0		
	W.	4 45	87	38.3			
Means			87.0		$2u^d$	68.35	

Coefficient of torsion, $v = 4.50$ div.

Monte Video, January 18, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$4^h\ 45^m$	87°	$54^d.4$			$r = 2.5$ ft.
	E.			89.5	$54^d.4$	$35^d.1$	
	W.			54.4	89.5		
	E.			89.5			
East.	E.			89.7			
	W.			54.7	89.6	35.0	
	E.			89.6	54.6		
	W.	4 55	88	54.6			
Means			87.5		$2u^d$	35.05	

Sandy Point, February 7, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$12^h\ 45^m$	72°	$43^d.0$			$r = 2.0$ ft.
	E.			110.2	$43^d.5$	$66^d.8$	
	W.			44.0	110.3		
	E.			110.3			
East.	E.			110.7			
	W.			42.6	110.8	68.2	
	E.			110.9	42.6		
	W.	1 8	69	42.5			
Means			70.5		$2u^d$	67.50	

Coefficient of torsion, $v = 8.25$ div.

A high wind blowing which made the magnet very unsteady.

Sandy Point, February 7, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$1^h\ 8^m$	69°	$58^d.8$			$r = 2.5$ ft.
	E.			93.2	$58^d.6$	$34^d.6$	
	W.			58.3	93.2		
	E.			93.2			
East.	E.			93.4			
	W.			58.9	93.7	34.7	
	E.			94.0	59.0		
	W.	1 23	68	59.1			
Means			68.5		$2u^d$	34.65	

HORIZONTAL INTENSITY. OBSERVATIONS OF DEFLECTIONS.

Valparaiso, March 2, 1866.

Magnet.	North end.	Time. P. M.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W. E. W. E.	$5^h\ 52^m$	71°.	$38^d.3$ 103.7 37.9 103.1	$38^d.1$ 103.4	$65^d.3$	$r = 2.0$ ft.
East.	E. W. E. W.	6 3	70.	103.3 38.7 103.2 37.7	103.2 38.2	65.0	
Means			70.5		$2u^d$	65.15	

Coefficient of torsion, $v = 6.87$ div.

Valparaiso, March 2, 1866.

Magnet.	North end.	Time. P. M.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W. E. W. E.	$6^h\ 3^m$	70.°	$53^d.8$ 87.1 53.7 87.1	$53^d.7$ 87.1	$33^d.4$	$r = 2.5$ ft.
East.	E. W. E. W.	6 14	68.	87.2 53.6 87.1 53.6	87.1 53.6	33.5	
Means			69.0		$2u^d$	33.45	

Valparaiso, March 19, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W. E. W. E.	$1^h\ 10^m$	75.°	$37^d.9$ 103.6 37.7 103.7	$37^d.8$ 103.6	$65^d.8$	$r = 2.0$ ft.
East.	E. W. E. W.	1 20	76.	103.7 38.4 103.7 38.5	103.7 38.4	65.3	
Means			75.5		$2u^d$	65.55	

Coefficient of torsion, $v = 4.80$ div.

Valparaiso, March 19, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W. E. W. E.	$1^h\ 20^m$	76.°	$54^d.2$ 87.7 54.0 87.7	$54^d.1$ 87.7	$33^d.6$	$r = 2.5$ ft.
East.	E. W. E. W.	1 35	78.	87.8 54.3 87.8 54.5	87.8 54.4	33.4	
Means			77.0		$2u^d$	33.50	

Valparaiso, March 29, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W. E. W. E.	$12^h\ 0^m$	69.°	$36^d.9$ 102.1 36.9 102.6	$36^d.9$ 102.4	$65^d.5$	$r = 2.0$ ft.
	E. W. E. W.	12 13	68.	102.8 37.2 102.8 37.3	102.8 37.3	65.5	
Means			68.5		$2u^d$	65.50	

Coefficient of torsion, $v = 4.62$ div.

Valparaiso, March 29, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W. E. W. E.	$12^h\ 13^m$	68.°	$53^d.1$ 86.7 52.9 86.6	$53^d.0$ 86.6	$33^d.6$	$r = 2.5$ ft.
East.	E W. E. W.	12 28	68.	86.8 53.5 86.8 53.2	86.8 53.3	33.5	
Means			68.0		$2u^d$	33.55	

HORIZONTAL INTENSITY. OBSERVATIONS OF DEFLECTIONS.

Valparaiso April 7, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$8^h\ 55^m$	65°	$38^d.2$			$r = 2.0$ ft.
	E.			102.9	$38^d.0$	$64^d.9$	
	W.			37.9	102.9		
	E.			103.0			
East.	E.			104.0			
	W.			37.2	103.9	66.7	
	E.			103.9	37.2		
	W.	9 10	67	37.2			
Means			66.0		$2u^d$	65.80	

Coefficient of torsion, $v = 4.68$ div.

Valparaiso, April 7, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$9^h\ 10^m$	67°	$53^d.8$			$r = 2.5$ ft.
	E.			87.2	$53^d.9$	$33^d.4$	
	W.			54.0	87.3		
	E.			87.3			
East.	E.			87.7			
	W.			53.6	87.6	34.1	
	E.			87.6	53.5		
	W.	9 25	69	53.4			
Means			68.0		$2u^d$	33.75	

Valparaiso, April 11, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$1^h\ 0^m$	74.°	$39^d.2$			$r = 2.0$ ft.
	E.			104.3	$39^d.2$	$65^d.1$	
	W.			39.3	104.3		
	E.			104.4			
East.	E.			105.2			
	W.			38.9	105.2	66.2	
	E.			105.3	39.0		
	W.	1 11	74.	39.2			
Means			74.0		$2u^d$	65.65	

Valparaiso, April 11, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$1^h\ 11^m$	74°	$55^d.2$			$r = 2.5$ ft.
	E.			88.4	$55^d.2$	$33^d.3$	
	W.			55.2	88.5		
	E.			88.6			
East.	E.			88.9			
	W.			54.9	88.9	34.0	
	E.			88.9	54.9		
	W.	1 23	74	54.8			
Means			74.0		$2u^d$	33.65	

Valparaiso, April 13, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$1^h\ 55^m$	71°.	$37^d.2$			$r = 2.0$ ft.
	E.			102.0	$37^d.0$	$64^d.8$	
	W.			36.9	101.8		
	E.			101.6			
East.	E.			102.2			
	W.			36.0	101.9	66.1	
	E.			101.7	35.8		
	W.	2 7	65.	35.6			
Means			68.0		$2u^d$	65.45	

Valparaiso, April 13, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$2^h\ 7^m$	65°.	$51^d.9$			$r = 2.5$ ft.
	E.			84.9	$51^d.7$	$33^d.2$	
	W.			51.5	84.9		
	E.			84.9			
East.	E.			85.4			
	W.			51.0	85.2	34.2	
	E.			85.0	51.0		
	W.	2 20	62.	50.9			
Means			63.5		$2u^d$	33.70	

Horizontal Intensity. Observations of Deflections.

San Lorenzo Island, April 26, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	11^{h} 40^{m}	79°	51^{d}.0			$r = 2.0$ ft.
	E.			109.7	50^{d}.9	58^{d}.7	
	W.			50.9	109.6		
	E.			109.6			
East.	E.			110.4			
	W.			50.9	110.4	59.6	
	E.			110.4	50.8		
	W.	11 52	82	50.7			
Means			80.5		2u^{d}.	59.15	

Coefficient of torsion, $v = 4.25$ div.

San Lorenzo Island, April 26, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	11^{h} 52^{m}	82°	65^{d}.3			$r = 2.5$ ft.
	E.			95.4	65^{d}.1	30^{d}.0	
	W.			65.0	95.1		
	E.			94.9			
East.	E.			95.4			
	W.			64.8	95.4	30.5	
	E.			95.4	64.9		
	W.	12 7	74	65.0			
Means			78.0		2u^{d}	30.25	

Payta, May 7, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	7^{h} 33^{m}	77°	52^{d}.2			$r = 2.0$ ft.
	E.			107.7	52^{d}.1	55^{d}.6	
	W.			52.0	107.7		
	E.			107.8			
East.	E.			108.4			
	W.			51.6	108.4	56.8	
	E.			108.3	51.6		
	W.	7 46	77	51.6			
Means			77.0		2u^{d}	56.20	

Coefficient of torsion, $v = 3.62$ div.

Payta, May 7, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	7^{h} 46^{m}	77°	65^{d}.2			$r = 2.5$ ft.
	E.			93.7	65^{d}.1	28^{d}.6	
	W.			65.0	93.7		
	E.			93.6			
East.	E.			94.0			
	W.			64.7	94.0	29.3	
	E.			94.0	64.7		
	W.	7 59	77	64.7			
Means			77.0		2u^{d}	28.95	

Flamenco Island, Panama Bay, May 14, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	7^{h} 55^{m}	83°	50^{d}.7			$r = 2.0$ ft.
	E.			104.6	50^{d}.8	53^{d}.8	
	W.			51.0	104.6		
	E.			104.7			
East.	E.			105.6			
	W.			50.4	105.5	53.3	
	E.			105.5	52.2		
	W.	8 5	82	50.1			
Means			82.5		2u^{d}	53.55	

Coefficient of torsion, $v = 3.18$ div.

Flamenco Island, Panama Bay, May 14, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternute Means.	Diff's.	Dist.
West.	W.	8^{h} 5^{m}	82°	64^{d}.0			$r = 2.5$ ft.
	E.			91.7	64^{d}.0	27^{d}.6	
	W.			64.0	91.6		
	E.			91.6			
East.	E.			92.0			
	W.			63.8	92.0	28.2	
	E.			92.0	63.8		
	W.	8 15	82	63.8			
Means			82.0		2u^{d}	27.90	

Horizontal Intensity. Observations of Deflections.

Acapulco, May 30, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$7^h\ 22^m$	86°	$53^d.9$			$r = 2.0$ ft.
	E.			107.0	$53^d.9$	$53^d.1$	
	W.			53.9	107.0		
	E.			107.0			
East.	E.			107.5			
	W.			53.5	107.6	54.0	
	E.			107.7	53.6		
	W.	7 32	84	53.8			
Means			85.0		$2u^d$	53.55	

Coefficient of torsion, $v = 3.45$ div.

Acapulco, May 30, 1866.

Magnet.	North end.	Time.	Temp. t	Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$7^h\ 32^m$	84°	$66^d.9$			$r = 2.5$ ft.
	E.			94.1	$66^d.9$	$27^d.3$	
	W.			66.9	94.2		
	E.			94.2			
East.	E.			94.4			
	W.			66.8	94.4	27.6	
	E.			94.4	66.8		
	W.	7 40	85	66.8			
Means			84.5		$2u^d$	27.45	

Magdalena Bay, June 9, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$1^h\ 14^m$	65°	$49^d.4$			$r = 2.0$ ft.
	E.			106.6	$49^d.4$	$57^d.3$	
	W.			49.4	106.7		
	E.			106.8			
East.	E.			106.7			
	W.			49.6	107.3	57.6	
	E.			107.9	49.7		
	W.	1 40	65	49.7			
Means			65.0		$2u^d$	57.45	

Assumed coefficient of torsion, $v = 3.87$ div.
Magnet very unsteady, and its readings uncertain on account of a stiff breeze which shook the instrument.

Magdalena Bay, June 9, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$1^h\ 40^m$	65°	$64^d.0$			$r = 2.5$ ft.
	E.			93.1	$63^d.9$	$29^d.7$	
	W.			63.7	93.6		
	E.			94.1			
East.	E.			94.7			
	W.			65.0	95.1	29.7	
	E.			95.4	65.4		
	W.	2 15	65	65.8			
Means			65.0		$2u^d$	29.70	

San Diego Bay, June 15, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$2^h\ 44^m$	72°	$45^d.9$			$r = 2.0$ ft.
	E.			111.3	$46^d.1$	$65^d.2$	
	W.			46.3	111.3		
	E.			111.2			
East.	E.			112.6			
	W.			45.8	112.5	66.7	
	E.			112.5	45.8		
	W.	2 53	71	45.8			
Means			71.5		$2u^d$	65.95	

Coefficient of torsion, $v = 4.28$ div.

San Diego Bay, June 15, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W.	$2^h\ 53^m$	71°	$62^d.2$			$r = 2.5$ ft.
	E.			95.4	$62^d.2$	$33^d.2$	
	W.			62.2	95.4		
	E.			95.4			
East.	E.			95.4			
	W.			61.6	95.6	33.9	
	E.			95.8	61.7		
	W.	3 6	70	61.8			
Means			70.5		$2u^d$	33.55	

Horizontal Intensity. Observations of Deflections.

San Francisco Bay, June 26, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
est.	W. E. W. E.	$6^h\ 40^m$	65.°	$42^d.3$ 114.8 42.6 115.1	$42^d.4$ 114.9	$72^d.5$	$r = 2.0$ ft.
East.	E. W. E. W.	6 50	62.	116.1 43.0 116.3 43.0	116.2 43.0	73.2	
Means			63.5		$2u^d$	72.85	

Coefficient of torsion, $v = 5.30$ div.

San Francisco Bay, June 26, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W. E. W. E.	$6^h\ 50^m$	62.°	$60^d.8$ 98.0 60.7 98.4	$60^d.8$ 98.2	$37^d.4$	$r = 2.5$ ft.
East.	E. W. E. W.	6 59	63.	98.4 61.0 98.4 60.9	98.4 60.9	37.5	
Means			62.5		$2u^d$	37.45	

U. S. N. Observatory, Washington, Nov. 1, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W. E. W. E.	$1^h\ 4^m$	66.°	$28^d.5$ 123.6 28.5 122.8	$28^d.5$ 123.2	$94^d.7$	$r = 2.0$ ft.
East.	E. W. E. W.	1 22	66.	124.5 29.3 125.5 28.1	125.0 28.7	96.3	
Means			66.0		$2u^d$	95.50	

Coefficient of torsion, $v = 7.05$ div.

U. S. N. Observatory, Washington, Nov. 1, 1866.

Magnet.	North end.	Time.	Temp. t	Scale Readings.	Alternate Means.	Diff's.	Dist.
West.	W. E. W. E.	$1^h\ 22^m$	66.°	$52^d.5$ 100.9 52.6 100.5	$52^d.5$ 100.7	$48^d.2$	$r = 2.5$ ft.
East.	E. W. E. W.	1 44	67.	102.0 52.6 101.4 52.3	101.7 52.5	49.2	
Means			66.5		$2u^d$	48.70	

SECTION V.

OBSERVATIONS ON THE MAGNETISM OF THE SHIP.

THE Monadnock is a second rate iron-clad vessel, of the Monitor type, of 1564 tons old or 1091 tons new measurement. On deck her length is 260.5 feet, and her breadth 52.0 feet. She has a wooden hull, but her deck is covered by three layers of iron plates, each one inch thick; and her sides, for a depth of five feet from the deck, are covered by six layers of iron plates, each one inch thick. Thus the deck is protected by three, and the sides by six inches of iron. She is provided with two iron turrets, cylindrical in form, each 22.8 feet in outside diameter, 9.0 feet high, and 11 inches thick. On top of each of them stands an iron pilot-house, 7.7 feet in outside diameter, 6.4 feet high, and 11 inches thick. Each of these pilot-houses is cylindrical in form, and so placed that its axis coincides with the axis of the turret upon which it stands. The sides of the turrets and pilot-houses are not solid, but are composed of iron plates, each one inch thick, placed one upon the other and bolted together till a total thickness of eleven inches is attained. To each of the iron pilot-houses are bolted wooden stanchions, which carry wooden pilot-houses whose floors are about nine and a half feet above the tops of the iron pilot-houses. The centres of the wooden pilot-houses are respectively in the same vertical lines with the centres of the turrets and iron pilot-houses over which they stand. The centres of the turrets coincide with the midships line. The distance from the stern of the vessel to the centre of the after turret is 84.5 feet; from the centre of the after turret to the centre of the forward turret, 99.1; and from the centre of the forward turret to the cut-water, 76.9 feet. Passing forward from the after turret, we come first to the ventilator, which is 6.5 feet in diameter, and 22.8 feet high above the deck; and then to the smoke-stack, which is 9.9 feet in diameter, and 31.0 feet high above the deck, both it and the ventilator being of iron. The distance from the centre of the after turret to the centre of the ventilator is 31.3 feet; from the centre of the ventilator to the centre of the smoke-stack, 16.5 feet; and from the centre of the smoke-stack to the centre of the forward turret, 51.3 feet.

At St. Thomas, before the magnetic observations on board ship were made at that place, a wooden mast 77.7 feet high was placed on the ship in order to enable her to carry some sail. Its centre is 22 feet forward of the centre of the forward turret, and what little iron was used in its construction is so placed that it is not at all probable that it affected the deviation of the compasses in its neighborhood in the slightest.

The following are the designations and positions of the compasses which were used during the cruise:—

The Forward Alidade was a Sands Alidade Compass, and was on top of the forward wooden pilot-house, 33.5 feet above the iron deck.

The Forward Binnacle was a Ritchie Liquid Compass, and was in the binnacle of the forward wooden pilot-house, 27.2 feet above the iron deck.

The Forward Ritchie was a Ritchie Monitor Compass, and was 6.7 feet above the top of the iron pilot-house on the forward turret. It was 22.1 feet above the iron deck.

Of these three compasses, the Forward Alidade and Forward Ritche were placed exactly in the vertical line passing through the centre of the forward turret, and the Forward Binnacle was placed about two feet further forward, but nearly in the same vertical plane.

The Admiralty Standard Compass was on top of the after wooden pilot-house, 37.0 feet above the iron deck.

The After Binnacle was a Ritchie Liquid Compass, and was in the binnacle of the after wooden pilot-house, 27.2 feet above the iron deck.

The After Ritchie was a Ritchie Monitor Compass, and was 6.7 feet above the top of the iron pilot-house on the after turret. It was 22.1 feet above the iron deck.

Of these three compasses, the Admiralty Standard and After Ritchie were placed exactly in the vertical line passing through the centre of the after turret, and the After Binnacle was placed about two feet futher forward, but nearly in the same vertical plane.

The After Azimuth was a common Azimuth Compass which was set up temporarily on the quarter deck every time the ship was swung; small cavities having been cut in the iron surface of the deck for the reception of the feet of the tripod, so as to make sure that the instrument always occupied precisely the same position. It stood 47.5 feet abaft the centre of the after turret, and there were two vertical iron stanchions, each two inches in diameter, 10.3 feet high above the deck, and 12.1 feet distant from the compass, one of them being directly forward and the other directly aft of it. This compass was elevated 4.6 feet above the iron deck; but when observations of magnetic force were made, it was necessary to remove it and substitute an Admiralty Standard Compass, which occupied precisely the same position, except that it was 4.8 feet above the deck. When the dip circle was used it also stood 4.8 feet above the deck.

It will be observed that *all* the compasses stood in the midships line, no matter what their elevation above the deck might be.

All the observations for determining the deviations of the compasses were made by swinging the ship in the following manner: The true azimuth of a well defined distant object was determined by a solar bearing, as explained in Section III, page 26, and the declination of the magnetic needle having been applied to it, its true magnetic azimuth became known; then, supposing the sight vanes of the Admiralty Standard Compass to be kept pointed steadily to that object while the ship was swung, the reading which they would indicate on the azimuth circle attached to the cover of the compass, as the ship's head pointed successively to each of the true magnetic points, was computed by means of the formula

$$R = 180° + A - \zeta$$

where

R = reading of sight vanes on the azimuth circle attached to the cover of the compass.

A = true magnetic azimuth of the distant object; the azimuth being counted from the south around by the west.

ζ = azimuth of the ship's head, counted from the correct magnetic north around by the east.

This having been done, on a tolerably calm day steam was got up in the boilers, and, the vessel riding at a single anchor, slack water was waited for. As soon as the tide ceased to run, the executive officer took the deck; an officer was stationed at each of the compasses; I went to the Admiralty Standard; and a quartermaster was stationed at the ship's bell. Then the helm was put hard-a-starboard, or hard-a-port, depending on the direction in which it was desired to have her head swing, and the engines having been started, one forward and the other backward (the Monadnock was provided with twin screws which were entirely independent of each other), the vessel at once began to turn, without bringing any considerable strain on her cable. Her motion was perfectly under control, and could be made fast or slow at pleasure by merely varying the speed of the engines. I then set the sight vanes of the Admiralty Standard Compass to the reading (on the azimuth circle) of the point at which the ship's head would first arrive, and placing my eye to them I watched for the instant when they pointed to the distant object chosen as an azimuth mark. As the thread of the sight vane approached the object I cautioned the quartermaster to be ready, and at the instant it covered the object I made a signal, by dropping my outstretched arm, and the quartermaster struck a single stroke on the bell. Upon hearing this, every officer at once read off and recorded the heading of the ship, as indicated by the compass at which he was stationed. Then, the engines not having been stopped, I turned the sight vanes forward to the reading of the next point, and the same process was repeated; and so on, till the readings of all the compasses had been observed at each of the thirty-two points, which was generally accomplished in about an hour, or an hour and a half. The difference between any observed reading and the true point to which the vessel's head was directed at the time that reading was made, was of course the deviation of the compass on that point.

The forward iron and wooden pilot-houses were fixed and did not revolve with the turret, so that the lubber lines of the compasses in them always remained in the same position. But with the after iron and wooden pilot-houses the case was different. They were attached to the turret and revolved with it, and by so doing caused the lubber lines of the compasses in them also to revolve. As the turrets were frequently turned, it became necessary to establish marks by which the position of the after one could always be referred to some fixed position, so that a correction could be applied to the readings of the compasses in its pilot-houses to reduce them to what they would have been if their lubber lines had not moved For this purpose, whenever the ship was swung, a fixed line on the under side of the hurricane deck was produced till it touched the after turret, and then the distance from its point of contact with the turret to a joint (marked number XII) on the outside of the turret was measured. This distance, having been converted into degrees and minutes by means of the known diameter of the turret, was the correction to be applied to the position of the lubber lines. The following table gives the measured distance, and its angular equivalent, at every station where the ship was swung; but it must be noticed that these corrections apply *only to the After Binnacle and After Ritchie Compasses.* The lubber line of the Admiralty Standard Compass was always properly adjusted before beginning to observe.

Station.	Joint XII.	Lubber Line.
Hampton Roads	$14^{in}.4$ port	Assumed correct.
St. Thomas	14.4 "	" "
Salute Islands	0.6 starboard	6° 18′ east.
Ceara	0.6 "	6 18 "
Bahia	0.6 "	6 18 "
Rio Janeiro	0.8 port	5 43 "
Monte Video	4.5 "	4 9 "
Sandy Point	4.5 "	4 9 "
Valparaiso	4.2 "	4 17 "
Callao	5.5 "	3 44 "
Panama	5.5 "	3 44 "
Acapulco	5.5 "	3 44 "
Magdalena Bay	5.5 "	3 44 "
San Francisco	5.3 "	3 49 "

When the ship was being swung, I always read the Admiralty Standard Compass myself. Each of the other compasses was usually read by the officer whose name is set opposite to it in the following table.

Forward Alidade,	Lieutenant M. Miller.
Forward Binnacle,	Lieut. Miller, assisted by a Quartermaster.
Forward Ritchie,	Lieutenant Geo. Smith.
After Binnacle,	Ensign F. Wildes.
After Ritchie,	Master Wm. Barrymore.
After Azimuth,	Mate Jno. Ponte.

My instruments for the measurement of magnetic force restricted me to the method of deflections, and the only compasses on board at which that method could be applied were the Admiralty Standard and the After Azimuth. As the ship was always riding at anchor, and of course swinging a little, when such observations were made, in order to render them as accurate as possible the following plan was adopted.

The deflecting bar was screwed to the movable circle which carried the sight vanes of the Admiralty Standard Compass in such a position as to be at right angles to them. That is, when the sight vanes pointed north and south the deflecting bar pointed east and west. Then, 1°. The sights being directed exactly north and south, as indicated by the compass card, the point, which we will designate by *H*, cut by them on the northern or southern horizon, as might be most convenient, was noted. 2°. The deflecting magnets were placed in the carriers, one to the east and the other to the west of the compass card, both being at the same distance from the centre of the card, and with their similar poles pointing in the same direction. Then, keeping the sight vanes pointed steadily to the object *H*, as soon as the compass card ceased to vibrate it was read off by means of the prism attached to the sight vane. Let this reading be designated as *A*. 3°. Each deflecting magnet was reversed, end for end, in its own carrier, and, the sight vanes being still kept directed to the object *H*, the card was again read. Let this reading be designated as *B*. Then the observed angle of deflection is $\frac{A-B}{2}$.

The dip was obtained by removing the Admiralty Standard Compass with which the deflections had been observed, and putting in its place a dip circle; the axle of the dipping needle occupying precisely the same position that had previously been occupied by the pivot of the compass card.

The observations of the deviations of the compasses made during the cruise have been compared with the following theory, which is taken from the English Admiralty Manual of the Deviations of the Compass, edition of 1863.

Let

X, Y, Z, represent the force of the earth's magnetism drawing the north point of the compass needle to the ship's head, to the starboard side and vertically downwards.

X', Y', Z', represent the combined force of the magnetism of the earth and ship in the same directions.

a, b, c, d, e, f, g, h, k, represent constant coefficients depending on the amount and arrangement of the soft iron of the ship.

P, Q, R, represent constant coefficients depending on the amount, arrangement, and independent magnetism of the hard iron of the ship.

$H =$ the horizontal force of the earth.

$H' =$ the horizontal force of the earth and ship.

θ = the dip.

ζ = azimuth of the ship's head measured eastward from the correct magnetic north.

ζ' = azimuth of the ship's head measured from the direction of the disturbed needle.

$\delta = \zeta - \zeta' =$ the deviation of the compass.

Then the whole mathematical theory of the deviations of the compass is comprised in the three following equations:

$$X' = X + aX + bY + cZ + P \qquad (1)$$

$$Y' = Y + dX + eY + fZ + Q \qquad (2)$$

$$Z' = Z + gX + hY + kZ + R \qquad (3)$$

We have also

$$X = H \cos\zeta \qquad Y = -H \sin\zeta \qquad Z = H \tan\theta$$
$$X' = H' \cos\zeta' \qquad Y' = -H \sin\zeta'$$

Substituting these values in equations (1), (2), and (3), and dividing by H, we have

$$\frac{H'}{H} \cos\zeta' = (1+a)\cos\zeta - b\sin\zeta + c\tan\theta + \frac{P}{H} \tag{4}$$

$$-\frac{H}{H} \sin\zeta' = d\cos\zeta - (1+e)\sin\zeta + f\tan\theta + \frac{Q}{H} \tag{5}$$

$$\frac{Z'}{H} = g\cos\zeta - h\sin\zeta + (1+k)\tan\theta + \frac{R}{H} \tag{6}$$

Equation (6) may be written

$$0 = 1 - \frac{Z'}{Z} + g\frac{\cos\zeta}{\tan\theta} - h\frac{\sin\zeta}{\tan\theta} + k + \frac{R}{Z} \tag{6a}$$

From equations (4) and (5) we obtain the following:

(4) cos ζ — (5) sin ζ gives after some reductions

$$\frac{H'}{H}\cos\delta = 1 + \frac{a+e}{2} + \left(c\tan\theta + \frac{P}{H}\right)\cos\zeta - \left(f\tan\theta + \frac{Q}{H}\right)\sin\zeta$$
$$+ \frac{a-e}{2}\cos 2\zeta - \frac{d+b}{2}\sin 2\zeta \qquad 7)$$

(4) sin ζ + (5) cos ζ gives after some reductions

$$\frac{H'}{H}\sin\delta = \frac{d-b}{2} + \left(c\tan\theta + \frac{P}{H}\right)\sin\zeta + \left(f\tan\theta + \frac{Q}{H}\right)\cos\zeta$$
$$+ \frac{a-e}{2}\sin 2\zeta + \frac{d+b}{2}\cos 2\zeta \tag{8}$$

Now let

$$1 + \frac{a+e}{2} = \lambda \qquad \frac{d-b}{2} = \lambda\mathfrak{A}$$
$$\frac{a-e}{2} = \lambda\mathfrak{D} \qquad \frac{d+b}{2} = \lambda\mathfrak{E}$$
$$c\tan\theta + \frac{P}{H} = \lambda\mathfrak{B} \qquad f\tan\theta + \frac{Q}{H} = \lambda\mathfrak{C}$$

Then from equations (7) and (8) we get the following:

$$\frac{H}{\lambda H}\cos\delta = 1 + \mathfrak{B}\cos\zeta - \mathfrak{C}\sin\zeta + \mathfrak{D}\cos 2\zeta - \mathfrak{E}\sin 2\zeta \tag{9}$$

$$\frac{H'}{\lambda H}\sin\delta = \mathfrak{A} + \mathfrak{B}\sin\zeta + \mathfrak{C}\cos\zeta + \mathfrak{D}\sin 2\zeta + \mathfrak{E}\cos 2\zeta \tag{10}$$

Dividing (10) by (9),

$$\tan\delta = \frac{\mathfrak{A} + \mathfrak{B}\sin\zeta + \mathfrak{C}\cos\zeta + \mathfrak{D}\sin 2\zeta + \mathfrak{E}\cos 2\zeta}{1 + \mathfrak{B}\cos\zeta - \mathfrak{C}\sin\zeta + \mathfrak{D}\cos 2\zeta - \mathfrak{E}\sin 2\zeta} \tag{11}$$

From (11) we easily get

$$\begin{aligned}\sin\delta &= \mathfrak{A}\cos\delta + \mathfrak{B}\sin\zeta' + \mathfrak{C}\cos\zeta' + \mathfrak{D}\sin(\zeta + \zeta') + \mathfrak{E}\cos(\zeta + \zeta') \qquad (12)\\ &= \mathfrak{A}\cos\delta + \mathfrak{B}\sin\zeta' + \mathfrak{C}\cos\zeta' + \mathfrak{D}\sin(2\zeta' + \delta) + \mathfrak{E}\cos(2\zeta' + \delta)\end{aligned}$$

Of the last three equations (11) is used when the deviations are given on the correct magnetic points, (12) when the deviations are given on the compass points affected by deviation.

Equation (12) may be put under the following form, which is sometimes convenient, and which is very nearly exact, viz.:

$$\sin\delta = \frac{1}{1 - \mathfrak{D}\cos 2\zeta'}\left\{\mathfrak{A} + \mathfrak{B}\sin\zeta' + \mathfrak{C}\cos\zeta' + \mathfrak{D}\sin 2\zeta' + \mathfrak{E}\cos 2\zeta'\right\} \qquad (12a)$$

By means of the expressions for sin δ we may calculate the values of the coefficients $\mathfrak{A}$, $\mathfrak{B}$, $\mathfrak{C}$, $\mathfrak{D}$, $\mathfrak{E}$, if we know the deviations on five points. If we have the deviations on more than five points, we may determine the most probable values of the coefficients by the method of least squares; but the calculation will in general be long and difficult.

If, however, the compass points on which the deviations are given divide the circumference into equal parts, we may determine the exact coefficients $\mathfrak{A}$, $\mathfrak{B}$, $\mathfrak{C}$, $\mathfrak{D}$, $\mathfrak{E}$, with great ease, and a sufficient degree of approximation, by determining first the approximate coefficients A, B, C, D, E, and then deducing from them the values of the exact coefficients. For that purpose we proceed as follows:

If the coefficients are less than 20° their squares and products may be neglected, and equation (12) may be put under the form

$$\delta = A + B\sin\zeta' + C\cos\zeta' + D\sin 2\zeta' + E\cos 2\zeta' \qquad (13)$$

Let δ_0 δ_1 $\delta_2 \ldots \delta_{31}$ be the deviations observed on the 32 points, by compass, S_1 S_2 S_3 $\ldots S_7$ the natural sines of the rhumbs or of the angles 11° 15′, 22° 30′.... 78° 45′ respectively, then if the observations have been made on the 32 points we have the following 32 equations from which to determine A, B, C, D, E.

Compass Courses.	Deviation.	A	$+ B \sin \zeta'$	$+ C \cos \zeta'$	$+ D$ and 2ζ	$+ E \cos 2 \zeta'$
North	δ_0	A		$+ C$		$+ E$
N. by E.	δ_1	A	$+ B S_1$	$+ C S_7$	$+ D S_2$	$+ E S_6$
N. N. E.	δ_2	A	$+ B S_2$	$+ C S_6$	$+ D S_4$	$+ E S_4$
N. E. by N.	δ_3	A	$+ B S_3$	$+ C S_5$	$+ D S_6$	$+ E S_2$
N. E.	δ_4	A	$+ B S_4$	$+ C S_4$	$+ D$	
N. E. by E.	δ_5	A	$+ B S_5$	$+ C S_3$	$+ D S_6$	$- E S_2$
E. N. E.	δ_6	A	$+ B S_6$	$+ C S_2$	$+ D S_4$	$- E S_4$
E. by N.	δ_7	A	$+ B S_7$	$+ C S_1$	$+ D S_2$	$- E S_6$
East	δ_8	A	$+ B$			$- E$
E. by S.	δ_9	A	$+ B S_7$	$- C S_1$	$- D S_2$	$- E S_6$
E. S. E.	δ_{10}	A	$+ B S_6$	$- C S_2$	$- D S_4$	$- E S_4$
S. E. by E.	δ_{11}	A	$+ B S_5$	$- C S_3$	$- D S_6$	$- E S_2$
S. E.	δ_{12}	A	$+ B S_4$	$- C S_4$	$- D$	
S. E. by S.	δ_{13}	A	$+ B S_3$	$- C S_5$	$- D S_6$	$+ E S_2$
S. S. E.	δ_{14}	A	$+ B S_2$	$- C S_6$	$- D S_4$	$+ E S_4$
S. by E.	δ_{15}	A	$+ B S_1$	$- C S_7$	$- D S_2$	$+ E S_6$
South	δ_{16}	A		$- C$		$+ E$
S. by W.	δ_{17}	A	$- B S_1$	$- C S_7$	$+ D S_2$	$+ E S_6$
S. S. W.	δ_{18}	A	$- B S_2$	$- C S_6$	$+ D S_4$	$+ E S_4$
S. W. by S.	δ_{19}	A	$- B S_3$	$- C S_5$	$+ D S_6$	$+ E S_2$
S. W.	δ_{20}	A	$- B S_4$	$- C S_4$	$+ D$	
S. W. by W.	δ_{21}	A	$- B S_5$	$- C S_3$	$+ D S_6$	$- E S_2$
W. S. W	δ_{22}	A	$- B S_6$	$- C S_2$	$+ D S_4$	$- E S_4$
W. by S.	δ_{23}	A	$- B S_7$	$- C S_1$	$+ D S_2$	$- E S_6$
West	δ_{24}	A	$- B$			$- E$
W. by N.	δ_{25}	A	$- B S_7$	$+ C S_1$	$- D S_2$	$- E S_6$
W. N. W.	δ_{26}	A	$- B S_6$	$+ C S_2$	$- D S_4$	$- E S_4$
N. W. by W.	δ_{27}	A	$- B S_5$	$+ C S_3$	$- D S_6$	$- E S_2$
N. W.	δ_{28}	A	$- B S_4$	$+ C S_4$	$- D$	
N. W. by N.	δ_{29}	A	$- B S_3$	$+ C S_5$	$- D S_6$	$+ E S_2$
N. N. W.	δ_{30}	A	$- B S_2$	$+ C S_6$	$- D S_4$	$+ E S_4$
N. by W.	δ_{31}	A	$- B S_1$	$+ C S_7$	$- D S_2$	$+ E S_6$

By the method of least squares we obtain, from these 32 equations of condition, the five normal equations

$$\delta_0 + \delta_1 + \delta_2 \ldots\ldots\ldots\ldots\ldots + \delta_{31} = 32 A.$$

$$\delta_1 S_1 + \delta_2 S_2 + \delta_3 S_3 + \&c. \ldots\ldots\ldots = 16 B.$$

$$\delta_0 + \delta_1 S_7 + \delta_2 S_6 + \&c. \ldots\ldots\ldots\ldots = 16 C.$$

$$\delta_1 S_2 + \delta_2 S_4 + \delta_3 S_6 + \&c. \ldots\ldots\ldots = 16 D.$$

$$\delta_0 + \delta_1 S_6 + \delta_2 S_4 + \&c. \ldots\ldots\ldots\ldots = 16 E.$$

For convenience of computation these equations have been put under the form

$$\begin{aligned} 8 A = & \ \tfrac{1}{2}\left(\frac{\delta_0 + \delta_{16}}{2} + \frac{\delta_8 + \delta_{24}}{2}\right) \\ & + \tfrac{1}{2}\left(\frac{\delta_1 + \delta_{17}}{2} + \frac{\delta_9 + \delta_{25}}{2}\right) \\ & + \tfrac{1}{2}\left(\frac{\delta_2 + \delta_{18}}{2} + \frac{\delta_{10} + \delta_{26}}{2}\right) \end{aligned}$$

$$+\tfrac{1}{2}\left(\frac{\delta_3+\delta_{19}}{2}+\frac{\delta_{11}+\delta_{27}}{2}\right)$$

$$+\tfrac{1}{2}\left(\frac{\delta_4+\delta_{20}}{2}+\frac{\delta_{12}+\delta_{28}}{2}\right)$$

$$+\tfrac{1}{2}\left(\frac{\delta_5+\delta_{21}}{2}+\frac{\delta_{13}+\delta_{29}}{2}\right)$$

$$+\tfrac{1}{2}\left(\frac{\delta_6+\delta_{22}}{2}+\frac{\delta_{14}+\delta_{30}}{2}\right)$$

$$+\tfrac{1}{2}\left(\frac{\delta_7+\delta_{23}}{2}+\frac{\delta_{15}+\delta_{31}}{2}\right)$$

$$8B = \frac{\delta_8+\delta_{24}}{2}$$

$$+\frac{\delta_1-\delta_{17}}{2}S_1+\frac{\delta_9-\delta_{25}}{2}S_7$$

$$+\frac{\delta_2-\delta_{18}}{2}S_2+\frac{\delta_{10}-\delta_{26}}{2}S_6$$

$$+\frac{\delta_3-\delta_{19}}{2}S_3+\frac{\delta_{11}-\delta_{27}}{2}S_5$$

$$+\frac{\delta_4-\delta_{20}}{2}S_4+\frac{\delta_{12}-\delta_{28}}{2}S_4$$

$$+\frac{\delta_5-\delta_{21}}{2}S_5+\frac{\delta_{13}-\delta_{29}}{2}S_3$$

$$+\frac{\delta_6-\delta_{22}}{2}S_6+\frac{\delta_{14}-\delta_{30}}{2}S_2$$

$$+\frac{\delta_7-\delta_{23}}{2}S_7+\frac{\delta_{15}-\delta_{31}}{2}S_1.$$

$$8C = \frac{\delta_0-\delta_{16}}{2}$$

$$+\frac{\delta_1-\delta_{17}}{2}S_7-\frac{\delta_9-\delta_{25}}{2}S_1$$

$$+\frac{\delta_2-\delta_{18}}{2}S_6-\frac{\delta_{10}-\delta_{26}}{2}S_2$$

$$+\frac{\delta_3-\delta_{19}}{2}S_5-\frac{\delta_{11}-\delta_{27}}{2}S_3$$

$$+\frac{\delta_4-\delta_{20}}{2}S_4-\frac{\delta_{12}-\delta_{28}}{2}S_4$$

$$+\frac{\delta_5-\delta_{21}}{2}S_3-\frac{\delta_{13}-\delta_{29}}{2}S_5$$

$$+\frac{\delta_6-\delta_{22}}{2}S_2-\frac{\delta_{14}-\delta_{30}}{2}S_6$$

$$+\frac{\delta_7-\delta_{23}}{2}S\;-\frac{\delta_{15}-\delta_{31}}{2}S_7$$

$$\begin{aligned} 4D = & \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad + \tfrac{1}{2}\left(\frac{\delta_4+\delta_{20}}{2}-\frac{\delta_{12}+\delta_{28}}{2}\right) \\ & + \tfrac{1}{2}\left(\frac{\delta_1+\delta_{17}}{2}-\frac{\delta_9+\delta_{25}}{2}\right)S_2 + \tfrac{1}{2}\left(\frac{\delta_5+\delta_{21}}{2}-\frac{\delta_{13}+\delta_{29}}{2}\right)S_6 \\ & + \tfrac{1}{2}\left(\frac{\delta_2+\delta_{18}}{2}-\frac{\delta_{10}+\delta_{26}}{2}\right)S_4 + \tfrac{1}{2}\left(\frac{\delta_6+\delta_{22}}{2}-\frac{\delta_{14}+\delta_{30}}{2}\right)S_4 \\ & + \tfrac{1}{2}\left(\frac{\delta_3+\delta_{19}}{2}-\frac{\delta_{11}+\delta_{27}}{2}\right)S_6 + \tfrac{1}{2}\left(\frac{\delta_7+\delta_{23}}{2}-\frac{\delta_{15}+\delta_{31}}{2}\right)S_2 \end{aligned}$$

$$\begin{aligned} 4E = & \quad \tfrac{1}{2}\left(\frac{\delta_0+\delta_{16}}{2}-\frac{\delta_8+\delta_{24}}{2}\right) \\ & + \tfrac{1}{2}\left(\frac{\delta_1+\delta_{17}}{2}-\frac{\delta_9+\delta_{25}}{2}\right)S_6 - \tfrac{1}{2}\left(\frac{\delta_5+\delta_{21}}{2}-\frac{\delta_{13}+\delta_{29}}{2}\right)S_2 \\ & + \tfrac{1}{2}\left(\frac{\delta_2+\delta_{18}}{2}-\frac{\delta_{10}+\delta_{26}}{2}\right)S_4 - \tfrac{1}{2}\left(\frac{\delta_6+\delta_{22}}{2}-\frac{\delta_{14}+\delta_{30}}{2}\right)S_4 \\ & + \tfrac{1}{2}\left(\frac{\delta_3+\delta_{19}}{2}-\frac{\delta_{11}+\delta_{27}}{2}\right)S_2 - \tfrac{1}{2}\left(\frac{\delta_7+\delta_{23}}{2}-\frac{\delta_{15}+\delta_{31}}{2}\right)S_6 \end{aligned}$$

But the deviations about to be discussed were all observed, not on the compass points, but on the correct magnetic points. Treating them in the manner which has just been described, we obtain the approximate coefficients A_1, B_1, C_1, D_1, E_1, which belong to the correct magnetic points. Then, from equation (11) we get, going to terms of the third order inclusive,

$$\begin{aligned} \delta = & \mathfrak{A} \\ & + (\mathfrak{B} + \mathfrak{A}\mathfrak{C}) \sin\zeta + (\mathfrak{C} - \mathfrak{A}\mathfrak{B} \cos\zeta \\ & + \left\{\mathfrak{D} - \frac{\mathfrak{B}^2 - \mathfrak{C}^2}{2}\right\} \sin 2\zeta + \left\{\mathfrak{E} - \mathfrak{B}\mathfrak{C} - \mathfrak{A}\mathfrak{D}\right\} \cos 2\zeta \\ & + \left\{-\mathfrak{B}\mathfrak{D} + \mathfrak{C}\mathfrak{E} + \frac{\mathfrak{B}^3}{3} - \mathfrak{B}\mathfrak{C}^2\right\} \sin 3\zeta \\ & + \left\{-\mathfrak{B}\mathfrak{E} - \mathfrak{C}\mathfrak{D} - \frac{\mathfrak{C}^3}{3} + \mathfrak{B}^2\mathfrak{C}\right\} \cos 3\zeta \\ & + \left\{-\frac{\mathfrak{D}^2}{2} + (\mathfrak{B}^2 - \mathfrak{C}^2)\mathfrak{D}\right\} \sin 4\zeta + \left\{-\mathfrak{D}\mathfrak{E} + 2\mathfrak{B}\mathfrak{C}\mathfrak{D}\right\} \cos 4\zeta \\ & + \mathfrak{B}\mathfrak{D}^2 \sin 5\zeta + \mathfrak{C}\mathfrak{D}^2 \cos 5\zeta \\ & + \tfrac{1}{3}\mathfrak{D}^3 \sin 6\zeta \end{aligned} \tag{14}$$

where δ is expressed in terms of the arc which is equal to radius. If we suppose the complete expression for δ to be

$$\begin{aligned} \delta = & A_1 + B_1 \sin\zeta + C_1 \cos\zeta + D_1 \sin 2\zeta + E_1 \cos 2\zeta \\ & + F_1 \sin 3\zeta + G_1 \cos 3\zeta + H_1 \sin 4\zeta + K_1 \cos 4\zeta \\ & + L_1 \sin 5\zeta + M_1 \cos 5\zeta + N_1 \sin 6\zeta \end{aligned} \tag{15}$$

Then, comparing equation (14) with equation (15), we find, to terms of the third order inclusive,

$$\begin{aligned}
\mathfrak{A} &= A_1 \\
\mathfrak{B} &= B_1 - A_1 C_1 \\
\mathfrak{C} &= C_1 + A_1 B_1 \\
\mathfrak{D} &= D_1 + \frac{B_1^2 - C_1^2}{2} \\
\mathfrak{E} &= E_1 + B_1 C_1 + A_1 D_1 \\
F_1 &= - B_1 D_1 + C_1 E_1 - \frac{B_1^3}{6} - \frac{B_1 C_1^2}{2} \\
G_1 &= - C_1 D_1 + B_1 E_1 \frac{C_1^3}{6} + \frac{C_1 B_1^2}{2} \\
H_1 &= - \frac{D_1^2}{2} + \frac{D_1 B_1^2}{2} - \frac{D_1 C_1^2}{2} \\
K_1 &= - D_1 E_1 + 2 B_1 C_1 D_1 \\
L_1 &= B_1 D_1^2 \\
M_1 &= C_1 D_1^2 \\
N_1 &= \tfrac{1}{3} D_1^3
\end{aligned} \qquad (16)$$

"When the deviation of the compass is small, the several parts of which it is composed are simply added together; these parts are,

1. A, the constant deviation.
2. $B \sin \zeta' + C \cos \zeta'$, the semicircular deviation.
3. $D \sin 2\zeta' + E \cos 2\zeta'$, the quadrantal deviation.

"When the deviation is large, $\mathfrak{A}$, $\mathfrak{B}$, $\mathfrak{C}$, $\mathfrak{D}$, $\mathfrak{E}$, or the angles of which these quantities are the natural sines, may still be considered as the constant and as the several parts of the semicircular and the quadrantal deviation, each of these angles being in fact the maximum deviation which would exist if all the other coefficients were zero; but their effects are no longer combined by simple addition."

Before submitting the observed deviations to comparison with the theory, it is necessary to free them from constant errors. These errors originated in two ways.

1°. When the ship was swung, the variation of the needle at the port where she was lying was seldom accurately known. Hence, in order to obtain the true magnetic azimuth of the object used as an azimuth mark, it was necessary to adopt, for the time being, the best value of the variation which happened to be accessible. In order to facilitate the setting of the sight vanes of the Admiralty Standard Compass while the ship was being swung, the value thus adopted was always so taken that, when the ship's head pointed successively to each of the true magnetic points, the reading of the sight vanes on the azimuth circle attached to the cover of that compass was always either some whole degree or some quarter of a degree. When the declinometer observations were reduced, the true value of the variation of the compass at each port became known, and then it was discovered that in some cases the adopted value was in error by more than three degrees. But an error in the adopted value of the variation produced an error of the same amount in the magnetic azimuth of the distant object used as an azimuth mark, and, therefore, in the pointing of the ship's head to each of the true magnetic points. Bearing in mind that the observed deviations were obtained by simply taking the difference between the heading of the ship and the reading of the compass, it will be apparent that if we apply to each observed deviation the difference between the true and adopted variation of the compass, with its proper sign, we shall obtain the true deviations for the directions in which the ship's head actually pointed at the time the readings of the compasses were made. From these corrected deviations the deviations on the true magnetic points can be found by simple interpolation. Therefore, if we let

m = the true, minus the adopted, magnetic azimuth of the distant object used as an azimuth mark: the azimuths being taken as increasing from the south around by the west.

δ' = the observed deviation of the compass when the ship headed in the direction A.

δ'' = the observed deviation of the compass when the ship headed in the direction $A \mp 11^\circ\ 15'$; the upper sign being taken when m is positive, the lower when m is negative.

δ = the deviation of the compass when the ship heads to the true magnetic point which lies between A and $A \mp 11^\circ\ 15'$; that point being of the same name as A was intended to be when the ship was swung.

Then we shall have with sufficient accuracy

$$\delta = \delta' + m \mp \frac{m\,(\delta' - \delta'')}{11^\circ\ 15'}$$

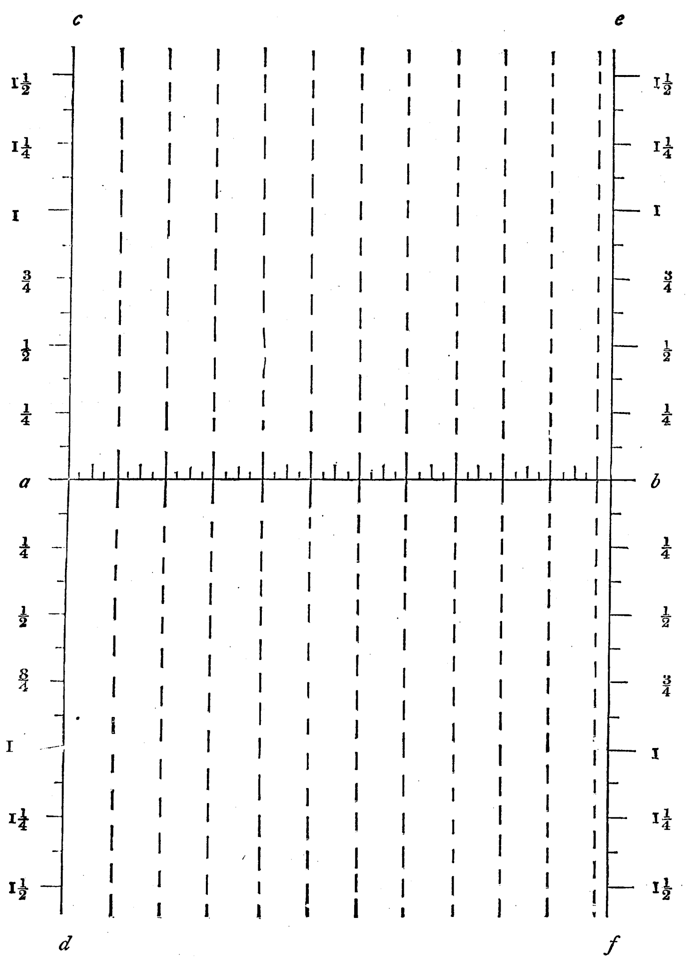
the upper sign being taken when m is positive, the lower when m is negative. By this formula the deviations of the Forward Alidade, Forward Binnacle, Forward Ritchie, Admiralty Standard, and After Azimuth Compasses, on the true magnetic points, have been computed from the observed deviations.

2°. In addition to the correction which has just been explained, the observed deviations of the After Binnacle and After Ritchie Compasses require a further correction on account of the lubber lines of these instruments revolving with the after turret, and thus being frequently out of their true position. This correction, which we will represent by L, is constant, and is equal in amount to the displacement of the lubber line. Its sign is + if the lubber line is to starboard, — if it is to port, of its true position. The deviations of the After Binnacle and After Ritchie Compasses, on the true magnetic points, were therefore computed from the observed deviations by the formula

$$\delta = \delta' + (m + L) \mp \frac{m\,(\delta' - \delta'')}{11^\circ\ 15'}$$

the upper sign being taken when m is positive, the lower when m is negative.

To have computed *numerically* all the values of δ for each compass by means of the expressions just given, would have involved a great amount of labor; it was therefore done graphically as follows:



On a piece of cardboard of suitable size a horizontal line $a\,b$, $5\frac{5}{8}$ inches long, was drawn, and divided into eighths of an inch; each half inch representing one degree, and the whole line representing 11° 15′, or one point of the compass. Touching the extremities of the line $a\,b$, and at right angles to it, were drawn the line $c\,d$ and $e\,f$; and each of them was divided, upward and downward from the line $a\,b$, into points and eights of points;[1] each point occupying the space of $2\frac{13}{16}$ of an inch. Finally, a straight slip of drawing paper was divided on its edge into degrees and sixths of a degree, each degree occupying a space of one-quarter of an inch; and the graduation was numbered from the middle towards each extremity.

Then, to compute the values of δ for any compass at any place, the paper scale was laid down parallel to, and to the right of, $c\,d$, and at a distance from it (measured on the line $a\,b$) equal to m; next, without moving the paper scale at all in the direction $a\,b$, it was slipped up or down, as might be necessary, in the direction parallel to $c\,d$, till the line $a\,b$ cut the division on it which was equal to $(m + L)$; the zero of the scale being above the line $a\,b$ if $(m + L)$ was negative, below it if

---

[1] For computing the deviations of the Admiralty Standard and After Azimuth Compasses the lines $c\,d$ and $e\,f$ were divided into degrees and sixths of a degree, each degree occupying the space of one-quarter of an inch.

$(m + L)$ was positive. Things being thus arranged, a weight was placed on the paper scale to prevent it from moving. Then a ruler being laid so that, while it crossed the line cd at a distance from a equal to δ', it also crossed the line ef at a distance from b equal to δ'' (the distances δ' and δ'' being taken *above* the line ab if they were *positive*, *below* it if they were *negative*), the reading of the point on the paper scale where the ruler crossed its edge was the required value of δ. In that way, without again moving the paper scale, the values of the deviations on each of the thirty-two true magnetic points were computed from the observed values.

The following table contains the constants which were used in computing from the observed deviations the deviations on the true magnetic points. The first column gives the name of the station. The second column, the distance in miles from the ship to the object used as an azimuth mark. The third column, the assumed magnetic azimuth of the object used as an azimuth mark; the azimuth being counted from the south around by the west. The fourth column, the true magnetic azimuth of the same object, found by applying the magnetic declination given in the table on page 61, section IV, to the true azimuth given in the table on page 36, section III. The fifth column, the value of m. The sixth column, the value of L; and the seventh column, the value of $(m + L)$.

Station.	Distance of Object in Miles.	Assumed Magnetic Azimuth.	True Magnetic Azimuth.	m	L	$(m + L)$
Hampton Roads . . .	6¼	9° 15′	13° 12′	+ 3° 57′	0° 0′	+ 3° 57′
St. Thomas	4½	327 30	327 45	+ 0 15	0 0	+ 0 15
Salute Islands	25	11 0	10 58	— 0 2	+ 6 18	+ 6 16
Ceara	4	268 45	270 36	+ 1 51	+ 6 18	+ 8 9
Bahia	5	103 30	106 0	+ 2 30	+ 6 18	+ 8 48
Rio Janeiro	5	126 30	129 14	+ 2 44	+ 5 43	+ 8 27
Monte Video	5	93 0	92 47	— 0 13	+ 4 9	+ 3 56
Sandy Point	26	345 15	345 22	+ 0 7	+ 4 9	+ 4 16
Valparaiso	3½	195 15	195 16	+ 0 1	+ 4 17	+ 4 18
Callao	5½	72 45	72 51	+ 0 6	+ 3 44	+ 3 50
Panama	7	15 0	15 1	+ 0 1	+ 3 44	+ 3 45
Acapulco	4	243 15	243 21	+ 0 6	+ 3 44	+ 3 50
Magdalena Bay	8	303 30	302 50	— 0 40	+ 3 44	+ 3 4
San Francisco	9	150 30	149 45	— 0 45	+ 3 49	+ 3 4

The following tables contain all the deviations of the compasses which were observed during the cruise. In each table the first column contains the assumed magnetic azimuth of the ship's head at the time the reading of the compass, given on the same line in the second column, was taken. The third column contains the observed deviation of the compass for each point, obtained by subtracting the readings in the second column from those in the first column. Hence, a deviation of the north point of the compass to the east is designated by the sign +; a deviation to the west by the sign —. The fourth column contains the deviation of the compass on each of the thirty-two true magnetic points. obtained from the observed deviations in the manner already explained.

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE ADMIRALTY STANDARD COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Hampton Roads, November 1, 1865.

Correction for Object = + 3° 57′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{8}$ E.	— $\frac{1}{8}$	° ′	+ 1° 30′
N. by E.	N. by E. $\frac{1}{8}$ E.	— $\frac{1}{8}$		+ 2 30
N. N. E.	N. N. E. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 4 20
N. E. by N.	N. E. by N. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 6 20
N. E.	N. E. $\frac{5}{8}$ N.	+ $\frac{5}{8}$		+ 9 30
N. E. by E.	N. E. by E. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 10 20
E. N. E.	E. N. E. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 9 30
E. by N.	E. by N. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 9 30
EAST.	E. $\frac{5}{8}$ N.	+ $\frac{5}{8}$		+ 10 30
E. by S.	E. by S. $\frac{5}{8}$ E.	+ $\frac{5}{8}$		+ 11 00
E. S. E.	E. S. E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 10 00
S. E. by E.	S. E. by E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 9 30
S. E.	S. E. $\frac{3}{8}$ E.	+ $\frac{3}{8}$		+ 8 40
S. E. by S.	S. E. by S. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 7 20
S. S. E.	S. S. E. $\frac{1}{4}$ S.	— $\frac{1}{4}$		+ 3 20
S. by E.	S. by E.	0		+ 3 0
SOUTH.	S. $\frac{1}{8}$ W.	— $\frac{1}{8}$		+ 3 0
S. by W.	S. by W. $\frac{3}{8}$ W.	— $\frac{3}{8}$		+ 0 40
S. S. W.	S. S. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 20
S. W. by S.	S. W. by S. $\frac{5}{8}$ W.	— $\frac{5}{8}$		— 2 30
S. W.	S. W. $\frac{3}{4}$ W.	— $\frac{3}{4}$		— 4 0
S. W. by W.	S. W. by W. $\frac{3}{4}$ W.	— $\frac{3}{4}$		— 4 30
W. S. W.	W. by S.	— 1		— 6 20
W. by S.	WEST.	— 1		— 7 20
WEST.	W. by N.	— 1		— 7 20
W. by N.	W. N. W.	— 1		— 7 20
W. N. W.	N. W. by W.	— 1		— 7 20
N. W. by W.	N. W. by W. $\frac{7}{8}$ N.	— $\frac{7}{8}$		— 6 20
N. W.	N. W. $\frac{7}{8}$ N.	— $\frac{7}{8}$		— 5 50
N. W. by N.	N. W. by N. $\frac{5}{8}$ N.	— $\frac{5}{8}$		— 4 0
N. N. W.	N. N. W. $\frac{5}{8}$ N.	— $\frac{5}{8}$		— 3 0
N. by W.	N. by W. $\frac{3}{8}$ N.	— $\frac{3}{8}$		— 1 20
NORTH.		— $\frac{1}{8}$		+ 1 30

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 1° 37′.4 B = + 9° 4′.6 C = — 0° 33′.1
D = + 0° 29′.2 E = — 0° 7′.5

Assumed magnetic bearing of tree S. 9° 15′ W. Distant $6\frac{1}{4}$ miles.

St. Thomas, West Indies, November 16, 1865.

Correction for Object = + 0° 16′ Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	— 0° 10′
N. by E.	N. by E. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 1 10
N. N. E.	N. N. E. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 40
N. E. by N.	N. E. by N. $\frac{3}{8}$ N.	+ $\frac{3}{8}$		+ 4 0
N. E.	N. E. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 5 20
N. E. by E.	N. E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 5 20
E. N. E.	N. E. by E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 5 20
E. by N.	E. N. E. $\frac{3}{8}$ E.	+ $\frac{5}{8}$		+ 6 40
EAST.	E. $\frac{5}{8}$ N.	+ $\frac{5}{8}$		+ 6 40
E. by S.	E. $\frac{1}{4}$ S.	+ $\frac{3}{4}$		+ 8 0
E. S. E.	E. by S. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 20
S. E. by E.	E. S. E. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 20
S. E.	S. E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 30
S. E. by S.	S. E. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 2 30
S. S. E.	S. S. E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 30
S. by E.	S. by E.	0		— 0 20
SOUTH.	SOUTH.	0		— 0 20
S. by W.	S. by W. $\frac{1}{8}$ W.	— $\frac{1}{8}$		— 1 40
S. S. W.	S. S. W. $\frac{1}{4}$ W.	— $\frac{1}{4}$		— 3 10
S. W. by S.	S. W. by S. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 5 50
S. W.	S. W. $\frac{3}{8}$ W.	— $\frac{3}{8}$		— 4 30
S. W. by W.	S. W. by W. $\frac{1}{4}$ W.	— $\frac{1}{4}$		— 3 10
W. S. W.	W. S. W. $\frac{3}{8}$ W.	— $\frac{3}{8}$		— 4 30
W. by S.	W. $\frac{5}{8}$ S.	— $\frac{3}{8}$		— 4 30
WEST.	W. $\frac{3}{8}$ N.	— $\frac{3}{8}$		— 4 30
W. by N.	W. by N. $\frac{3}{8}$ N.	— $\frac{3}{8}$		— 4 30
W. N. W.	W. N. W. $\frac{3}{8}$ N.	— $\frac{3}{8}$		— 4 30
N. W. by W.	N. W. $\frac{5}{8}$ W.	— $\frac{3}{8}$		— 4 30
N. W.	N. W. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 3 0
N. W. by N.	N. W. by N. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 3 0
N. N. W.	N. N. W. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 3 0
N. by W.	N. by W.	0		— 0 20
NORTH.		0		— 0 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 0° 14′.6 B = + 5° 45′.5 C = + 0° 33′.5
D = + 0° 3′.2 E = — 0° 48′.2

Assumed magnetic bearing of Nipple S. 32° 30′ E. Distant $4\frac{1}{2}$ miles.

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE ADMIRALTY STANDARD COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Isle Royal, Salute Islands, November 30, 1865.

Assumed Magnetic Bearing of Object = S. 11° 0′ W.
Correction for Object = — 0° 2′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.				
N. by E.				
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.	S. 5° 20′ W.		+ 5° 40′	+ 5° 40′
E. by S.	S. 5 40 W.		+ 5 20	+ 5 20
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = B = C =
D = E =

Ceara, December 19, 1865.

Assumed Magnetic Bearing of Object = N. 88° 45′ E.
Correction for Object = + 1° 51′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.				
N. by E.	N. 87° 40′ E.		+ 1° 5′	+ 2° 50′
N. N. E.	N. 87 0 E.		+ 1 45	+ 3 30
N. E. by N.	N. 86 0 E.		+ 2 45	+ 4 20
N. E.	N. 84 30 E.		+ 4 15	+ 5 50
N. E. by E.	N. 85 0 E.		+ 3 45	+ 5 40
E. N. E.	N. 85 0 E.		+ 3 45	+ 5 30
E. by N.	N. 85 30 E.		+ 3 15	+ 5 10
EAST.	N. 87 0 E.		+ 1 45	+ 3 50
E. by S.	N. 87 0 E.		+ 1 45	+ 3 30
E. S. E.	N. 88 0 E.		+ 0 45	+ 2 50
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 0° 34′.7 B = + 4° 46′.1 C = + 2° 18′.7
D = + 0° 49′.2 E = — 0° 14′.4

Observations for Determining the Deviations of the Admiralty Standard Compass on the U. S. Iron Clad Monadnock.

Bahia, December 30, 1865.

Assumed Magnetic Bearing of Object = N. 76° 30′ W.
Correction for Object = + 2° 30′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 76° 0′ W.		— 0° 30′	+ 1° 40′
N. by E.	N. 77 40 W.		+ 1 10	+ 3 20
N. N. E.	N. 77 40 W.		+ 1 10	+ 3 40
N. E. by N.	N. 78 40 W.		+ 2 10	+ 4 30
N. E.	N. 78 40 W.		+ 2 10	+ 4 40
N. E. by E.	N. 79 0 W.		+ 2 30	+ 5 0
E. N. E.	N. 79 40 W.		+ 3 10	+ 5 30
E. by N.	N. 79 40 W.		+ 3 10	+ 5 40
EAST.	N. 79 10 W.		+ 2 40	+ 5 20
E. by S.	N. 79 10 W.		+ 2 40	+ 5 10
E. S. E.	N. 78 40 W.		+ 2 10	+ 4 40
S. E. by E.	N. 78 10 W.		+ 1 40	+ 4 20
S. E.	N. 77 0 W.		+ 0 30	+ 3 20
S. E. by S.	N. 76 40 W.		+ 0 10	+ 2 40
S. S. E.	N. 76 10 W.		— 0 20	+ 2 10
S. by E.	N. 76 0 W.		— 0 30	+ 2 0
SOUTH.	N. 75 40 W.		— 0 50	+ 1 40
S. by W.	N. 75 10 W.		— 1 20	+ 1 20
S. S. W.	N. 75 0 W.		— 1 30	+ 1 0
S. W. by S.	N. 74 20 W.		— 2 10	+ 0 30
S. W.	N. 74 0 W.		— 2 30	0 0
S. W. by W.	N. 73 10 W.		— 3 20	— 0 40
W. S. W.	N. 72 40 W.		— 3 50	— 1 10
W. by S.	N. 72 0 W.		— 4 30	— 1 50
WEST.	N. 72 0 W.		— 4 30	— 2 0
W. by N.	N. 71 40 W.		— 4 50	— 2 10
W. N. W.	N. 72 0 W.		— 4 30	— 2 0
N. W. by W.	N. 72 0 W.		— 4 30	— 2 0
N. W.	N. 72 0 W.		— 4 30	— 2 0
N. W. by N.	N. 73 0 W.		— 3 30	— 1 10
N. N. W.	N. 74 0 W.		— 2 30	— 0 10
N. by W.	N. 74 40 W.		— 1 50	+ 0 30
NORTH.				+ 1 40

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 1° 40′.2 B = + 3° 38′.5 C = + 0° 0′.4
D = + 0° 47′.8 E = 0° 0′.0

Rio Janeiro, January 10, 1866.

Assumed Magnetic Bearing of Object = N. 53° 30′ W.
Correction for Object = + 2° 44′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.				
N. by E.				
N. N. E.				
N. E. by N.	N. 56° 0′ W.		+ 2° 30′	+ 4° 50′
N. E.	N. 57 0 W.		+ 3 30	+ 6 0
N. E. by E.	N. 57 20 W.		+ 3 50	+ 6 30
E. N. E.	N. 56 20 W.		+ 2 50	+ 5 50
E. by N.	N. 56 20 W.		+ 2 50	+ 5 30
EAST.	N. 56 0 W.		+ 2 30	+ 5 20
E. by S.	N. 55 40 W.		+ 2 10	+ 5 0
E. S. E.	N. 55 20 W.		+ 1 50	+ 4 40
S. E. by E.	N. 55 0 W.		+ 1 30	+ 4 20
S. E.	N. 54 40 W.		+ 1 10	+ 4 0
S. E. by S.	N. 54 0 W.		+ 0 30	+ 3 20
S. S. E.	N. 54 20 W.		+ 0 50	+ 3 30
S. by E.	N. 53 20 W.		— 0 10	+ 2 50
SOUTH.	N. 53 20 W.		— 0 10	+ 2 30
S. by W.	N. 53 0 W.		— 0 30	+ 2 20
S. S. W.	N. 52 40 W.		— 0 50	+ 2 0
S. W. by S.	N. 52 0 W.		— 1 30	+ 1 30
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 2° 35′.7 B = + 2° 58′.5 C = + 0° 0′.2
D = + 0° 53′.5 E = — 0° 3′.1

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE ADMIRALTY STANDARD COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Monte Video, January 24, 1866.

Assumed Magnetic Bearing of Object = N. 87° 0′ W.
Correction for Object = — 0° 13′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.				(+ 2°. 20′)
N. by E.	S. 89° 10′ W.		+ 3° 50′	+ 3 40
N. N. E.	S. 89 20 W.		+ 3 40	+ 3 30
N. E. by N	S. 88 40 W.		+ 4 20	+ 4 10
N. E.	S. 88 20 W.		+ 4 40	+ 4 30
N. E. by E.	S. 87 20 W.		+ 5 40	+ 5 30
E. N. E.	S. 87 40 W.		+ 5 20	+ 5 10
E. by N.	S. 88 30 W.		+ 4 30	+ 4 20
EAST.	S. 88 0 W.		+ 5 0	+ 4 50
E. by S.	S. 88 40 W.		+ 4 20	+ 4 00
E. S. E.	S. 89 10 W.		+ 3 50	+ 3 30
S. E. by E.	N. 89 40 W.		+ 2 40	+ 2 30
S. E.	N. 90 0 W.		+ 3 0	+ 2 50
S. E. by S.	N. 89 40 W.		+ 2 40	+ 2 20
S. S. E.	N. 89 0 W.		+ 2 0	+ 1 40
S. by E.	N. 89 0 W.		+ 2 0	+ 1 40
SOUTH.	N. 88 20 W.		+ 1 20	+ 1 0
S. by W.	N. 88 20 W.		+ 1 20	+ 1 0
S. S. W.	N. 88 0 W.		+ 1 0	+ 0 50
S. W. by S.	S. W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$	+ 2 49	+ 2 30
S. W.	S. W. $\frac{1}{8}$ S.	+ $\frac{1}{8}$	+ 1 24	+ 1 0
S. W. by W.	S. W. by W.	0	0 0	— 0 20
W. S. W.	W. S. W.	0	0 0	— 0 20
W. by S.	W. by S.	0	0 0	— 0 20
WEST.	W. $\frac{1}{8}$ N.	— $\frac{1}{8}$	— 1 24	— 1 40
W. by N.	W. by N. $\frac{1}{4}$ N.	— $\frac{1}{4}$	— 2 49	— 3 10
W. N. W.	W. N. W. $\frac{1}{4}$ N.	— $\frac{1}{4}$	— 2 49	— 3 10
N. W. by W.	N. W. $\frac{3}{4}$ W.	— $\frac{1}{4}$	— 2 49	— 3 0
N. W.	N. W. $\frac{1}{8}$ N.	— $\frac{1}{8}$	— 1 24	— 1 40
N. W. by N.	N. 87° 0′ W.		0 0	— 0 20
N. N. W.	N. 87 0 W.		0 0	— 0 10
N. by W.	N. 88 0 W.		+ 1 0	+ 0 50
NORTH.				(+ 2 20)

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 1° 32′.8 B = + 3° 4′.8 C = + 0° 5′.8
D = + 1° 19′.5 E = + 0° 14′.5

Sandy Point, February 10, 1866.

Assumed Magnetic Bearing of Object = S. 14° 45′ E.
Correction for Object = + 0° 7′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	S. 15° 0′ E.		+ 0° 15′	+ 0° 30′
N. by E.	S. 15 0 E.		+ 0 15	+ 0 30
N. N. E.	S. 15 40 E.		+ 0 55	+ 1 10
N. E. by N.	S. 16 0 E.		+ 1 15	+ 1 30
N. E.	S. 16 0 E.		+ 1 15	+ 1 30
N. E. by E.	S. 16 40 E.		+ 1 55	+ 2 10
E. N. E.	S. 17 0 E.		+ 2 15	+ 2 30
E. by N.	S. 16 40 E.		+ 1 55	+ 2 10
EAST.	S. 15 50 E.		+ 1 5	+ 1 20
E. by S.	S. 16 20 E.		+ 1 35	+ 1 50
E. S. E.	S. 16 0 E.		+ 1 15	+ 1 30
S. E. by E.	S. 16 20 E.		+ 1 35	+ 1 50
S. E.	S. 16 0 E.		+ 1 15	+ 1 30
S. E. by S.	S. 15 20 E.		+ 0 35	+ 0 50
S. S. E.	S. 15 40 E.		+ 0 55	+ 1 10
S. by E.	S. 15 20 E.		+ 0 35	+ 0 50
SOUTH.	S. 15 20 E.		+ 0 35	+ 0 50
S. by W.	S. 16 0 E.		+ 1 15	+ 1 30
S. S. W.	S. 16 0 E.		+ 1 15	+ 1 30
S. W. by S.	S. 15 50 E.		+ 1 5	+ 1 20
S. W.	S. 15 40 E.		+ 0 55	+ 1 10
S. W. by W.	S. 15 30 E.		+ 0 45	+ 1 0
W. S. W.	S. 14 40 E.		— 0 5	+ 0 10
W. by S.	S. 14 0 E.		— 0 45	— 0 30
WEST.	S. 14 10 E.		— 0 35	— 0 20
W. by N.	S. 13 0 E.		— 1 45	— 1 30
W. N. W.	S. 12 50 E.		— 1 55	— 1 40
N. W. by W.	S. 12 40 E.		— 2 5	— 1 50
N. W.	S. 12 40 E.		— 2 5	— 1 50
N. W. by N.	S. 13 0 E.		— 1 45	— 1 30
N. N. W.	S. 13 20 E.		— 1 25	— 1 10
N. by W.	S. 14 0 E.		— 0 45	— 0 30
NORTH.	S. 15 0 E.		+ 0 15	+ 0 30

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 0° 35′.9 B = + 1° 20′.6 C = — 0° 40′.6
D = + 0° 53′.5 E = + 0° 1′.5

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE ADMIRALTY STANDARD COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Valparaiso, April 4, 1866.

Assumed Magnetic Bearing of Object = N. 15° 15′ E.
Correction for Object = + 0° 1′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass
NORTH.	N. 15° 30′ E.		— 0° 15′	— 0° 10′
N. by E.	N. 14 0 E.		+ 1 15	+ 1 20
N. N. E.	N. 14 0 E.		+ 1 15	+ 1 20
N. E. by N.	N. 13 30 E.		+ 1 45	+ 1 50
N. E.	N. 13 0 E.		+ 2 15	+ 2 20
N. F. by E.	N. 13 0 E.		+ 2 15	+ 2 20
E. N. E.	N. 12 40 E.		+ 2 35	+ 2 40
E. by N.	N. 12 40 E.		+ 2 35	+ 2 40
EAST.	N. 13 0 E.		+ 2 15	+ 2 20
E. by S.	N. 14 0 E.		+ 1 15	+ 1 20
E. S. E.	N. 13 40 E.		+ 1 35	+ 1 40
S. E. by E.	N. 14 20 E.		+ 0 55	+ 1 0
S. E.	N. 14 40 E.		+ 0 35	+ 0 40
S. E. by S.	N. 15 0 E.		+ 0 15	+ 0 20
S. S. E.	N. 15 0 E.		+ 0 15	+ 0 20
S. by E.	N. 15 0 E.		+ 0 15	+ 0 20
SOUTH.	N. 14 40 E.		+ 0 35	+ 0 40
S. by W.	N. 14 20 E.		+ 0 55	+ 1 0
S. S. W.	N. 14 40 E.		+ 0 35	+ 0 40
S. W. by S.	N. 14 40 E.		+ 0 35	+ 0 40
S. W.	N. 15 0 E.		+ 0 15	+ 0 20
S. W. by W.	N. 14 30 E.		+ 0 45	+ 0 50
W. S. W.	N. 15 20 E.		— 0 5	0 0
W. by S.	N. 15 40 E.		— 0 25	— 0 20
WEST.	N. 15 30 E.		— 0 15	— 0 10
W. by N.	N. 16 30 E.		— 1 15	— 1 10
W. N. W.	N. 16 40 E.		— 1 25	— 1 20
N. W. by W.	N. 16 40 E.		— 1 25	— 1 20
N. W.	N. 17 0 E.		— 1 45	— 1 40
N. W. by N.	N. 16 30 E.		— 1 15	— 1 10
N. N. W.	N. 15 20 E.		— 0 5	— 0 0
N. by W.	N. 15 40 E.		— 0 25	— 0 20
NORTH.	N. 15 30 E.		— 0 15	— 0 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 0° 35′.6 B = + 1° 20′.2 C = — 0° 6′.9
D = + 0° 54′.2 E = — 0° 10′.2

Callao, April 29, 1866.

Assumed Magnetic Bearing of Object = S. 72° 45′ W.
Correction for Object = + 0° 6′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	S. 72° 40′ W.		+ 0° 5′	+ 0° 10′
N. by E.	S. 72 40 W.		+ 0 5	+ 0 10
N. N. E.	S. 71 40 W.		+ 1 5	+ 1 10
N. E. by N.	S. 71 0 W.		+ 1 45	+ 1 50
N. E.	S. 70 20 W.		+ 2 25	+ 2 30
N. E. by E.	S. 70 20 W.		+ 2 25	+ 2 30
E. N. E.	S. 70 0 W.		+ 2 45	+ 2 50
E. by N.	S. 70 30 W.		+ 2 15	+ 2 20
EAST.	S. 71 0 W.		+ 1 45	+ 1 50
E. by S.	S. 70 40 W.		+ 2 5	+ 2 10
E. S. E.	S. 71 40 W.		+ 1 5	+ 1 10
S. F. by E.	S. 71 40 W.		+ 1 5	+ 1 10
S. E.	S. 72 0 W.		+ 0 45	+ 0 50
S. E. by S.	S. 72 40 W.		+ 0 5	+ 0 10
S. S. E.	S. 72 40 W.		+ 0 5	+ 0 10
S. by E.	S. 73 0 W.		— 0 15	— 0 10
SOUTH.	S. 73 0 W.		— 0 15	— 0 10
S. by W.	S. 73 0 W.		— 0 15	— 0 10
S. S. W.	S. 73 0 W.		— 0 15	— 0 10
S. W. by S.	S. 73 0 W.		— 0 15	— 0 10
S. W.	S. 74 0 W.		— 1 15	— 1 10
S. W. by W.	S. 74 0 W.		— 1 15	— 1 10
W. S. W.	S. 74 0 W.		— 1 15	— 1 10
W. by S.	S. 75 30 W.		— 2 45	— 2 40
WEST.	S. 76 0 W.		— 3 15	— 3 10
W. by N.	S. 75 40 W.		— 2 55	— 2 50
W. N. W.	S. 76 0 W.		— 3 15	— 3 10
N. W. by W.	S. 75 30 W.		— 2 45	— 2 40
N. W.	S. 75 40 W.		— 2 55	— 2 50
N. W. by N.	S. 75 0 W.		— 2 15	— 2 10
N. N. W.	S. 74 20 W.		— 1 35	— 1 30
N. by W.	S. 73 20 W.		— 0 35	— 0 30
NORTH.	S. 72 40 W.		+ 0 5	+ 0 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 0° 9′.1 B = + 2° 21′.1 C = — 0° 1′.8
D = + 0° 52′.5 E = + 0° 5′.8

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE ADMIRALTY STANDARD COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Panama, May 20, 1866.

Assumed Magnetic Bearing of Object = S. 15° 0′ W.
Correction for Object = + 0° 1′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	S. 14° 0′ W.		+ 1° 0′	+ 1° 0′
N. by E.	S. 13 30 W.		+ 1 30	+ 1 30
N. N. E.	S. 12 40 W.		+ 2 20	+ 2 20
N. E. by N.	S. 12 20 W.		+ 2 40	+ 2 40
N. E.	S. 11 20 W.		+ 3 40	+ 3 40
N. E. by E.	S. 11 20 W.		+ 3 40	+ 3 40
E. N. E.	S. 11 0 W.		+ 4 0	+ 4 0
E. by N.	S. 11 0 W.		+ 4 0	+ 4 0
EAST.	S. 11 20 W.		+ 3 40	+ 3 40
E. by S.	S. 12 0 W.		+ 3 0	+ 3 0
E. S. E.	S. 12 0 W.		+ 3 0	+ 3 0
S. E. by E.	S. 13 0 W.		+ 2 0	+ 2 0
S. E.	S. 13 30 W.		+ 1 30	+ 1 30
S. E. by S.	S. 14 0 W.		+ 1 0	+ 1 0
S. S. E.	S. 14 0 W.		+ 1 0	+ 1 0
S. by E.	S. 14 20 W.		+ 0 40	+ 0 40
SOUTH.	S. 14 20 W.		+ 0 40	+ 0 40
S. by W.	S. 14 20 W.		+ 0 40	+ 0 40
S. S. W.	S. 14 40 W.		+ 0 20	+ 0 20
S. W. by S.	S. 15 0 W.		0 0	0 0
S. W.	S. 15 40 W.		— 0 40	— 0 40
S. W. by W.	S. 16 20 W.		— 1 20	— 1 20
W. S. W.	S. 16 40 W.		— 1 40	— 1 40
W. by S.	S. 17 50 W.		— 2 50	— 2 50
WEST.	S. 18 0 W.		— 3 0	— 3 0
W. by N.	S. 17 30 W.		— 2 30	— 2 30
W. N. W.	S. 18 0 W.		— 3 0	— 3 0
N. W. by W.	S. 18 0 W.		— 3 0	— 3 0
N. W.	S. 17 10 W.		— 2 10	— 2 10
N. W. by N.	S. 17 0 W.		— 2 0	— 2 0
N. N. W.	S. 16 0 W.		— 1 0	— 1 0
N. by W.	S. 15 20 W.		— 0 20	— 0 20
NORTH.	S. 14 0 W.		+ 1 0	+ 1 0

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

$A = +0^\circ\ 31'.6 \qquad B = +3^\circ\ 2'.1 \qquad C = +0^\circ\ 1'.9$
$D = +0^\circ\ 55'.0 \qquad E = +0^\circ\ 8'.0$

Acapulco, June 1, 1866.

Assumed Magnetic Bearing of Object = N. 63° 15′ E.
Correction for Object = + 0° 6′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 63° 40′ E.		— 0° 25′	— 0° 20′
N. by E.	N. 63 0 E.		+ 0 15	+ 0 20
N. N. E.	N. 62 10 E.		+ 1 5	+ 1 10
N. E. by N.	N. 61 30 E.		+ 1 45	+ 1 50
N. E.	N. 61 0 E.		+ 2 15	+ 2 20
N. E. by E.	N. 60 50 E.		+ 2 25	+ 2 30
E. N. E.	N. 60 40 E.		+ 2 35	+ 2 40
E. by N.	N. 60 50 E.		+ 2 25	+ 2 30
EAST.	N. 61 20 E.		+ 1 55	+ 2 0
E. by S.	N. 61 50 E.		+ 1 25	+ 1 30
E. S. E.	N. 62 0 E.		+ 1 15	+ 1 20
S. E. by E.	N. 62 20 E.		+ 0 55	+ 1 0
S. E.	N. 63 20 E.		— 0 5	0 0
S. E. by S.	N. 63 30 E.		— 0 15	— 0 10
S. S. E.	N. 63 40 E.		— 0 25	— 0 20
S. by E.	N. 64 0 E.		— 0 45	— 0 40
SOUTH.	N. 63 50 E.		— 0 35	— 0 30
S. by W.	N. 63 50 E.		— 0 35	— 0 30
S. S. W.	N. 64 10 E.		— 0 55	— 0 50
S. W. by S.	N. 64 30 E.		— 1 15	— 1 10
S. W.	N. 65 0 E.		— 1 45	— 1 40
S. W. by W.	N. 65 30 E.		— 2 15	— 2 10
W. S. W.	N. 66 0 E.		— 2 45	— 2 40
W. by S.	N. 66 40 E.		— 3 25	— 3 20
WEST.	N. 67 0 E.		— 3 45	— 3 40
W. by N.	N. 67 0 E.		— 3 45	— 3 40
W. N. W.	N. 67 20 E.		— 4 5	— 4 0
N. W. by W.	N. 67 0 E.		— 3 45	— 3 40
N. W.	N. 66 40 E.		— 3 25	— 3 20
N. W. by N.	N. 66 10 E.		— 2 55	— 2 50
N. N. W.	N. 65 20 E.		— 2 5	— 2 0
N. by W.	N. 64 40 E.		— 1 25	— 1 20
NORTH.	N. 63 40 E.		— 0 25	— 0 20

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

$A = -0^\circ\ 36'.9 \qquad B = +2^\circ\ 45'.4 \qquad C = +0^\circ\ 5'.5$
$D = +0^\circ\ 56'.8 \qquad E = +0^\circ\ 8'.0$

Observations for Determining the Deviations of the Admiralty Standard Compass on the U. S. Iron Clad Monadnock.

Magdalena Bay, June 9, 1866.

Assumed Magnetic Bearing of Object = S. 56° 30′ E.
Correction for Object = — 0° 41′. Correction for Lubber Line = o.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	S. 56° 30′ E.		0° 0′	— 0° 40′
N. by E.	S. 56 40 E.		+ 0 10	— 0 30
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.				
E. by S.				
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.	S. 57 0 E.		+ 0 30	— 0 20
S. W. by W.	S. 56 20 E.		— 0 10	— 1 0
W. S. W.	S. 55 30 E.		— 1 0	— 1 50
W. by S.	S. 55 0 E.		— 1 30	— 2 20
WEST.	S. 54 20 E.		— 2 10	— 3 0
W. by N.	S. 53 20 E.		— 3 10	— 3 50
W. N. W.	S. 53 20 E.		— 3 10	— 3 50
N. W. by W.	S. 53 0 E.		— 3 30	— 4 10
N. W.	S. 53 30 E.		— 3 0	— 3 40
N. W. by N.	S. 53 30 E.		— 3 0	— 3 40
N. N. W.	S. 54 30 E.		— 2 0	— 2 40
N. by W.	S. 55 30 E.		— 1 0	— 1 40
NORTH.	S. 56 30 E.		0 0	— 0 40

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 0° 9′.0   B = + 3° 12′.1   C = — 1° 10′.3
D = + 0° 53′.5   E = + 0′.8

San Francisco, June 23, 1866.

Assumed Magnetic Bearing of Object = N. 29° 30′ W.
Correction for Object = — 0° 45′. Correction for Lubber Line = o.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 28° 20′ W.		— 1° 10′	— 1° 50′
N. by E.	N. 29 30 W.		0 0	— 0 40
N. N. E.	N. 31 0 W.		+ 1 30	+ 0 50
N. E. by N.	N. 32 0 W.		+ 2 30	+ 1 50
N. E.	N. 33 0 W.		+ 3 30	+ 2 50
N. E. by E.	N. 33 30 W.		+ 4 0	+ 3 20
E. N. E.	N. 34 30 W.		+ 5 0	+ 4 10
E. by N.	N. 34 30 W.		+ 5 0	+ 4 10
EAST.	N. 34 15 W.		+ 4 45	+ 4 0
E. by S.	N. 33 30 W.		+ 4 0	+ 3 20
E. S. E.	N. 34 0 W.		+ 4 30	+ 3 40
S. F. by E.	N. 33 30 W.		+ 4 0	+ 3 20
S. E.	N. 33 30 W.		+ 4 0	+ 3 10
S. E. by S.	N. 33 0 W.		+ 3 30	+ 2 40
S. S. E.	N. 32 20 W.		+ 2 50	+ 2 0
S. by E.	N. 31 30 W.		+ 2 0	+ 1 10
SOUTH.	N. 31 0 W.		+ 1 30	+ 0 40
S. by W.	N. 30 0 W.		+ 0 30	— 0 20
S. S. W.	N. 29 40 W.		+ 0 10	— 0 40
S. W. by S.	N. 28 40 W.		— 0 50	— 1 40
S. W.	N. 28 0 W.		— 1 30	— 2 20
S. W. by W.	N. 27 0 W.		— 2 30	— 3 20
W. S. W.	N. 26 20 W.		— 3 10	— 4 0
W. by S.	N. 25 20 W.		— 4 10	— 5 0
WEST.	N. 25 0 W.		— 4 30	— 5 20
W. by N.	N. 24 30 W.		— 5 0	— 5 50
W. N. W.	N. 24 0 W.		— 5 30	— 6 20
N. W. by W.	N. 23 30 W.		— 6 0	— 6 50
N. W.	N. 24 0 W.		— 5 30	— 6 10
N. W. by N.	N. 25 15 W.		— 4 15	— 5 0
N. N. W.	N. 26 0 W.		— 3 30	— 4 10
N. by W.	N. 27 30 W.		— 2 0	— 2 50
NORTH.	N. 28 20 W.		— 1 10	— 1 50

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 0° 39′.6   B = + 4° 53′.2   C = — 1° 15′.4
D = + 0° 51′.2   E = + 0° 5′.8

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE AFTER BINNACLE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Hampton Roads, November 1, 1865.

Correction for Object = + 3° 57′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{3}{8}$ E.	− $\frac{3}{8}$	° ′	− 0° 50′
N. by E.	N. by E. $\frac{1}{8}$ E.	− $\frac{1}{8}$		+ 1 30
N. N. E.	N. N. E.	0		+ 3 30
N. E. by N.	N. E. by N. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 4 50
N. E.	N. E. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 6 20
N. E. by E.	N. E. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		+ 6 40
E. N. E.	N. E. by E. $\frac{5}{8}$ E.	+ $\frac{3}{8}$		+ 7 40
E. by N.	E. by N. $\frac{3}{8}$ N.	+ $\frac{3}{8}$		+ 8 10
EAST.	E. $\frac{3}{8}$ N.	+ $\frac{3}{8}$		+ 8 10
E. by S.	E. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 7 10
E. S. E.	E. by S. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 6 40
S. E. by E.	S. E. by E. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 5 50
S. E.	S. E.	0		+ 4 30
S. E. by S.	S. E. by S.	0		+ 4 0
S. S. E.	S. by E. $\frac{7}{8}$ E.	− $\frac{1}{8}$		+ 3 0
S. by E.	S. $\frac{3}{4}$ E.	− $\frac{1}{4}$		+ 1 40
SOUTH.	S. $\frac{1}{8}$ W.	− $\frac{1}{8}$		+ 2 0
S. by W.	S. by W. $\frac{1}{4}$ W.	− $\frac{1}{4}$		+ 1 40
S. S. W.	S. S. W. $\frac{3}{8}$ W.	− $\frac{3}{8}$		+ 0 10
S. W. by S.	S. W. $\frac{1}{2}$ S.	− $\frac{1}{2}$		− 1 10
S. W.	S. W. $\frac{1}{2}$ W.	− $\frac{1}{2}$		− 1 40
S. W. by W.	S. W. by W. $\frac{3}{4}$ W.	− $\frac{3}{4}$		− 3 30
W. S. W.	W. by S. $\frac{1}{4}$ S.	− $\frac{3}{4}$		− 4 30
W. by S.	W.	− 1		− 6 20
WEST.	W. by N.	− 1		− 7 20
W. by N.	W. N. W.	− 1		− 7 20
W. N. W.	N. W. $\frac{7}{8}$ W.	− 1$\frac{1}{8}$		− 8 20
N. W. by W.	N. W.	− 1		− 7 50
N. W.	N. W. by N.	− 1		− 7 20
N. W. by N.	N. N. W. $\frac{1}{4}$ W.	− $\frac{3}{4}$		− 5 30
N. N. W.	N. by W. $\frac{1}{4}$ W.	− $\frac{3}{4}$		− 4 30
N. by W.	N. $\frac{1}{2}$ W.	− $\frac{1}{2}$		− 2 40
NORTH.		− $\frac{3}{8}$		− 0 50

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign −.

From the observations given above, the following values of the coefficients of the deviation are obtained:

$$A = +0° \; 27'.5 \qquad B = +7° \; 16'.8 \qquad C = -1° \; 14'.1$$
$$D = +1° \; 39'.2 \qquad E = +0° \; 6'.2$$

St. Thomas, November 18, 1865.

Correction for Object = + 0° 16′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	° ′
N. by E.	N. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		
N. N. E.	N. N. E. $\frac{1}{4}$ E.	− $\frac{1}{4}$		
N. E. by N.	N. E. by N.	0		
N. E.	N. E. $\frac{1}{2}$ E.	− $\frac{1}{2}$		
N. E. by E.	N. E. by E. $\frac{1}{4}$ E.	− $\frac{1}{4}$		
E. N. E.	E. N. E.	0		
E. by N.	E. by N.	0		
EAST.	E. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		
E. by S.	E. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		
E. S. E.	E. by S. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		
S. E. by E.	S. E. by E.	0		
S. E.	S. E. $\frac{3}{4}$ S.	− $\frac{3}{4}$		
S. E. by S.	S. E. by S. $\frac{1}{2}$ S.	− $\frac{1}{2}$		
S. S. E.	S. S. E. $\frac{1}{4}$ S.	− $\frac{1}{4}$		
S. by E.	S. by E.	0		
SOUTH.	S. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		
S. by W.	S. by W.	0		
S. S. W.	S. S. W. $\frac{1}{4}$ W.	− $\frac{1}{4}$		
S. W. by S.	S. W. by S. $\frac{1}{4}$ W.	− $\frac{1}{4}$		
S. W.	S. W. $\frac{1}{4}$ W.	− $\frac{1}{4}$		
S. W. by W.	S. W. by W. $\frac{1}{2}$ W.	− $\frac{1}{2}$		
W. S. W.	W. S. W. $\frac{1}{2}$ W.	− $\frac{1}{2}$		
W. by S.	W. by S. $\frac{1}{2}$ W.	− $\frac{1}{2}$		
WEST.	W. $\frac{3}{4}$ N.	− $\frac{3}{4}$		
W. by N.	W. by N. $\frac{1}{2}$ N.	− $\frac{1}{2}$		
W. N. W.	W. N. W.	0		
N. W. by W.	N. W. $\frac{1}{2}$ W.	− $\frac{1}{2}$		
N. W.	N. W. $\frac{1}{2}$ N.	− $\frac{1}{2}$		
N. W. by N.	N. W. by N. $\frac{1}{2}$ N.	− $\frac{1}{2}$		
N. N. W.	N. N. W. $\frac{1}{4}$ N.	− $\frac{1}{4}$		
N. by W.	N. $\frac{3}{4}$ W.	− $\frac{1}{4}$		
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign −.

The officer who usually read this compass was on shore when the ship was swung. He was replaced by another who made the above observations, which, however, are evidently worthless. No use has been made of them.

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE AFTER BINNACLE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Isle Royal, Salute Islands, November 30, 1865.

Correction for Object = — 0° 2′. Correction for Lubber Line = + 6° 18′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.			° ′	
N. by E.				
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.	EAST.	0		+ 6° 20′
E. by S.	E. by S.	0		+ 6 20
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign + ; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = B = C =
D = E =

Ceara, December 19, 1865.

Correction for Object = + 1° 51′. Correction for Lubber Line = + 6° 18′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.				
N. by E.	N. by E. $\frac{3}{8}$ E.	— $\frac{3}{8}$	° ′	+ 3° 40′
N. N. E.	N. E. by N. $\frac{3}{4}$ N.	— $\frac{1}{4}$		+ 5 10
N. E. by N.	N. E. $\frac{7}{8}$ N.	— $\frac{1}{8}$		+ 6 30
N. E.	N. E.	0		+ 7 50
N. E. by E.	N. E. by E. $\frac{1}{8}$ E.	— $\frac{1}{8}$		+ 7 0
E. N. E.	E. by N. $\frac{7}{8}$ N.	— $\frac{1}{8}$		+ 6 50
E. by N.	E. $\frac{7}{8}$ N.	— $\frac{1}{8}$		+ 6 50
EAST.	E. $\frac{3}{8}$ S.	— $\frac{3}{8}$		+ 4 20
E. by S.	E. by S. $\frac{3}{8}$ S.	— $\frac{3}{8}$		+ 4 0
E. S. E.	S. E. by E. $\frac{1}{2}$ E.	— $\frac{1}{2}$		+ 2 50
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign + ; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 0° 21′.5 B = + 4° 34′.9 C = + 2° 4′.8
D = + 2° 3′.4 E = — 0° 16′.5

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE AFTER BINNACLE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Bahia, December 30, 1865.

Correction for Object = + 2° 30′. Correction for Lubber Line = + 6° 18′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. ½ E.	— ½	° ′	+ 2° 30′
N. by E.	N. by E. ½ E.	— ½		+ 3 10
N. N. E.	N. N. E. ¼ E.	— ¼		+ 5 20
N. E. by N.	N. E. ¾ N.	— ¼		+ 6 0
N. E.	N. E. ¼ E.	— ¼		+ 6 0
N. E. by E.	N. E. by E. ¼ E.	— ¼		+ 6 0
E. N. E.	E. N. E.	0		+ 8 10
E. by N.	E. by N.	0		+ 8 50
EAST.	E. ⅛ S.	— ⅛		+ 7 40
E. by S.	E. by S. ¼ S.	— ¼		+ 6 20
E. S. E.	S. E. by E. ¾ E.	— ¼		+ 6 0
S. E. by E.	S. E. ⅝ E.	— ⅜		+ 4 50
S. E.	S. E. ½ S.	— ½		+ 3 30
S. E. by S.	S. S. E. ½ E.	— ½		+ 3 10
S. S. E.	S. by E. ⅜ E.	— ⅝		+ 2 0
S. by E.	S. ⅜ E.	— ⅝		+ 1 50
SOUTH.	S. ⅝ W.	— ⅝		+ 1 50
S. by W.	S. by W. ⅝ W.	— ⅝		+ 1 50
S. S. W.	S. S. W. ¾ W.	— ¾		+ 0 40
S. W. by S.	S. W. ¼ S.	— ¾		+ 0 20
S. W.	S. W. ⅞ W.	— ⅞		— 0 40
S. W. by W.	W. S. W.	— 1		— 2 10
W. S. W.	W. by S.	— 1		— 2 30
W. by S.	W. ⅛ N.	— 1⅛		— 3 30
WEST.	W. by N. ⅛ N.	— 1⅛		— 3 50
W. by N.	N. W. by W. ¾ W.	— 1¼		— 5 0
W. N. W.	N. W. ¾ W.	— 1¼		— 5 20
N. W. by W.	N. W. ¼ N.	— 1¼		— 5 20
N. W.	N. N. W. ¾ W.	— 1¼		— 5 20
N. W. by N.	N. N. W.	— 1		— 3 10
N. N. W.	N. by W. ⅛ W.	— ⅞		— 1 20
N. by W.	N. ¼ W.	— ¾		0 0
NORTH.		— ½		+ 2 30

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 1° 29′.8   B = + 5° 43′.6   C = — 0° 6′.9
D = + 1° 41′.5   E = + 0° 7′.8

Rio Janeiro, January 10, 1866.

Correction for Object = + 2° 44′ Correction for Lubber Line = + 5° 43′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.			° ′	
N. by E.				
N. N. E.				
N. E. by N.	N. E. ¾ N.	— ¼		+ 5° 20′
N. E.	N. E. ⅛ E.	— ⅛		+ 6 50
N. E. by E.	N. E. by E. ⅛ E.	— ⅛		+ 7 10
E. N. E.	E. by N. ⅞ N.	— ⅛		+ 7 10
E. by N.	E. ¾ N.	— ¼		+ 6 0
EAST.	E. ¼ S.	— ¼		+ 5 40
E. by S.	E. by S. ¼ S.	— ¼		+ 5 40
E. S. E.	S. E. by E. ⅝ E.	— ⅜		+ 4 40
S. E. by E.	S. E. ⅝ E.	— ⅜		+ 4 20
S. E.	S. E. ½ S.	— ½		+ 3 10
S. E. by S.	S. S. E. ½ E.	— ½		+ 2 50
S. S. E.	S. by E. ⅜ E	— ⅝		+ 1 50
S. by E.	S. ⅜ E.	— ⅝		+ 1 30
SOUTH.	S. ⅝ W.	— ⅝		+ 1 30
S. by W.	S. by W. ¾ W.	— ¾		+ 0 20
S. S. W.	S. S. W. ¾ W.	— ¾		+ 0 10
S. W. by S.	S. W. ¼ S.	— ¾		+ 0 10
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 0° 51′.4   B = + 5° 24′.9   C = — 0° 24′.8
D = + 1° 56′.7   E = — 0° 4′.2

Observations for Determining the Deviations of the After Binnacle Compass on the U. S. Iron Clad Monadnock.

Monte Video, January 24, 1866.

Correction for Object = — 0° 13′. Correction for Lubber Line = + 4° 9′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N $\frac{3}{8}$ E.	— $\frac{3}{8}$	° ′	— 0° 20′
N. by E.	N. by E.	0		+ 4 0
N. N. E.	N. by E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 5 20
N. E. by N.	N. E. by N. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 6 40
N. E.	N. E. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 6 40
N. E. by E.	N. E. $\frac{5}{8}$ E.	+ $\frac{3}{8}$		+ 8 10
E. N. E.	N. E. by E. $\frac{5}{8}$ E.	+ $\frac{3}{8}$		+ 8 10
E. by N.	E. by N. $\frac{3}{8}$ N.	+ $\frac{3}{8}$		+ 8 0
EAST.	E. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 6 40
E. by S.	E. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 6 40
E. S. E.	E. by S. $\frac{7}{8}$ S.	+ $\frac{1}{8}$		+ 5 20
S. E. by E.	S. E. by E.	0		+ 4 0
S. E.	S. E. $\frac{1}{8}$ S.	— $\frac{1}{8}$		+ 2 30
S. E. by S.	S. E. by S. $\frac{1}{4}$ S.	— $\frac{1}{4}$		+ 1 0
S. S. E.	S. by E. $\frac{3}{4}$ E.	— $\frac{1}{4}$		+ 1 0
S. by E.	S. $\frac{5}{8}$ E.	— $\frac{3}{8}$		— 0 20
SOUTH.	S. $\frac{3}{8}$ W.	— $\frac{3}{8}$		— 0 20
S. by W.	S. by W. $\frac{3}{8}$ W.	— $\frac{3}{8}$		— 0 20
S. S. W.	S. S. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 40
S. W. by S.	S. W. $\frac{5}{8}$ S.	— $\frac{3}{8}$		— 0 20
S. W.	S. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 40
S. W. by W.	S. W. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 40
W. S. W.	W. by S. $\frac{1}{2}$ S.	— $\frac{1}{2}$		— 1 40
W. by S.	W. $\frac{3}{8}$ S.	— $\frac{5}{8}$		— 3 20
WEST.	W. $\frac{3}{4}$ N.	— $\frac{3}{4}$		— 4 30
W. by N.	W. by N. $\frac{3}{4}$ N.	— $\frac{3}{4}$		— 4 30
W. N. W.	N. W. by W. $\frac{1}{4}$ W.	— $\frac{3}{4}$		— 4 30
N. W. by W.	N. W. $\frac{1}{4}$ W.	— $\frac{3}{4}$		— 4 30
N. W.	N. W. $\frac{3}{4}$ N.	— $\frac{3}{4}$		— 4 30
N. W. by N.	N. N. W. $\frac{3}{8}$ W.	— $\frac{5}{8}$		— 3 0
N. N. W.	N. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 40
N. by W.	N. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 40
NORTH.		— $\frac{3}{8}$		— 0 20

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 1° 3′.1 B = + 5° 30′.6 C = + 0° 41′.9
D = + 1° 57′.5 E = — 0° 42′.5

Sandy Point, February 10, 1866.

Correction for Object = + 0° 7′. Correction for Lubber Line = + 4° 9′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{2}$ E.	— $\frac{1}{2}$	° ′	— 1° 20′
N. E.	N. by E. $\frac{1}{8}$ E.	— $\frac{1}{8}$		+ 2 50
N. N. E.	N. N. E. $\frac{1}{8}$ E.	— $\frac{1}{8}$		+ 2 50
N. E. by N.	N. E. by N.	0		+ 4 20
N. E.	N. E. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 5 40
N. E. by E.	N. E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 5 40
E. N. E.	N. E. by E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 5 40
E. by N.	E. by N. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 5 40
EAST.	E. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 5 40
E. by S.	E. by S.	0		+ 4 20
E. S. E.	E. S. E.	0		+ 4 20
S. E. by E.	S. E. $\frac{7}{8}$ E.	— $\frac{1}{8}$		+ 2 50
S. E.	S. E. $\frac{1}{4}$ S.	— $\frac{1}{4}$		+ 1 30
S. E. by S.	S. E. by S. $\frac{1}{4}$ S.	— $\frac{1}{4}$		+ 1 30
S. S. E.	S. by E. $\frac{5}{8}$ E.	— $\frac{3}{8}$		0 0
S. by E.	S. $\frac{5}{8}$ E.	— $\frac{3}{8}$		0 0
SOUTH.	S. $\frac{3}{8}$ W.	— $\frac{3}{8}$		0 0
S. by W.	S. by W. $\frac{3}{8}$ W.	— $\frac{3}{8}$		0 0
S. S. W.	S. S. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 20
S. W. by S.	S. W. $\frac{1}{2}$ S.	— $\frac{1}{2}$		— 1 20
S. W.	S. W. $\frac{5}{8}$ W.	— $\frac{5}{8}$		— 2 50
S. W. by W.	S. W. by W. $\frac{5}{8}$ W.	— $\frac{5}{8}$		— 2 50
W. S. W.	W. by S. $\frac{1}{4}$ S.	— $\frac{3}{4}$		— 4 10
W. by S.	W. $\frac{1}{8}$ S.	— $\frac{7}{8}$		— 5 40
WEST.	W. $\frac{7}{8}$ N.	— $\frac{7}{8}$		— 5 40
W. by N.	W. N. W.	— 1		— 7 0
W. N. W.	N. W. by W.	— 1		— 7 0
N. W. by W.	N. W.	— 1		— 7 0
N. W.	N. W. by N.	— 1		— 7 0
N.W. by N.	N. N. W. $\frac{1}{8}$ W.	— $\frac{7}{8}$		— 5 40
N. N. W.	N. by W. $\frac{1}{4}$ W.	— $\frac{3}{4}$		— 4 10
N. by W.	N. $\frac{3}{8}$ W.	— $\frac{5}{8}$		— 2 50
NORTH.				— 1 20

A deviation of the North Point of the Compass to the East is designated by the sign + a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviations are obtained:

A = — 0° 24′.5 B = + 5° 44′.4 C = — 0° 14′.6
D = + 1° 58′.5 E = + 0° 0′.2

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE AFTER BINNACLE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Valparaiso, April 4, 1866.

Correction for Object = + 0° 1′. Correction for Lubber Line = + 4° 17′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 3/8 E.	— 3/8	° ′	0° 0′
N. by E.	N. by E. 1/4 E.	— 1/4		+ 1 30
N. N. E.	N. N. E. 1/8 E.	— 1/8		+ 2 50
N. E. by.N.	N. E. by N.	0		+ 4 20
N. E.	N. E. 1/8 N.	+ 1/8		+ 5 40
N. E. by E.	N. E. 7/8 E.	+ 1/8		+ 5 40
E. N. E.	N. E. by E. 7/8 E.	+ 1/8		+ 5 40
E. by N.	E. by N.	0		+ 4 20
EAST.	EAST.	0		+ 4 20
E. by S.	E. by S. 1/4 S.	— 1/4		+ 1 30
E. S. E.	S. E. by E. 7/8 E.	— 1/8		+ 2 50
S. E. by E.	S. E. 3/4 E.	— 1/4		+ 1 30
S. E.	S. E. 1/4 S.	— 1/4		+ 1 30
S. E. by S.	S. E. by S. 3/8 S.	— 3/8		0 0
S. S. E.	S. by E. 5/8 E.	— 3/8		0 0
S. by E.	S. 5/8 E.	— 3/8		0 0
SOUTH.	S. 3/8 W.	— 3/8		0 0
S. by W.	S. by W. 3/8 W.	— 3/8		0 0
S. S. W.	S. S. W. 3/8 W.	— 3/8		·0 0
S. W. by S.	S. W. 5/8 S.	— 3/8		0 0
S. W.	S. W. 1/2 W.	— 1/2		— 1 20
S. W. by W.	S. W. by W. 1/2 W.	— 1/2		— 1 20
W. S. W.	W. by S. 3/8 S.	— 5/8		— 2 50
W. by S.	W. 3/8 S.	— 5/8		— 2 50
WEST.	W. 3/4 N.	— 3/4		— 4 10
W. by N.	W. by N. 3/4 N.	— 3/4		— 4 10
W. N. W.	N. W. by W. 1/4 W.	— 3/4		— 4 10
N. W. by W.	N. W. 1/8 W.	— 7/8		— 5 40
N. W.	N. W. 3/4 N.	— 3/4		— 4 10
N. W. by N.	N. N. W. 1/4 W.	— 3/4		— 4 10
N. N. W.	N. by W. 3/8 W.	— 5/8		— 2 50
N. by W	N. 1/2 W.	— 1/2		— 1 20
NORTH.		— 3/8		0 0

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 0° 4′.9 B = + 3° 58′.8 C = + 0° 7′.9
D = + 2° 1′.5 E = — 0° 0′.2

Callao, April 29, 1866.

Correction for Object = + 0° 6′. Correction for Lubber Line = + 3° 44′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 3/8 E.	— 3/8	° ′	— 0° 20′
N. by E.	N. by E. 1/4 E.	— 1/4		+ 1 0
N. N. E.	N. N. E. 1/8 E.	— 1/8		+ 2 30
N. E. by N.	N. E. by N.	0		+ 3 50
N. E.	N. E. 1/8 N.	+ 1/8		+ 5 20
N. E. by E.	N. E. 7/8 E.	+ 1/8		+ 5 20
E. N. E.	E. N. E.	0		+ 3 50
E. by N.	E. by N.	0		+ 3 50
EAST.	EAST.	0		+ 3 50
E. by S.	E. by S. 1/8·S.	— 1/8		+ 2 30
E. S. E.	S. E. by E. 7/8 E.	— 1/8		+ 2 30
S. E. by E.	S. E. 3/4 E.	— 1/4		+ 1 0
S. E.	S. E. 1/4 S.	— 1/4		+ 1 0
S. E. by S.	S. S. E. 5/8 E.	— 3/8		— 0 20
S. S. E.	S. by E. 5/8 E.	— 3/8		— 0 20
S. by E.	S. 5/8 E.	— 3/8		— 0 20
SOUTH.	S. 3/8 W.	— 3/8		— 0 20
S. by W.	S. by W. 3/8 W.	— 3/8		— 0 20
S. S. W.	S. S. W. 3/8 W.	— 3/8		— 0 20
S. W. by S.	S. W. 5/8 S.	— 3/8		— 0 20
S. W.	S. W. 1/2 W.	— 1/2		— 1 50
S. W. by W.	S. W. by W. 1/2 W.	— 1/2		— 1 50
W. S. W.	W. by S. 3/8 S.	— 5/8		— 3 10
W. by S.	W. 3/8 S..	— 5/8		— 3 10
WEST.	W. 3/4 N.	— 3/4		— 4 40
W. by N.	W. by N. 7/8 N.	— 7/8		— 6 0
W. N. W.	N. W. by W. 1/8 W.	— 7/8		— 6 0
N. W. by W.	N. W. 1/8 W.	— 7/8		— 6 0
N. W.	N. W. 7/8 N.	— 7/8		— 6 0
N. W. by N.	N. N. W. 1/4 W.	— 3/4		— 4 40
N. N. W.	N. by W. 3/8 W.	— 5/8		— 3 10
N. by W.	N. 1/2 W.	— 1/2		— 1 50
NORTH.		— 3/8		— 0 20

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviations are obtained:

A = — 0° 27′.1 B = + 4° 12′.5 C = — 0° 3′.9
D = + 2° 7′.5 E = + 0° 9′.0

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE AFTER BINNACLE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Panama, May 20, 1866.

Correction for Object = + 0° 1′. Correction for Lubber Line = + 3° 44′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{3}{8}$ E.	— $\frac{3}{8}$	° ′	— 0° 30′
N. by E.	N. by E. $\frac{1}{4}$ E.	— $\frac{1}{4}$		+ 1 0
N. N. E.	N. E. by N. $\frac{7}{8}$ N.	— $\frac{1}{8}$		+ 2 20
N. E. by N.	N. E. by N.	0		+ 3 40
N. E.	N. E.	0		+ 3 40
N. E. by E.	N. E. by E.	0		+ 3 40
E. N. E.	N. E. by E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 5 10
E. by N.	E. by N.	0		+ 3 40
EAST.	E. $\frac{1}{8}$ S.	— $\frac{1}{8}$		+ 2 20
E. by S.	E. by S. $\frac{1}{8}$ S.	— $\frac{1}{8}$		+ 2 20
E. S. E.	S. E. by E. $\frac{3}{4}$ E.	— $\frac{1}{4}$		+ 1 0
S. E. by E.	S. E. $\frac{5}{8}$ E.	— $\frac{3}{8}$		— 0 30
S. E.	S. E. $\frac{3}{8}$ S.	— $\frac{3}{8}$		— 0 30
S. E. by S.	S. E. by S. $\frac{5}{8}$ S.	— $\frac{5}{8}$		— 3 20
S. S. E.	S. by E. $\frac{1}{2}$ E.	— $\frac{1}{2}$		— 1 50
S. by E.	S. $\frac{1}{2}$ E.	— $\frac{1}{2}$		— 1 50
SOUTH.	S. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 50
S. by W.	S. by W. $\frac{3}{8}$ W.	— $\frac{3}{8}$		— 0 30
S. S. W.	S. W. by S. $\frac{5}{8}$ S.	— $\frac{3}{8}$		— 0 30
S. W. by S.	S. W. $\frac{5}{8}$ S.	— $\frac{3}{8}$		— 0 30
S. W.	S. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 50
S. W. by W.	S. W. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 50
W. S. W.	W. by S. $\frac{1}{2}$ S.	— $\frac{1}{2}$		— 1 50
W. by S.	W. $\frac{1}{2}$ S.	— $\frac{1}{2}$		— 1 50
WEST.	W. $\frac{5}{8}$ N.	— $\frac{5}{8}$		— 3 20
W. by N.	W. by N. $\frac{3}{4}$ N.	— $\frac{3}{4}$		— 4 40
W. N. W.	N. W. by W. $\frac{1}{8}$ W.	— $\frac{7}{8}$		— 6 10
N. W. by W.	N. W. $\frac{1}{8}$ W.	— $\frac{7}{8}$		— 6 10
N. W.	N. W. $\frac{7}{8}$ N.	— $\frac{7}{8}$		— 6 10
N. W. by N.	N. W. by N. $\frac{3}{4}$ N.	— $\frac{3}{4}$		— 4 40
N. N. W.	N. by W. $\frac{3}{8}$ W.	— $\frac{5}{8}$		— 3 20
N. by W.	N. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 50
NORTH.		— $\frac{3}{8}$		— 0 30

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 0° 50′.0 B = + 3° 19′.5 C = + 0° 22′.0
D = + 2° 32′.7 E = — 0° 18′.0

Acapulco, June 1, 1866.

Correction for Object = + 0° 6′. Correction for Lubber Line = + 3° 44′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{3}{4}$ E.	— $\frac{3}{4}$	° ′	— 4° 40′
N. by E.	N. by E. $\frac{1}{4}$ E.	— $\frac{1}{4}$		+ 1 0
N. N. E.	N. N. E. $\frac{1}{4}$ E.	— $\frac{1}{4}$		+ 1 0
N. E. by N.	N. E. $\frac{7}{8}$ N.	— $\frac{1}{8}$		+ 2 30
N. E.	N. E.	0		+ 3 50
N. E. by E.	N. E. by E.	0		+ 3 50
E. N. E.	E. N. E.	0		+ 3 50
E. by N.	E. $\frac{7}{8}$ N.	— $\frac{1}{8}$		+ 2 30
EAST.	E. $\frac{1}{8}$ S.	— $\frac{1}{8}$		+ 2 30
E. by S.	E. by S. $\frac{1}{4}$ S.	— $\frac{1}{4}$		+ 1 0
E. S. E.	S. E. by E. $\frac{3}{4}$ E.	— $\frac{1}{4}$		+ 1 0
S. E. by E.	S. E. $\frac{5}{8}$ E.	— $\frac{3}{8}$		— 0 20
S. E.	S. E. $\frac{3}{8}$ S.	— $\frac{3}{8}$		— 0 20
S. E. by S.	S. S. E. $\frac{1}{2}$ E.	— $\frac{1}{2}$		— 1 50
S. S. E.	S. by E. $\frac{1}{2}$ E.	— $\frac{1}{2}$		— 1 50
S. by E.	S. $\frac{1}{2}$ E.	— $\frac{1}{2}$		— 1 50
SOUTH.	S. $\frac{3}{8}$ W.	— $\frac{3}{8}$		— 0 20
S. by W.	S. by W. $\frac{3}{8}$ W.	— $\frac{3}{8}$		— 0 20
S. S. W.	S. S. W. $\frac{3}{8}$ W.	— $\frac{3}{8}$		— 0 20
S. W. by S.	S. W. $\frac{5}{8}$ S.	— $\frac{3}{8}$		— 0 20
S. W.	S. W. $\frac{3}{8}$ W.	— $\frac{3}{8}$		— 0 20
S. W. by W.	S. W. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 50
W. S. W.	W. by S. $\frac{1}{2}$ S.	— $\frac{1}{2}$		— 1 50
W. by S.	W. $\frac{3}{8}$ S.	— $\frac{5}{8}$		— 3 10
WEST.	W. $\frac{3}{4}$ N.	— $\frac{3}{4}$		— 4 40
W. by N.	W. by N. $\frac{3}{4}$ N.	— $\frac{3}{4}$		— 4 40
W. N. W.	N. W. by W. $\frac{1}{4}$ W.	— $\frac{3}{4}$		— 4 40
N. W. by W.	N. W. $\frac{1}{8}$ W.	— $\frac{7}{8}$		— 6 0
N. W.	N. W. $\frac{3}{4}$ N.	— $\frac{3}{4}$		— 4 40
N. W. by N.	N. N. W. $\frac{1}{4}$ W.	— $\frac{3}{4}$		— 4 40
N. N. W.	N. by W. $\frac{1}{4}$ W.	— $\frac{3}{4}$		— 4 40
N. by W.	N. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 50
NORTH.				— 4 40

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 1° 0′.2 B = + 3° 4′.4 C = — 0° 17′.1
D = + 2° 15′.2 E = — 0° 17′.2

Observations for Determining the Deviations of the After Binnacle Compass on the U. S. Iron Clad Monadnock.

Magdalena Bay, June 9, 1866.

Correction for Object = — 0° 41′. Correction for Lubber Line = + 3° 44′.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. ½ E.	— ½	° ′	— 2 30′
N. by E.	N. by E. ⅜ E.	— ⅜		— 1 10
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.				
E. by S.				
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.	S. W. ¼ W.	— ¼		+ 0 10
S. W. by W.	S. W. by W. ¼ W.	— ¼		+ 0 10
W. S. W.	W. by S. ⅝ S.	— ⅜		— 1 20
W. by S.	W. ½ S.	— ½		— 2 40
WEST.	W. ½ N.	— ½		— 2 50
W. by N.	W. by N. ¾ N.	— ¾		— 5 20
W. N. W.	N. W. by W. ¼ W.	— ¾		— 5 20
N. W. by W.	N. W. ¼ W.	— ¾		— 5 20
N. W.	N. W. ¾ N.	— ¾		— 5 20
N. W. by N.	N. N. W. ¼ W.	— ¾		— 5 20
N. N. W.	N. by W. ¼ W.	— ¾		— 5 20
N. by W.	N. ⅜ W.	— ⅝		— 3 50
NORTH.		— ½		— 2 30

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 1° 10′.7 B = + 2° 16′.0 C = — 1° 16′.8

D = + 2° 10′.2 E = — 0° 3′.5

San Francisco, June 23, 1866.

Correction for Object = — 0° 45′. Correction for Lubber Line = + 3° 49′.

Assumed Magnetic Direction of Ship's Head.	Bearing of Object by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. ½ E.	— ½	° ′	— 2° 30′
N. by E.	N. by E. ⅜ E.	— ⅜		— 1 10
N. N. E.	N. E. by N. ¾ N.	— ¼		+ 0 20
N. E. by N.	N. E. ⅞ N.	— ⅛		+ 1 40
N. E.	N. E. ⅛ E.	— ⅛		+ 1 40
N. E. by E.	N. E. by E. ⅛ E.	— ⅛		+ 1 50
E. N. E.	E. N. E.	0		+ 3 0
E. by N.	E. by N.	0		+ 3 0
EAST.	EAST.	0		+ 3 0
E. by S.	E. by S.	0		+ 3 0
E. S. E.	S. E. by E. ⅞ E.	— ⅛		+ 1 40
S. F. by E.	S. E. ⅞ E.	— ⅛		+ 1 40
S. E.	S. E. ⅛ S.	— ⅛		+ 1 40
S. E. by S.	S. E. by E. ⅛ S.	— ⅛		+ 1 40
S. S. E.	S. by E. ⅞ E.	— ⅛		+ 1 40
S. by E.	S. ⅞ E.	— ⅛		+ 1 40
SOUTH.	S. ⅛ W.	— ⅛		+ 1 40
S. by W.	S. by W. ⅛ W.	— ⅛		+ 1 40
S. S. W.	S. W. by S. ⅞ S.	— ⅛		+ 1 40
S. W. by S.	S. W. ⅞ S.	— ⅛		+ 1 40
S. W.	S. W. ¼ W.	— ¼		+ 0 10
S. W. by W.	S. W. by W. ⅜ W.	— ⅜		— 1 10
W. S. W.	W. by S. ⅝ S.	— ⅜		— 1 20
W. by S.	W. ½ S.	— ½		— 2 50
WEST.	W. ¾ N.	— ¾		— 5 20
W. by N.	W. by N. ¾ N.	— ¾		— 5 20
W. N. W.	N. W. by W. ¼ W.	— ¾		— 5 20
N. W. by W.	N. W. ¼ W.	— ¾		— 5 30
N. W.	N. W. ⅞ N.	— ⅞		— 6 50
N. W. by N.	N. W. by N. ⅞ N.	— ⅞		— 6 40
N. N. W.	N. by W. ¼ W.	— ¾		— 5 20
N. by W.	N. ⅜ W.	— ⅝		— 3 50
NORTH.		— ½		— 2 30

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 0° 35′.2 B = + 3° 28′.2 C = — 2° 13′.9

D = + 1° 47′.5 E = + 0° 10′.2

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE AFTER RITCHIE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Hampton Roads, November 1, 1865.

Correction for Object = + 3° 57′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{8}$ W.	+ $\frac{1}{8}$	° ′	+ 4° 20′
N. by E.	N. $\frac{5}{8}$ E.	+ $\frac{3}{8}$		+ 7 10
N. N. E.	N. by E. $\frac{1}{4}$ E.	+ $\frac{3}{4}$		+ 10 50
N. E. by N.	N. N. E.	+ 1		+ 14 10
N. E.	N. E. by N.	+ 1		+ 15 10
N. E. by E.	N. E. $\frac{1}{4}$ N.	+ 1$\frac{1}{4}$		+ 17 0
E. N. E.	N. E. $\frac{3}{4}$ E.	+ 1$\frac{1}{4}$		+ 18 0
E. by N.	N. E. by E. $\frac{1}{2}$ E.	+ 1$\frac{1}{2}$		+ 19 50
EAST.	E. by N. $\frac{1}{4}$ N.	+ 1$\frac{1}{4}$		+ 19 0
E. by S.	E. $\frac{1}{2}$ N.	+ 1$\frac{1}{2}$		+ 19 50
E. S. E.	E. $\frac{3}{4}$ S.	+ 1$\frac{1}{4}$		+ 19 0
S. E. by E.	E. S. E. $\frac{1}{4}$ E.	+ 1$\frac{1}{4}$		+ 18 0
S. E.	S. E. by E.	+ 1		+ 16 10
S. E. by S.	S. E.	+ 1		+ 15 10
S. S. E.		+ $\frac{3}{4}$		+ 13 20
S. by E.	S. by E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 10 30
SOUTH.	S. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 9 30
S. by W.	S. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 7 40
S. S. W.	S. S. W.	0		+ 5 0
S. W. by S.	S. W. $\frac{3}{4}$ S.	— $\frac{1}{4}$		+ 2 10
S. W.	S. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 0 40
S. W. by W.	S. W. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 40
W. S. W.	W. by S. $\frac{3}{8}$ S.	— $\frac{5}{8}$		— 2 40
W. by S.	W. $\frac{1}{2}$ S.	— $\frac{1}{2}$		— 2 10
WEST.	W. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 1 40
W. by N.	W. by N. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 1 40
W. N. W.		— $\frac{1}{2}$		— 1 40
N. W. by W.	N. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 40
N. W.	N. W. $\frac{5}{8}$ N.	— $\frac{5}{8}$		— 2 40
N. W. by N.	N. N. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 2 10
N. N. W.	N. by W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		+ 0 10
N. by W.	N. $\frac{7}{8}$ W.	— $\frac{1}{8}$		+ 2 0
NORTH.		+ $\frac{1}{8}$		+ 4 20

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 7° 40′.0   B = + 11° 26′.5   C = — 1° 44′.1
D = + 0° 15′.5   E = — 0° 54′.5

St. Thomas, November 18, 1865.

Correction for Object = + 0° 16′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{3}{8}$ W.	+ $\frac{3}{8}$	° ′	+ 4° 0′
N. by E.	N. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 5 30
N. N. E.	N. by E. $\frac{1}{4}$ E.	+ $\frac{3}{4}$		+ 8 10
N. E. by N.	N. N. E.	+ 1		+ 11 0
N. E.	N. E. by N.	+ 1		+ 11 0
N. E. by E.	N. E. $\frac{1}{8}$ N.	+ 1$\frac{1}{8}$		+ 12 20
E. N. E.	N. E. $\frac{7}{8}$ E.	+ 1$\frac{1}{8}$		+ 12 20
E. by N.	N. E. by E. $\frac{7}{8}$ E.	+ 1$\frac{1}{8}$		+ 12 20
EAST.	E. by N.	+ 1		+ 11 0
E. by S.	E. $\frac{1}{8}$ N.	+ 1$\frac{1}{8}$		+ 12 20
E. S. E.	E. by S.	+ 1		+ 11 0
S. E. by E.	S. E. by E. $\frac{7}{8}$ E.	+ $\frac{7}{8}$		+ 9 30
S. E.	S. E. $\frac{5}{8}$ E.	+ $\frac{5}{8}$		+ 6 40
S. E. by S.	S. E. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 20
S. S. E.	S. E. by S. $\frac{5}{8}$ S.	+ $\frac{3}{8}$		+ 4 0
S. by E.	S. by E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 30
SOUTH.	S. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 10
S. by W.	S. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 1 10
S. S. W.	S. S. W.	0		— 0 20
S. W. by S.	S. W. by S.	0		— 0 20
S. W.	S. W. $\frac{1}{8}$ W.	— $\frac{1}{8}$		— 1 40
S. W. by W.	S. W. by W. $\frac{1}{8}$ W.	— $\frac{1}{8}$		— 1 40
W. S. W.	W. by S. $\frac{7}{8}$ S.	— $\frac{1}{8}$		— 1 40
W. by S.	W. $\frac{3}{4}$ S.	— $\frac{1}{4}$		— 3 10
WEST.	W. $\frac{3}{8}$ N.	— $\frac{3}{8}$		— 4 30
W. by N.	W. by N. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 5 50
W. N. W.	N. W. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 5 50
N. W. by W.	N. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 5 50
N. W.	N. W. $\frac{3}{8}$ N.	— $\frac{3}{8}$		— 4 30
N. W. by N.	N.W. by N. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 3 10
N. N. W.	N. N. W.	0		— 0 20
N. by W.	N. by W. $\frac{1}{8}$ W.	+ $\frac{1}{8}$		+ 1 10
NORTH.		+ $\frac{3}{8}$		+ 4 0

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 3° 14′.4   B = + 8° 26′.9   C = + 0° 40′.4
D = + 1° 54′.2   E = — 0° 37′.2

Observations for Determining the Deviations of the After Ritchie Compass on the U. S. Iron Clad Monadnock.

Isle Royal, Salute Islands, November 30, 1865.

Correction for Object = — 0° 2′. Correction for Lubber Line = + 6° 18′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
			° ′	
NORTH.				
N. by E.				
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.	E. ½ N.	+ ½		+ 11° 50′
E. by S.	E. ¼ S.	+ ¾		+ 14 40
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = B = C =
D = E =

Ceara, December 19, 1865.

Correction for Object = + 1°.51′ Correction for Lubber Line = + 6° 18′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
			° ′	
NORTH.				
N. by E.	N. ½ E.	+ ½		+ 13° 40′
N. N. E.	N. by E. ½ E.	+ ½		+ 13 40
N. E. by N.	N. N. E. ½ E.	+ ½		+ 13 40
N. E.	N. E. by N. ¼ E.	+ ¾		+ 16 10
N. E. by E.	N. E. ¼ E.	+ ¾		+ 16 30
E. N. E.	N. E. by E.	+ 1		+ 19 0
E. by N.	E. by N. ¾ N.	+ ¾		+ 17 0
EAST.	E. ½ N.	+ ½		+ 14 10
E. by S.	E. ¾ S.	+ ¼		+ 11 30
E. S. E.	E. by S. ¾ S.	+ ¼		+ 11 0
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 5° 54′.2 B = + 7° 56′.0 C = + 4° 55′.4
D = + 1° 36′.6 E = — 0° 43′.7

Observations for Determining the Deviations of the After Ritchie Compass on the U. S. Iron Clad Monadnock.

Bahia, December 30, 1865.

Correction for Object = + 2° 30′. Correction for Lubber Line = + 6° 18′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N.	0	° ′	+ 8° 10′
N. by E.	N ¾ E.	+ ¼		+ 11 0
N. N. E.	N. N. E. ¼ N.	+ ¼		+ 11 40
N. E. by N.	N. E. by N. ½ N.	+ ½		+ 13 50
N. E.	N. E. ½ N.	+ ½		+ 14 20
N. E. by E.	N. E. ½ E.	+ ½		+ 14 20
E. N. E.	N. E. by E. ¼ E.	+ ¾		+ 16 30
E. by N.	E. by N. ¾ N.	+ ¾		+ 17 10
EAST.	E. ½ N.	+ ½		+ 15 0
E. by S.	E. ½ S.	+ ½		+ 14 20
E. S. E.	E. by S. ½ S.	+ ½		+ 14 20
S. E. by E.	S. E. by E. ½ E.	+ ½		+ 14 20
S. E.	S. E. ¼ E.	+ ¼		+ 12 10
S. E. by S.	S. E. ¾ S.	+ ¼		+ 11 40
S. S. E.	S. S. E. ¼ E.	+ ¼		+ 11 40
S. by E.	S. by E.	0		+ 9 30
SOUTH.	SOUTH.	0		+ 8 50
S. by W.	S. by W.	0		+ 8 50
S. S. W.	S. S. W.	0		+ 8 50
S. W. by S.	S. W. by S.	0		+ 8 50
S. W.	S. W. ¼ W.	— ¼		+ 6 40
S. W. by W.	S. W. by W. ¼ W.	— ¼		+ 6 0
W. S. W.	W. by S. ½ S.	— ½		+ 3 50
W. by S.	W. ½ S.	— ½		+ 3 10
WEST.	W. ¾ N.	— ¾		+ 1 0
W. by N.		— ¾		+ 0 20
W. N. W.	N. W. by W. ¼ W.	— ¾		+ 0 20
N. W. by W.	N. W. ¼ W.	— ¾		+ 0 20
N. W.	N. W. ¾ N.	— ¾		+ 0 20
N.W. by N.	N. N. W. ½ W.	— ½		+ 2 30
N. N. W.	N. by W. ¾ W.	— ¼		+ 5 20
N. by W.	N. ¾ W.	— ¼		+ 6 0
NORTH.		0		+ 8 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

$A = +8^\circ\ 47'.1 \qquad B = +6^\circ\ 55'.6 \qquad C = -0^\circ\ 57'.2$

$D = +1^\circ\ 59'.7 \qquad E = +0^\circ\ 14'\ 2$

Rio Janeiro, January 10, 1866.

Correction for Object = + 2° 44′. Correction for Lubber Line = + 5° 43′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.			° ′	
N. by E.				
N. N. E.				
N. E. by N.	N. E. by N. ½ N.	+ ½		+ 14° 0′
N. E.	N. E. ½ N.	+ ½		+ 14 0
N. E. by E.	N. E. ½ E.	+ ½		+ 14 0
E. N. E.	N. E. by E. ¼ E.	+ ¾		+ 16 10
E. by N.	E. by N. ¾ N.	+ ¾		+ 16 50
EAST.	E. ½ N.	+ ½		+ 14 40
E. by S.	E. ¾ S.	+ ¼		+ 12 0
E. S. E.	E. S. E. ⅛ E.	+ ⅛		+ 10 10
S. E. by E.	S. E. by E. ⅛ E.	+ ⅛		+ 9 50
S. E.	S. E. ⅛ E.	+ ⅛		+ 9 50
S. E. by S.	S. E. by S.	0		+ 8 30
S. S. E.	S. S. E.	0		+ 8 30
S. by E.	S. by E.	0		+ 8 30
SOUTH.	SOUTH.	0		+ 8 30
S. by W.	S. by W.	0		+ 8 30
S. S. W.	S. S. W.	0		+ 8 30
S. W. by S.	S. W. by S.	0		+ 8 30
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N.. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign + a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviations are obtained:

$A = +9^\circ\ 39'.0 \qquad B = +3^\circ\ 46'.6 \qquad C = +1^\circ\ 9'.8$

$D = +1^\circ\ 50'.1 \qquad E = -0^\circ\ 7'.4$

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE AFTER RITCHIE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Monte Video, January 24, 1866.

Correction for Object = — 0° 13′. Correction for Lubber Line = + 4° 9′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	+ 4° 0′
N. by E.	N. ½ E.	+ ½		+ 9 30
N. N. E.	N. by E. ½ E.	+ ½		+ 9 30
N. E. by N.	N. E. by N. ¾ N.	+ ¾		+ 12 20
N. E.	N. E. ¾ N.	+ ¾		+ 12 20
N. E. by E.	N. E. ¼ E.	+ ¾		+ 12 20
E. N. E.	N. E. by E.	+ 1		+ 15 10
E. by N.	E. N. E.	+ 1		+ 15 0
EAST.	E. ½ N.	+ ½		+ 9 20
E. by S.	E. by S.	0		+ 4 0
E. S. E.	E. S. E.	0		+ 3 50
S. E. by E.	S. E. by E. ¼ S.	— ¼		+ 1 0
S. E.	S. E. ¾ S.	— ¾		— 4 30
S. E. by S.	S. E. by S. ½ S.	— ½		— 1 40
S. S. E.	S. S. E.	0		+ 4 0
S. by E.				+ 4 0
SOUTH.	SOUTH.	0		+ 4 0
S. by W.	S. ¾ W.	+ ¼		+ 6 50
S. S. W.	S. by W. ¾ W.	+ ¼		+ 6 50
S. W. by S.	S. W. by S.	0		+ 4 0
S. W.	S. W.	0		+ 4 0
S. W. by W.	S. W. ½ W.	+ ½		+ 9 30
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 6° 32′.8 B = + 0° 50′.3 C = + 3° 10′.9
D = + 2° 1′.8 E = — 0° 5′.5

Sandy Point, February 10, 1866.

Correction for Object = + 0° 7′. Correction for Lubber Line = + 4° 9′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. ⅛ W.	+ ⅛	° ′	+ 5° 40′
N. by E.	N. ¾ E.	+ ¼		+ 7 0
N. N. E.	N. by E. ½ E.	+ ½		+ 9 50
N. E. by N.	N. E. by N. ½ N.	+ ½		+ 9 50
N. E.	N. E. ½ N.	+ ½		+ 9 50
N. E. by E.	N. E. ¼ E.	+ ¾		+ 12 40
E. N. E.	N. E. by E. ½ E.	+ ½		+ 9 50
E. by N.	E. by N. ½ N.	+ ½		+ 9 50
EAST.				+ 9 50
E. by S.	E. ½ S.	+ ½		+ 9 50
E. S. E.	E. by S. ¼ S.	+ ¾		+ 12 40
S. E. by E.	E. S. E. ⅛ S.	+ ⅞		+ 14 0
S. E.	S. E. by E. ¼ S.	+ ¾		+ 12 40
S. E. by S.	S. E. ⅛ S.	+ ⅞		+ 14 0
S. S. E.	S. E. by S. ⅛ S.	+ ⅞		+ 14 0
S. by E.	S. by E. ¾ E.	+ ¾		+ 12 40
SOUTH.	S. ½ E.	+ ½		+ 9 50
S. by W.	S. ½ W.	+ ½		+ 9 50
S. S. W.	S. by W. ¼ W.	+ ¾		+ 12 40
S. W. by S.	S. W. by S. ¾ S.	+ ¾		+ 12 40
S. W.	S. W. ½ S.	+ ½		+ 9 50
S. W. by W.	S. W. ¾ W.	+ ¼		+ 7 0
W. S. W.	W. S. W.	0		+ 4 20
W. by S.	W. by S.	0		+ 4 20
WEST.	WEST.	0		+ 4 20
W. by N.	W. by N. ⅛ N.	— ⅛		+ 2 50
W. N. W.	W. N. W. ⅛ N.	— ⅛		+ 2 50
N. W. by W.	N. W. ¾ W.	— ¼		+ 1 20
N. W.	N. W. ¼ N.	— ¼		+ 1 20
N. W. by N.	N. N. W. ¾ W.	— ¼		+ 1 20
N. N. W.	N. N. W. ⅛ N.	— ⅛		+ 2 50
N. by W.	N. by W.	0		+ 4 20
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 8° 18′.4 B = + 4° 3′.2 C = — 3° 25′.6
D = + 1° 14′.5 E = + 0° 58′.5

Observations for Determining the Deviations of the After Ritchie Compass on the U. S. Iron Clad Monadnock.

Valparaiso, April 4, 1866.

Correction for Object = + 0° 1′. Correction for Lubber Line = + 4° 17′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	+ 4° 20′
N. by E.	N. ¾ E.	+ ¼		+ 7 0
N. N. E.	N. by E. ¾ F.	+ ¼		+ 7 0
N. E. by.N.	N. E. by N. ½ N.	+ ½		+ 9 50
N. E.	N. E. ½ N.	+ ½		+ 9 50
N. E. by E.	N. E. ½ E.	+ ½		+ 9 50
E. N. E.	E. N. E. ¼ N.	+ ¼		+ 7 0
E. by N.	E. by N. ½ N.	+ ½		+ 9 50
EAST.	E. ¼ N.	+ ¼		+ 7 0
E. by S.	E. ¾ S.	+ ¼		+ 7 0
E. S. E.	E. S. E. ¼ E.	+ ¼		+ 7 0
S. E. by E.	S. E. by E. ¼ E.	+ ¼		+ 7 0
S. E.	S. E.	0		+ 4 20
S. E. by S.	S. E. by S.	0		+ 4 20
S. S. E.	S. S. E.	0		+ 4 20
S. by E.	S. by E.	0		+ 4 20
SOUTH.	S. ¼ W.	— ¼		+ 1 30
S. by W.	S. by W.	0		+ 4 20
S. S. W.	S. S. W.	0		+ 4 20
S. W. by S.	S. W. by S.	0		+ 4 20
S. W.	S. W.	0		+ 4 20
S. W. by W.	S. W. by W.	0		+ 4 20
W. S. W.	W. S. W.	0		+ 4 20
W. by S.	W. ¾ S.	— ¼		+ 1 30
WEST.	W. ½ N.	— ½		— 1 20
W. by N.	W. by N. ½ N.	— ½		— 1 20
W. N. W.	N. W. by W. ½ W.	— ½		— 1 20
N. W. by W.	N. W. ½ W.	— ½		— 1 20
N. W.	N. W. ¼ N.	— ¼		+ 1 30
N. W. by N.	N. W. by N. ½ N.	— ½		— 1 20
N. N. W.	N. by W. ¾ W.	— ¼		+ 1 30
N. by W	N. by W.	0		+ 4 20
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 4° 21′.9   B = + 3° 49′.1   C = + 0° 12′.4
D = + 2° 21′.0   E = + 0° 7′.5

Callao, April 29, 1866.

Correction for Object = + 0° 6′. Correction for Lubber Line = + 3° 44′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. ⅛ W.	+ ⅛	° ′	+ 5° 20′
N. by E.	N. ½ E.	+ ½		+ 9 30
N. N. E.	N. by E. ½ E.	+ ½		+ 9 30
N. E. by N.	N. E. by N. ½ N.	+ ½		+ 9 30
N. E.	N. E. ½ N.	+ ½		+ 9 30
N. E. by E.	N. E. ½ E.	+ ½		+ 9 30
E. N. E.	N. E. by E. ½ E.	+ ½		+ 9 30
E. by N.	E. by N. ½ N.	+ ½		+ 9 30
EAST.	E. ½ N.	+ ½		+ 9 30
E. by S.	E. ½ S.	+ ½		+ 9 30
E. S. E.	E. by S. ¾ S.	+ ¼		+ 6 40
S. E. by E.	S. E. by E. ¼ E.	+ ¼		+ 6 40
S. E.	S. E. ½ E.	+ ½		+ 9 30
S. E. by S.	S. E. ¾ S.	+ ¼		+ 6 40
S. S. E.				+ 6 40
S. by E.	S. by E.	0		+ 3 50
SOUTH.	SOUTH.	0		+ 3 50
S. by W.	S. by W.	0		+ 3 50
S. S. W.	S. S. W.	0		+ 3 50
S. W. by S.	S. W. by S.	0		+ 3 50
S. W.	S. W. ¼ W.	— ¼		+ 1 0
S. W. by W.	S. W. by W. ¼ W.	— ¼		+ 1 0
W. S. W.	W. by S. ½ S.	— ½		— 1 50
W. by S.	W. ½ S.	— ½		— 1 50
WEST.	W. ½ N.	— ½		— 1 50
W. by N.	W. by N. ½ N.	— ½		— 1 50
W. N. W.	N. W. by W. ½ W.	— ½		— 1 50
N. W. by W.	N. W. ½ W.	— ½		— 1 50
N. W.	N. W. ½ N.	— ½		— 1 50
N. W. by N.	N. W. by N. ½ N.	— ½		— 1 50
N. N. W.	N. by W. ¾ W.	— ¼		+ 1 0
N. by W.	N. by W.	0		+ 3 50
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviations are obtained:

A = + 4° 19′.4   B = + 5° 50′.1   C = + 0° 14′.1
D = + 1° 30′.5   E = + 0° 52′.0

Observations for Determining the Deviations of the After Ritchie Compass on the U. S. Iron Clad Monadnock.

Panama, May 20, 1866.

Correction for Object = + 0° 1′. Correction for Lubber Line = + 3° 44′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	+ 3° 50′
N. by E.	N. ¾ E.	+ ¼		+ 6 30
N. N. E.	N. by E. ¾ E.	+ ¼		+ 6 30
N. E. by N.	N. E. by N. ½ N.	+ ½		+ 9 20
N. E.	N. E. ½ N.	+ ½		+ 9 20
N. E. by E.	N. E. ½ E.	+ ½		+ 9 20
E. N. E.	N. E. by E. ½ E.	+ ½		+ 9 20
E. by N.	E. by N. ¾ N.	+ ¾		+ 12 10
EAST.	E. ¾ N.	+ ¾		+ 12 10
E. by S.	E. ½ S.	+ ½		+ 9 20
E. S. E.	E. by S. ½ S.	+ ½		+ 9 20
S. E. by E.	S. E. by E. ½ E.	+ ½		+ 9 20
S. E.	S. E. ⅛ E.	+ ⅛		+ 5 10
S. E. by S.	S. E. ¾ S.	+ ¼		+ 6 30
S. S. E.	S. E. by S. ¾ S.	+ ¼		+ 6 30
S. by E.	S. by E.	0		+ 3 40
SOUTH.	SOUTH.	0		+ 3 50
S. by W.	S. by W.	0		+ 3 40
S. S. W.	S. S. W.	0		+ 3 50
S. W. by S.	S. W. by S.	0		+ 3 40
S. W.	S. W.	0		+ 3 50
S. W. by W.	S. W. by W.	0		+ 3 40
W. S. W.	W. S. W.	0		+ 3 50
W. by S.	W. by S.	0		+ 3 40
WEST.	W. ⅛ N.	— ⅛		+ 2 20
W. by N.	W. by N. ⅛ N.	— ⅛		+ 2 20
W. N. W.	W. N. W. ⅛ N.	— ⅛		+ 2 20
N. W. by W.	N. W. ¾ W.	— ¼		+ 0 50
N. W.	N. W. ⅛ N.	— ⅛		+ 2 20
N. W. by N.	N.W. by N. ¼ N.	— ¼		+ 0 50
N. N. W.	N. by W. ¾ W.	— ¼		+ 0 50
N. by W.	N. ¾ W.	— ¼		+ 0 50
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 5° 20′.6 B = + 4° 3′.1 C = — 0° 10′.2
D = + 1° 17′.0 E = — 1° 33′.0

Acapulco, June 1, 1866.

Correction for Object = + 0° 6′. Correction for Lubber Line = + 3° 44′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. ¼ W.	+ ¼	° ′	+ 6° 40′
N. by E.	N. ¾ E.	+ ¼		+ 6 40
N. N. E.	N. by E. ¾ E.	+ ¼		+ 6 40
N. E. by N.	N. E. by N. ½ N.	+ ½		+ 9 30
N. E.	N. E. ½ N.	+ ½		+ 9 30
N. E. by E.	N. E. ½ E.	+ ½		+ 9 30
E. N. E.	N. E. by E. ½ E.	+ ½		+ 9 30
E. by N.	E. by N. ½ N.	+ ½		+ 9 30
EAST.	E. ¼ N.	+ ¼		+ 6 40
E. by S.	E. ¾ S.	+ ¼		+ 6 40
E. S. E.	E. S. E. ¼ E.	+ ¼		+ 6 40
S. E. by E.	S. E. by E. ¼ E	+ ¼		+ 6 40
S. E.	S. E.	0		+ 3 50
S. E. by S.	S. E. by S.	0		+ 3 50
S. S. E.	S. S. E.	0		+ 3 50
S. by E.	S. by E.	0		+ 3 50
SOUTH.	SOUTH.	0		+ 3 50
S. by W.	S. by W.	0		+ 3 50
S. S. W.	S. S. W.	0		+ 3 50
S. W. by S.	S. W. by S.	0		+ 3 50
S. W.	S. W. ¼ W.	— ¼		+ 1 0
S. W. by W.	S. W. by W. ½ W.	— ½		— 1 50
W. S. W.	W. by S. ½ S.	— ½		— 1 50
W. by S.	W. ½ S.	— ½		— 1 50
WEST.	W. ½ N.	— ½		— 1 50
W. by N.	W. by N. ¼ N.	— ¼		+ 1 0
W. N. W.	N. W. by W. ¾ W.	— ¼		+ 1 0
N. W. by W.	N. W. ½ W.	— ½		— 1 50
N. W.	N. W. ¼ N.	— ¼		+ 1 0
N. W. by N.	N. W. by N. ¼ N.	— ¼		+ 1 0
N. N. W.	N. N. W.	0		+ 3 50
N. by W.	N. by W.	0		+ 3 50
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 4° 0′.6 B = + 4° 29′.1 C = + 1° 12′.8
D = + 1° 12′.2 E = + 0° 47′.0

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE AFTER RITCHIE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Magdalena Bay, June 9, 1866.

Correction for Object = — 0° 41′. Correction for Lubber Line = + 3° 44′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. ⅛ E.	— ⅛	° ′	+ 1° 40′
N. by E.	N. by E.	0		+ 3 10
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.				
E. by S.				
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.	S. W. ⅛ W.	— ⅛		+ 1 40
S. W. by W.	S. W. by W.	0		+ 3 0
W. S. W.	W. S. W.	0		+ 3 0
W. by S.	W. by S.	0		+ 3 0
WEST.	W. ⅛ N.	— ⅛		+ 1 20
W. by N.	W. by N. ½ N.	— ½		— 2 50
W. N. W.	N. W. by W. ¼ W.	— ¾		— 5 30
N. W. by W.	N. W. ¼ W.	— ¾		— 5 20
N. W.	N. W. ½ N.	— ½		— 2 40
N. W. by N.	N. W. by N. ½ N.	— ½		— 2 40
N. N. W.	N. by W. ½ W.	— ½		— 2 30
N. by W.	N. ⅝ W.	— ⅜		— 1 0
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 3° 35′.5 B = + 4° 27′.3 C = — 2° 51′.0
D = + 1° 50′.7 E = + 0° 10′.6

San Francisco, June 23, 1866.

Correction for Object = — 0° 45′. Correction for Lubber Line = + 3° 49′.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. ⅛ E.	— ⅛	° ′	+ 2° 0′
N. by E.	N. ¾ E.	+ ¼		+ 5 50
N. N. E.	N. by E. ¾ E.	+ ¼		+ 6 10
N. E. by N.	N. N. E. ½ E.	+ ½		+ 8 50
N. E.	N. E. ¾ N.	+ ¾		+ 11 30
N. E. by E.	N. E. ¼ E.	+ ¾		+ 11 30
E. N. E.	N. E. by E. ¼ E.	+ ¾		+ 11 30
E. by N.	E. by N. ¾ N.	+ ¾		+ 11 30
EAST.	E. ¾ N.	+ ¾		+ 11 10
E. by S.	E. ½ S.	+ ½		+ 8 40
E. S. E.	E. by S. ½ S.	+ ½		+ 8 40
S. E. by E.	S. E. by E. ½ E.	+ ½		+ 8 40
S. E.	S. E. ½ E.	+ ½		+ 8 40
S. E. by S.	S. E. ¾ S.	+ ¼		+ 6 0
S. S. E.	S. S. E. ¼ E.	+ ¼		+ 6 0
S. by E.	S. by E. ¼ E	+ ¼		+ 6 0
SOUTH.	S. ¼ E.	+ ¼		+ 6 0
S. by W.	S. ¾ W.	+ ¼		+ 6 0
S. S. W.	S. by W. ¾ W.	+ ¼		+ 6 0
S. W. by S.	S. W. by S. ¼ S.	+ ¼		+ 5 40
S. W.	S. W.	0		+ 2 50
S. W. by W.	S. W. by W. ¼ W.	— ¼		+ 0 20
W. S. W.	W. by S. ¾ S.	— ¼		0 0
W. by S.	W. ½ S.	— ½		— 2 30
WEST.	W. ½ N.	— ½		— 2 50
W. by N.	W. by N. ¾ N.	— ¾		— 5 20
W. N. W.	N. W. by W. ¼ W.	— ¾		— 5 10
N. W. by W.	N. W. ½ W.	— ½		— 2 30
N. W.	N. W. ½ N.	— ½		— 2 30
N. W. by N.	N. W. by N. ½ N.	— ½		— 2 30
N. N. W.	N. N. W. ½ N.	— ½		— 2 20
N. by W.	N. ¾ W.	— ¼		+ 0 20
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 4° 11′.6 B = + 6° 46′.2 C = — 1° 31′.4
D = + 2° 28′.5 E = + 0° 21′.2

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE AFTER AZIMUTH COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Hampton Roads, November 1, 1865.

Correction for Object = + 3° 57′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 3° E.		— 3° 0′	+ 0° 10′
N. by E.	N. 15 E.		— 4 0	+ 0 10
N. N. E.	N. 26 E.		— 3 30	+ 0 10
N. E. by N.	N. 36 E.		— 2 0	+ 1 20
N. E.	N. 48 E.		— 3 0	+ 1 10
N. E. by E.	N. 60 E.		— 4 0	+ 0 10
E. N. E.	N. 74 E.		— 6 30	— 1 50
E. by N.	N. 87 E.		— 8 0	— 3 40
EAST.	S. 79 E.		— 11 0	— 6 0
E. by S.	S. 65 E.		— 14 0	— 9 10
E. S. E.	S. 53 E.		— 14 30	— 10 30
S. E. by E.	S. 42 E.		— 14 0	— 10 20
S. E.	S. 32 E.		— 13 0	— 9 30
S. E. by S.	S. 22 E.		— 12 0	— 8 30
S. S. E.	S. 13 E.		— 9 30	— 6 30
S. by E.	S. 5 E.		— 6 0	— 3 20
SOUTH.	S. 3 W.		— 3 0	— 0 10
S. by W.	S. 12 W.		— 1 0	+ 2 10
S. S. W.	S. 20 W.		+ 2 30	+ 5 10
S. W. by S.	S. 31 W.		+ 3 0	+ 6 40
S. W.	S. 42 W.		+ 3 0	+ 7 0
S. W. by W.	S. 52 W.		+ 4 0	+ 7 30
W. S. W.	S. 64 W.		+ 3 30	+ 7 30
W. by S.	S. 76 W.		+ 3 0	+ 7 0
WEST.	N. 89 W.		— 1 0	+ 4 20
W. by N.	N. 74 W.		— 5 0	+ 0 20
W. N. W.	N. 63 W.		— 4 30	— 0 50
N. W. by W.	N. 50 W.		— 6 0	— 1 40
N. W.	N. 37 W.		— 8 0	— 3 30
N. W. by N.	N. 25 W.		— 9 0	— 4 50
N. N. W.	N. 16 W.		— 6 30	— 3 30
N. by W.	N. 6 W.		— 5 0	— 1 40
NORTH.				+ 0 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 1° 5′.0   B = — 4° 53′.0   C = — 0° 9′.1
D = + 5° 35′.2   E = + 0° 17′.0

St. Thomas, November 18, 1865.

Correction for Object = + 0° 16′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N.		0° 0′	— 0° 10′
N. by E.	N. 9° E.		+ 2 15	+ 2 0
N. N. E.	N. 18 E.		+ 4 30	+ 4 20
N. E. by N.	N. 29 E.		+ 4 45	+ 4 30
N. E.	N. 41 E.		+ 4 0	+ 3 40
N. E. by E.	N. 53 E.		+ 3 15	+ 3 0
E. N. E.	N. 65 E.		+ 2 30	+ 2 10
E. by N.	N. 80 E.		— 1 15	— 1 30
EAST.	S. 86 E.		— 4 0	— 4 20
E. by S.	S. 71 E.		— 7 45	— 8 0
E. S. E.	S. 58 E.		— 9 30	— 9 50
S. E. by E.	S. 45 E.		— 11 15	— 11 30
S. E.	S. 33 E.		— 12 0	— 12 10
S. E. by S.	S. 25 E.		— 8 45	— 9 0
S. S. E.	S. 16 E.		— 6 30	— 6 50
S. by E.	S. 6 E.		— 5 15	— 5 30
SOUTH.	S. 2 W.		— 2 0	— 2 10
S. by W.	S. 11 W.		+ 0 15	0 0
S. S. W.	S. 19 W.		+ 3 30	+ 3 20
S. W. by S.	S. 29 W.		+ 4 45	+ 4 30
S. W.	S. 39 W.		+ 6 0	+ 5 50
S. W. by W.	S. 49 W.		+ 7 15	+ 7 0
W. S.W.	S. 60 W.		+ 7 30	+ 7 10
W. by S.	S. 74 W.		+ 4 45	+ 4 30
WEST.	S. 87 W.		+ 3 0	+ 2 40
W. by N.	N. 77 W.		— 1 45	— 2 10
W. N. W.	N. 64 W.		— 3 30	— 3 50
N. W. by W.	N. 52 W.		— 4 15	— 4 30
N. W.	N. 40 W.		— 5 0	— 5 10
N. W. by N.	N. 29 W.		— 4 45	— 5 0
N. N. W.	N. 20 W.		— 2 30	— 2 50
N. by W.	N. 10 W.		— 1 15	— 1 30
NORTH.				— 0 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the cofficients of the deviation are obtained:

A = — 1° 17′.5   B = — 3° 0′.9   C = + 1° 20′.0
D = + 6° 49′.2   E = + 0° 12′.2

Observations for Determining the Deviations of the After Azimuth Compass on the U. S. Iron Clad Monadnock.

Isle Royal, Salute Islands, November 30, 1865.

Correction for Object = — 0° 2′. Correction for Lubber Line = 0

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.				
N. by E.				
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.	S. 70° E.		— 20° 0	— 20° 0′
E. by S.	S. 63 E.		— 15 45	— 15 50
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = B = C =
D = E =

Ceara, December 19, 1865.

Correction for Object = + 1° 51′ Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.				
N. by E.	N. 4° E.		+ 7° 15′	+ 9° 0′
N. N. E.	N. 14 E.		+ 8 30	+ 10 10
N. E. by N.	N. 24 E.		+ 9 45	+ 11 20
N. E.	N. 38 E.		+ 7 0	+ 9 20
N. E. by E.	N. 45 E.		+ 11 15	+ 12 20
E. N. E.	N. 58 E.		+ 9 30	+ 11 40
E. by N.	N. 78 E.		+ 0 45	+ 4 0
EAST.	S. 69 E.		— 21 0	— 15 30
E. by S.	S. 59 E.		— 19 45	— 18 10
E. S. E.	S. 48 E.		— 19 30	— 17 40
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

The compass did not traverse well, and the observations are not sufficiently good to be worth the trouble of reducing.

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = B = C =
D = E =

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE AFTER AZIMUTH COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Bahia, December 30, 1865.

Correction for Object = + 2° 30′. Correction for Lubber Line = c.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 8° E.		— 8° 0′	— 5° 50′
N. by E.	N. 17 E.		— 5 45	— 3 50
N. N. E.	N. 27 E.		— 4 30	— 2 20
N. E. by N.	N. 35 E.		— 1 15	+ 0 30
N. E.	N. 46 E.		— 1 0	+ 1 30
N. E. by E.	N. 58 E.		— 1 45	+ 1 0
E. N. E.	N. 70 E.		— 2 30	+ 0 10
E. by N.	N. 86 E.		— 7 15	— 3 40
EAST..	S. 78 E.		— 12 0	— 8 20
E. by S.	S. 65 E.		— 13 45	— 10 50
E. S. E.	S. 51 E.		— 16 30	— 13 20
S. E. by E.	S. 39 E.		— 17 15	— 14 40
S. E.	S. 29 E.		— 16 0	— 13 50
S. E. by S.	S. 19 E.		— 14 45	— 12 30
S. S. E.	S. 10 E.		— 12 30	— 10 30
S. by E.	S. 2 E.		— 9 15	— 7 30
SOUTH.	S. 6 W.		— 6 0	— 4 20
S. by W.	S. 12 W.		— 0 45	+ 0 30
S. S. W.	S. 22 W.		+ 0 30	+ 2 40
S. W. by S.	S. 31 W.		+ 2 45	+ 4 40
S. W.	S. 40 W.		+ 5 0	+ 7 0
S. W. by W.	S. 50 W.		+ 6 15	+ 8 30
W. S. W.	S. 65 W.		+ 2 30	+ 5 50
W. by S.	S. 78 W.		+ 0 45	+ 3 30
WEST.	N. 89 W.		— 1 0	+ 1 50
W. by N.	N. 75 W.		— 3 45	— 0 40
W. N. W.	N. 62 W.		— 5 30	— 2 40
N. W. by W.	N. 46 W.		— 10 15	— 6 40
N. W.	N. 35 W.		— 10 0	— 7 30
N.W. by N.	N. 23 W.		— 10 45	— 8 10
N. N. W.	N. 11 W.		— 11 30	— 8 50
N. by W.	N. 2 W.		— 9 15	— 7 20
NORTH.			— 8 0	— 5 50

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 3° 36′.9 B = — 4° 28′.6 C = — 0° 19′.5
D = + 7° 22′.0 E = — 1° 5′.5

Rio Janeiro, January 10, 1866.

Correction for Object = + 2° 44′. Correction for Lubber Line = 0°.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.				
N. by E.				
N. N. E.				
N. E. by N.	E. 56° N.		— 0° 15′	+ 2° 40′
N. E.	E. 44 N.		— 1 0	+ 2 0
N. E. by E.	E. 32 N.		— 2 45	+ 0 20
E. N. E.	E. 17 N.		— 5 30	— 2 10
E. by N.	E. 6 N.		— 5 15	— 2 40
EAST.	S. 82 E.		— 8 0	— 4 40
E. by S.	S. 69 E.		— 9 45	— 6 30
E. S. E.	S. 58 E.		— 9 30	— 6 50
S. E. by E.	S. 46 E.		— 10 15	— 7 20
S. E.	S. 36 E.		— 9 0	— 6 40
S. E. by S.	S. 26 E.		— 7 45	— 5 20
S. S. E.	S. 17 E.		— 5 30	— 3 20
S. by E.	S. 8 E.		— 3 15	— 1 10
SOUTH.	S. 2 W.		— 2 0	+ 0 20
S. by W.	S. 10 W.		+ 1 15	+ 3 10
S. S. W.	S. 20 W.		+ 2 30	+ 4 50
S. W. by S.	S. 30 W.		+ 3 45	+ 6 10
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign + a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviations are obtained:

A = — 2° 29′.3 B = — 1° 8′.5 C = — 3° 9′.7
D = + 6° 28′.2 E = — 0° 4′.5

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE AFTER AZIMUTH COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Sandy Point, February 10, 1866.

Correction for Object = + 0° 7′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 1° E.		— 1° 0′	— 0° 50′
N. by E.	N. 11 E.		+ 0 15	+ 0 20
N. N. E.	N. 19 E.		+ 3 30	+ 3 40
N. E. by N.	N. 30 E.		+ 3 45	+ 3 50
N. E.	N. 40 E.		+ 5 0	+ 5 10
N. E. by E.	N. 54 E.		+ 2 15	+ 2 20
E. N. E.	N. 63 E.		+ 4 30	+ 4 40
E. by N.	N. 80 E.		— 1 15	— 1 10
EAST.	S. 89 E.		— 1 0	— 0 50
E. by S.	S. 71 E.		— 7 45	— 7 40
E. S. E.	S. 60 E.		— 7 30	— 7 20
S. E. by E.	S. 47 E.		— 9 15	— 9 10
S. E.	S. 36 E.		— 9 0	— 8 50
S. E. by S.	S. 27 E.		— 6 45	— 6 40
S. S. E.	S. 16 E.		— 6 30	— 6 20
S. by E.	S. 8 E.		— 3 15	— 3 10
SOUTH.	S. 1 E.		+ 1 0	+ 1 10
S. by W.	S. 6 W.		+ 5 15	+ 5 20
S. S. W.	S. 17 W.		+ 5 30	+ 5 40
S. W. by S.	S. 26 W.		+ 7 45	+ 7 50
S. W.	S. 37 W.		+ 8 0	+ 8 10
S. W. by W.	S. 47 W.		+ 9 15	+ 9 20
W. S. W.	S. 58 W.		+ 9 30	+ 9 40
W. by S.	S. 74 W.		+ 4 45	+ 4 50
WEST.	S. 86 W.		+ 4 0	+ 4 10
W. by N.	N. 80 W.		+ 1 15	+ 1 20
W. N. W.	N. 66 W.		— 1 30	— 1 20
N. W. by W.	N. 50 W.		— 6 15	— 6 10
N. W.	N. 39 W.		— 6 0	— 5 50
N. W. by N.	N. 28 W.		— 5 45	— 5 40
N. N. W.	N. 18 W.		— 4 30	— 4 20
N. by W.	N. 6 W.		— 5 15	— 5 10
NORTH.				— 0 50

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 0° 5′.6 B = — 2° 57′.8 C = — 0° 47′.2
D = + 7° 10′.2 E = — 0° 25′.5

Valparaiso, April 4, 1866.

Correction for Object = + 0° 1′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 2° E.		— 2° 0′	— 2° 0′
N. by E.	N. 10 E.		+ 1 15	+ 1 20
N. N. E.	N. 21 E.		+ 1 30	+ 1 30
N. E. by N.	N. 33 E.		+ 0 45	+ 0 50
N. E.	N. 45 E.		0 0	0 0
N. E. by E.	N. 57 E.		— 0 45	— 0 40
E. N. E.	N. 70 E.		— 2 30	— 2 30
E. by N.	N. 84 E.		— 5 15	— 5 10
EAST.	S. 82 E.		— 8 0	— 8 0
E. by S.	S. 66 E.		— 12 45	— 12 40
E. S. E.	S. 56 E.		— 11 30	— 11 30
S. E. by E.	S. 45 E.		— 11 15	— 11 10
S. E.	S. 33 E.		— 12 0	— 12 0
S. E. by S.	S. 24 E.		— 9 45	— 9 40
S. S. E.	S. 16 E.		— 6 30	— 6 30
S. by E.	S. 6 E.		— 5 15	— 5 10
SOUTH.	S. 2 W.		— 2 0	— 2 0
S. by W.	S. 11 W.		+ 0 15	+ 0 20
S. S. W.	S. 20 W.		+ 2 30	+ 2 30
S. W. by S.	S. 29 W.		+ 4 45	+ 4 50
S. W.	S. 38 W.		+ 7 0	+ 7 0
S. W. by W.	S. 50 W.		+ 6 15	+ 6 20
W. S. W.	S. 60 W.		+ 7 30	+ 7 30
W. by S.	S. 74 W.		+ 4 45	+ 4 50
WEST.	S. 87 W.		+ 3 0	+ 3 0
W. by N.	N. 78 W.		— 0 45	— 0 40
W. N. W.	N. 65 W.		— 2 30	— 2 30
N. W. by W.	N. 52 W.		— 4 15	— 4 10
N. W.	N. 40 W.		— 5 0	— 5 0
N. W. by N.	N. 29 W.		— 4 45	— 4 40
N. N. W.	N. 19 W.		— 3 30	— 3 30
N. by W.	N. 8 W.		— 3 15	— 3 10
NORTH.				— 2 0

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 2° 16′.2 B = — 4° 54′.1 C = + 0° 20′.9
D = + 5° 52′.5 E = + 0° 37′.5

Observations for Determining the Deviations of the After Azimuth Compass on the U. S. Iron Clad Monadnock.

Callao, April 29, 1866.

Correction for Object = + 0° 6′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 5° E.		— 5° 0′	— 4° 50′
N. by E.	N. 15 E.		— 3 45	— 3 40
N. N. E.	N. 21 E.		+ 1 30	+ 1 40
N. E. by N.	N. 35 E.		— 1 15	— 1 10
N. E.	N. 49 E.		— 4 0	— 3 50
N. E. by E.	N. 59 E.		— 2 45	— 2 40
E. N. E.	N. 69 E.		— 1 30	— 1 20
E. by N.	N. 82 E.		— 3 15	— 3 10
EAST.	S. 84 E.		— 6 0	— 5 50
E. by S.	S. 70 E.		— 8 45	— 8 40
E. S. E.	S. 59 E.		— 8 30	— 8 20
S. E. by E.	S. 45 E.		— 11 15	— 11 10
S. E.	S. 34 E.		— 11 0	— 10 50
S. E. by S.	S. 23 E.		— 10 45	— 10 40
S. S. E.	S. 15 E.		— 7 30	— 7 20
S. by E.	S. 8 E.		— 3 15	— 3 10
SOUTH.	S. 1 W.		— 1 0	— 0 50
S. by W.	S. 12 W.		— 0 45	— 0 40
S. S. W.	S. 22 W.		+ 0 30	+ 0 40
S. W. by S.	S. 31 W.		+ 2 45	+ 2 50
S. W.	S. 43 W.		+ 2 0	+ 2 10
S. W. by W.	S. 52 W.		+ 4 15	+ 4 20
W. S. W.	S. 65 W.		+ 2 30	+ 2 40
W. by S.	S. 80 W.		— 1 15	— 1 10
WEST.	N. 86 W.		— 4 0	— 3 50
W. by N.	N. 72 W.		— 6 45	— 6 40
W. N. W.	N. 62 W.		— 5 30	— 5 20
N. W. by W.	N. 49 W.		— 7 15	— 7 10
N. W.	N. 38 W.		— 7 0	— 6 50
N. W. by N.	N. 26 W.		— 7 45	— 7 40
N. N. W.	N. 15 W.		— 7 30	— 7 20
N. by W.	N. 5 W.		— 6 15	— 6 10
NORTH.				— 4 50

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 3° 56′.2   B = — 2° 0′.6   C = — 0° 49′.6
D = + 5° 6′.5   E = + 0° 35′.7

Panama, May 20, 1866.

Correction for Object = + 0° 1′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 1° E.		— 1° 0′	— 1° 0′
N. by E.	N. 11 E.		+ 0 15	+ 0 20
N. N. E.	N. 21 E.		+ 1 30	+ 1 30
N. E. by N.	N. 31 E.		+ 2 45	+ 2 50
N. E.	N. 41 E.		+ 4 0	+ 4 0
N. E. by E.	N. 53 E.		+ 3 15	+ 3 20
E. N. E.	N. 68 E.		— 0 30	— 0 30
E. by N.	N. 81 E.		— 2 15	— 2 10
EAST.	S. 84 E.		— 6 0	— 6 0
E. by S.	S. 69 E.		— 9 45	— 9 40
E. S. E.	S. 56 E.		— 11 30	— 11 30
S. E. by E.	S. 45 E.		— 11 15	— 11 10
S. E.	S. 33 E.		— 12 0	— 12 0
S. E. by S.	S. 23 E.		— 10 45	— 10 40
S. S. E.	S. 13 E.		— 9 30	— 9 30
S. by E.	S. 4 E.		— 7 15	— 7 10
SOUTH.	S. 5 W.		— 5 0	— 5 0
S. by W.	S. 13 W.		— 1 45	— 1 40
S. S. W.	S. 21 W.		+ 1 30	+ 1 30
S. W. by S.	S. 29 W.		+ 4 45	+ 4 50
S. W.	S. 40 W.		+ 5 0	+ 5 0
S. W. by W.	S. 51 W.		+ 5 15	+ 5 20
W. S. W.	S. 62 W.		+ 5 30	+ 5 30
W. by S.	S. 73 W		+ 5 45	+ 5 50
WEST.	S. 88 W.		+ 2 0	+ 2 0
W. by N.	N. 79 W.		+ 0 15	+ 0 20
W. N. W.	N. 65 W.		— 2 30	— 2 30
N. W. by W.	N. 53 W.		— 3 15	— 3 10
N. W.	N. 40 W.		— 5 0	— 5 0
N. W. by N.	N. 29 W.		— 4 45	— 4 40
N. N. W.	N. 19 W.		— 3 30	— 3 30
N. by W.	N. 8 W.		— 3 15	— 3 10
NORTH.				— 1 0

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 2° 6′.9   B = — 3° 47′.2   C = — 1° 44′.6
D = + 6° 21′.2   E = — 0° 34′.0

Observations for Determining the Deviations of the After Azimuth Compass on the U. S. Iron Clad Monadnock.

Acapulco, June 1, 1866.

Correction for Object = + 0° 6′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 2° E.		— 2° 0′	— 1° 50′
N. by E.	N. 13 E.		— 1 45	— 1 40
N. N. E.	N. 23 E.		— 0 30	— 0 20
N. E. by N.	N. 33 E.		+ 0 45	+ 0 50
N. E.	N. 45 E.		0 0	+ 0 10
N. E. by E.	N. 57 E.		— 0 45	— 0 40
E. N. E.	N. 70 E.		— 2 30	— 2 20
E. by N.	N. 83 E.		— 4 15	— 4 10
EAST.	S. 82 E.		— 8 0	— 7 50
E. by S.	S. 69 E.		— 9 45	— 9 40
E. S. E.	S. 56 E.		— 11 30	— 11 20
S. E. by E.	S. 45 E.		— 11 15	— 11 10
S. E.	S. 34 E.		— 11 0	— 10 50
S. E. by S.	S. 24 E.		— 9 45	— 9 40
S. S. E.	S. 14 E.		— 8 30	— 8 20
S. by E.	S. 5 E.		— 6 15	— 6 10
SOUTH.	S. 3 W.		— 3 0	— 2 50
S. by W.	S. 11 W.		+ 0 15	+ 0 20
S. S. W.	S. 21 W.		+ 1 30	+ 1 40
S. W. by S.	S. 30 W.		+ 3 45	+ 3 50
S. W.	S. 40 W.		+ 5 0	+ 5 10
S. W. by W.	S. 51 W.		+ 5 15	+ 5 20
W. S. W.	S. 63 W.		+ 4 30	+ 4 40
W. by S.	S. 77 W.		+ 1 45	+ 1 50
WEST.	N. 89 W.		+ 1 0	+ 1 10
W. by N.	N. 76 W.		— 2 45	— 2 40
W. N. W.	N. 62 W.		— 5 30	— 5 20
N. W. by W.	N. 49 W.		— 7 15	— 7 10
N. W.	N. 38 W.		— 7 0	— 6 50
N. W. by N.	N. 28 W.		— 5 45	— 5 40
N. N. W.	N. 17 W.		— 5 30	— 5 20
N. by W.	N. 6 W.		— 5 15	— 5 10
NORTH.				— 1 50

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 3° 11′.2 B = — 3° 25′.8 C = — 0° 0′.8

D = + 5° 54′.2 E = + 0° 23′.8

Magdalena Bay, June 9, 1866.

Correction for Object = — 0° 41′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 7° E.		— 7° 0′	— 7° 30′
N. by E.	N. 15 E.		— 3 45	— 4 20
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.				
E. by S.				
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.	S. 34 W.		+ 11 0	+ 10 10
S. W. by W.	S. 47 W.		+ 9 15	+ 8 40
W. S. W.	S. 58 W.		+ 9 30	+ 8 40
W. by S.	S. 71 W.		+ 7 45	+ 7 0
WEST.	S. 85 W.		+ 5 0	+ 4 30
W. by N.	N. 87 W.		+ 8 15	+ 7 30
W. N. W.	N. 73 W.		+ 5 30	+ 4 40
N. W. by W.	N. 59 W.		+ 2 45	+ 1 40
N. W.	N. 41 W.		— 4 0	— 4 10
N. W. by N.	N. 38 W.		+ 4 15	+ 3 40
N. N. W.	N. 27 W.		+ 4 30	+ 3 10
N. by W.	N. 4 W.		— 7 15	— 8 0
NORTH.				— 7 30

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

These observations exhibit such discordancies among themselves that they do not seem worth the trouble of reducing.

Observations for Determining the Deviations of the Forward Alidade Compass on the U. S. Iron Clad Monadnock.

Hampton Roads, November 1, 1865.

Correction for Object = + 3° 57′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{3}{8}$ E.	− $\frac{3}{8}$	° ′	+ 0° 10′
N. by E.	N. by E. $\frac{3}{8}$ E.	− $\frac{3}{8}$		− 0 20
N. N. E.	N. E. by N. $\frac{5}{8}$ N.	− $\frac{3}{8}$		− 0 20
N. E. by N.	N. E. $\frac{3}{4}$ N.	− $\frac{1}{4}$		+ 0 40
N. E.	N. E. $\frac{3}{8}$ E.	− $\frac{3}{8}$		+ 0 10
N. E. by E.	N. E. by E. $\frac{3}{8}$ E.	− $\frac{3}{8}$		− 0 20
E. N. E.	E. by N. $\frac{5}{8}$ N.	− $\frac{3}{8}$		− 0 20
E. by N.	E. $\frac{3}{8}$ N.	− $\frac{3}{8}$		− 0 20
EAST.	E. $\frac{3}{8}$ S.	− $\frac{3}{8}$		− 0 20
E. by S.	E. S. E. $\frac{3}{4}$ E.	− $\frac{1}{4}$		+ 0 40
E. S. E.	S. E. by E. $\frac{5}{8}$ E.	− $\frac{3}{8}$		+ 0 10
S. E. by E.	S. E. $\frac{5}{8}$ E.	− $\frac{3}{8}$		− 0 20
S. E.	S. E. $\frac{1}{4}$ S.	− $\frac{1}{4}$		+ 0 40
S. E. by S.	S. S. E. $\frac{3}{4}$ E.	− $\frac{1}{4}$		+ 1 10
S. S. E.	S. by E. $\frac{7}{8}$ E.	− $\frac{1}{8}$		+ 2 10
S. by E.	S. $\frac{7}{8}$ E.	− $\frac{1}{8}$		+ 2 30
SOUTH.	SOUTH.	0		+ 3 30
S. by W.	S. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 4 50
S. S. W.	S. by W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 6 20
S. W. by S.	S. W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 6 40
S. W.	S. W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 6 40
S. W. by W.	S. W. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 5 50
W. S. W.	S. W. by W. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 5 20
W. by S.	W. by S. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 5 20
WEST.	WEST.	0		+ 4 30
W. by N.	W. by N.	0		+ 4 0
W. N. W.	N. W. by W. $\frac{7}{8}$ W.	− $\frac{1}{8}$		+ 3 0
N. W. by W.	N. W. $\frac{3}{4}$ W.	− $\frac{1}{4}$		+ 1 40
N. W.	N. W. $\frac{1}{4}$ N.	− $\frac{1}{4}$		+ 1 10
N. W. by N.	N. N. W. $\frac{3}{4}$ W.	− $\frac{1}{4}$		+ 1 10
N. N. W.	N. by W. $\frac{3}{4}$ W.	− $\frac{1}{4}$		+ 1 10
N. by W.	N. $\frac{3}{4}$ W.	− $\frac{1}{4}$		+ 1 10
NORTH.				+ 0 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 2° 8′.1 B = — 2° 28′.4 C = — 1° 52′.0
D = + 1° 4′.2 E = 0° 0′.0

St. Thomas, November 18, 1865.

Correction for Object = + 0° 16′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N.	0	° ′	− 0° 10′
N. by E.	N. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 10
N. N. E.	N. by E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 10
N. E. by N.	N. E. by N. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 1 10
N. E.	N. E. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 1 10
N. E. by E.	N. E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 10
E. N. E.	N. E. by E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 10
E. by N.	E. by N.	0		− 0 20
EAST.	E.	0		− 0 20
E. by S.	E. by S.	0		− 0 20
E. S. E.	E. S. E.	0		− 0 20
S. E. by E.	S. E. by E.	0		− 0 20
S. E.	S. E.	0		− 0 20
S. E. by S.	S. E. by S.	0		− 0 20
S. S. E.	S. S. E.	0		− 0 10
S. by E.	S. by E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 30
SOUTH.	S. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 30
S. by W.	S. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 30
S. S. W.	S. by W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 30
S. W. by S.	S. W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 30
S. W.	S. W. $\frac{3}{8}$ S.	+ $\frac{3}{8}$		+ 3 50
S. W. by W.	S. W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 30
W. S. W.	S. W. by W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 30
W. by S.	W. S. W. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 1 10
WEST.	W. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 10
W. by N.	W. $\frac{7}{8}$ N.	+ $\frac{1}{8}$		+ 1 10
W. N. W.	W. N. W.	0		− 0 20
N. W. by W.	N. W. by W.	0		− 0 20
N. W.	N. W.	0		− 0 20
N. W. by N.	N. W. by N.	0		− 0 20
N. N. W.	N. N. W.	0		− 0 20
N. by W.	N. by W.	0		− 0 20
NORTH.				− 0 20

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 0° 50′.9 B = — 0° 35′.1 C = — 0° 46′.2
D = + 1° 15′.7 E = + 0° 20′.5

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD ALIDADE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Isle Royal, Salute Islands, November 30, 1865.

Correction for Object = — 0° 2′. Correction for Lubber Line = 0.°

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
			° ′	° ′
NORTH.				
N. by E.				
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.	EAST.			
E. by S.				
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = B = C =
D = E =

Ceara, December 19, 1865.

Correction for Object = + 1° 51′. Correction for Lubber Line = 0°.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.				
N. by E.	N. 7/8 E.	+ 1/8		+ 3° 0
N. N. E.	N. N. E. 1/4 N.	+ 1/4		+ 4 30
N. E. by N.	N. E. by N. 1/4 N.	+ 1/4		+ 4 40
N. E.	N. E. 1/4 N.	+ 1/4		+ 4 40
N. E. by E.	N. E. 7/8 E.	+ 1/8		+ 3 30
E. N. E.	E. N. E. 1/8 N.	+ 1/8		+ 3 20
E. by N.	E. by N.	0		+ 2 10
EAST.	EAST.	0		+ 1 50
E. by S.	E. by S.	0		+ 1 50
E. S. E.	S. E. by E. 7/8 E.	— 1/8		+ 0 40
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 2° 3′.6 B = + 0° 0′.1 C = + 1° 4′.7
D = + 1° 21′.4 E = + 0° 2′.4

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD ALIDADE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Bahia, December 30, 1865.

Correction for Object = + 2° 30′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	+ 2° 10′
N. by E.	N. by E.	0		+ 2 30
N. N. E.	N. N. E.	0		+ 2 30
N. E. by N.	N. E. by N.	0		+ 2 30
N. E.	N. E.	0		+ 2 30
N. E. by E.	N. E. by E.	0		+ 2 30
E. N. E.	E. N. E.	0		+ 2 30
E. by N.	E. by N.	0		+ 2 30
EAST.	EAST.	0		+ 2 30
E. by S.	E. by S. 1/8 S.	— 1/8		+ 1 30
E. S. E.	S. E. by E. 7/8 E.	— 1/8		+ 1 10
S. E. by E.	S. E. 7/8 E.	— 1/8		+ 1 10
S. E.	S. E. 1/8 S.	— 1/8		+ 1 10
S. E. by S.	S. S. E 7/8 E.	— 1/8		+ 1 10
S. S. E.	S. S. E.	0		+ 2 10
S. by E.	S. by E.	0		+ 2 30
SOUTH.	SOUTH.	0		+ 2 30
S. by W.	S. 7/8 W.	+ 1/8		+ 3 30
S. S. W.	S. by W. 7/8 W.	+ 1/8		+ 3 50
S. W. by S.	S. W. by S. 1/8 S.	+ 1/8		+ 3 50
S. W.	S. W. 1/8 S.	+ 1/8		+ 3 50
S. W. by W.	S. W. 7/8 W.	+ 1/8		+ 3 50
W. S. W.	S. W. by W. 7/8 W.	+ 1/8		+ 3 50
W. by S.	W. by S.	0		+ 2 50
WEST.	WEST.	0		+ 2 30
W. by N.	W. by N. 1/4 N.	— 1/4		+ 0 20
W. N. W.	N. W. by W. 3/4 W.	— 1/4		— 0 20
N. W. by W.	N. W. 7/8 W.	— 1/8		+ 0 50
N. W.	N. W. 1/8 N.	— 1/8		+ 1 10
N. W. by N.	N. W. by N. 1/8 N.	— 1/8		+ 1 10
N. N. W.	N. by W. 7/8 W.	— 1/8		+ 1 10
N. by W.	N. 7/8 W.	— 1/8		+ 1 10
NORTH.				+ 2 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 2° 9′.4 B = — 0° 6′.0 C = — 0° 34′.1
D = + 1° 15′.0 E = + 0° 14′.5

Rio Janeiro, January 10, 1866.

Correction for Object = + 2° 44′. Correction for Lubber Line = 0°.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.			° ′	
N. by E.				
N. N. E.				
N. E. by N.	N. E. by N. 1/8 N.	+ 1/8		+ 4° 10′
N. E.	N. E. 1/8 N.	+ 1/8		+ 4 10
N. E. by E.	N. E. 7/8 E.	+ 1/8		+ 4 10
E. N. E.	E. N. E.	0		+ 3 0
E. by N.	E. by N.	0		+ 2 40
EAST.	EAST.	0		+ 2 40
E. by S.	E. by S.	0		+ 2 40
E. S. E.	E. S. E.	0		+ 2 40
S. E. by E.	S. E. by E.	0		+ 2 40
S. E.	S. E.	0		+ 2 40
S. E. by S.	S. E. by S.	0		+ 2 40
S. S. E.	S. S. E. 1/8 E.	+ 1/8		+ 3 50
S. by E.		+ 1/8		+ 4 10
SOUTH.	E. 1/8 E.	+ 1/8		+ 4 10
S. by W.	S. 3/4 W.	+ 1/4		+ 5 10
S. S. W.	S. by W. 3/4 W.	+ 1/4		+ 5 30
S. W. by S.	S. S. W. 3/4 W.	+ 1/4		+ 5 30
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the cofficients of the deviation are obtained:

A = + 3° 31′.5 B = — 0° 28′.8 C = — 0° 57′.1
D = + 1° 21′.1 E = + 0° 1′.9

Observations for Determining the Deviations of the Forward Alidade Compass on the U. S. Iron Clad Monadnock.

Monte Video, January 24, 1866.

Correction for Object = — 0° 13′ Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
			° ′	
NORTH.	NORTH.	0		— 0° 10′
N. by E.	N. 7/8 E.	+ 1/8		+ 1 10
N. N. E.	N. by E. 3/4 E.	+ 1/4		+ 2 30
N. E. by N.	N. E. by N. 3/8 N.	+ 3/8		+ 4 0
N. E.	N. E. 3/8 N.	+ 3/8		+ 4 0
N. E. by E.	N. E. 5/8 E.	+ 3/8		+ 4 0
E. N. E.	E. N. E. 3/8 N..	+ 3/8		+ 4 0
E. by N.	E. by N. 3/8 N.	+ 3/8		+ 4 0
EAST.	E. 1/4 N.	+ 1/4		+ 2 30
E. by S.	E. 3/4 S.	+ 1/4		+ 2 30
E. S. E.	E. S. E. 1/4 E.	+ 1/4		+ 2 30
S. E. by E.	S. E. by E. 1/8 E.	+ 1/8		+ 1 10
S. E.	S. E. 1/4 E.	+ 1/4		+ 2 30
S. E. by S.	S. E. 3/4 S.	+ 1/4		+ 2 30
S. S. E.	S. S. E. 1/4 E.	+ 1/4		+ 2 30
S. by E.	S. by E. 1/4 E.	+ 1/4		+ 2 30
SOUTH.	S. 1/4 E.	+ 1/4		+ 2 30
S. by W.	S. 1/2 W.	+ 1/2		+ 5 20
S. S. W.	S. by W. 5/8 W.	+ 3/8		+ 4 0
S. W. by S.	S. W. by S. 3/8 S.	+ 3/8		+ 4 0
S. W.	S. W. 1/4 S.	+ 1/4		+ 2 30
S. W. by W.	S. W. 3/4 W.	+ 1/4		+ 2 30
W. S. W.	S. W. by W. 3/4 W.	+ 1/4		+ 2 30
W. by S.	W. by S. 1/8 S.	+ 1/8		+ 1 10
WEST.	W. 1/8 S.	+ 1/8		+ 1 10
W. by N.	W. 7/8 N.	+ 1/8		+ 1 10
W. N. W.		+ 1/8		+ 1 10
N. W. by W.	N. W. by W.	0		— 0 10
N. W.	N. W.	0		— 0 10
N.W. by N.	N. W. by N.	0		— 0 10
N. N. W.	N. N. W.	0		— 0 10
N. by W.	N. 7/8 W.	— 1/8		— 1 40
NORTH.				— 0 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 2° 7′.1 B = + 0° 57′.2 C = — 1° 5′.0
D = + 1° 23′.0 E = — 0° 9′.8

Sandy Point, February 10, 1866.

Correction for Object = + 0° 7′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
			° ′	
NORTH.	NORTH.	0		+ 0° 10′
N. by E.	N. 7/8 E.	+ 1/8		+ 1 30
N. N. E.	N. by E. 3/4 E.	+ 1/4		+ 3 0
N. E. by N.	N. N. E. 3/4 E.	+ 1/4		+ 3 0
N. E.	N. E. 1/4 N.	+ 1/4		+ 3 0
N. E. by E.	N. E. 3/4 E.	+ 1/4		+ 3 0
E. N. E.	N. E. by E. 5/8 E.	+ 3/8		+ 4 20
E. by N.	E. by N. 3/8 N.	+ 3/8		+ 4 20
EAST.	E. 3/8 N.	+ 3/8		+ 4 20
E. by S.	E. 3/4 S.	+ 1/4		+ 3 0
E. S. E.	E. by S. 3/4 S.	+ 1/4		+ 3 0
S. E. by E.	S. E. by E. 1/4 E.	+ 1/4		+ 3 0
S. E.	S. E. 1/4 E.	+ 1/4		+ 3 0
S. E. by S.	S. E. 7/8 S.	+ 1/8		+ 1 30
S. S. E.	S. S. E. 1/4 E.	+ 1/4		+ 3 0
S. by E.	S. by E. 3/8 E.	+ 3/8		+ 4 20
SOUTH.	S. 3/8 E.	+ 3/8		+ 4 20
S. by W.	S. 5/8 W.	+ 3/8		+ 4 20
S. S. W.	S. by W. 5/8 W.	+ 3/8		+ 4 20
S. W. by S.	S. W. by S. 1/2 S.	+ 1/2		+ 5 50
S. W.	S. W. 3/8 S.	+ 3/8		+ 4 20
S. W. by W.	S. W 5/8 W.	+ 3/8		+ 4 20
W. S. W.	S. W. by W. 3/4 W.	+ 1/4		+ 3 0
W. by S.	W. by S. 1/4 S.	+ 1/4		+ 3 0
WEST.	W. 1/4 S.	+ 1/4		+ 3 0
W. by N.	W. by N.	0		+ 0 10
W. N. W.	W. N. W.	0		+ 0 10
N. W. by W.	N. W. 7/8 W.	— 1/8		— 1 20
N. W.	N W. 1/8 N.	— 1/8		— 1 20
N. W. by N.	N. W. by N. 1/8 N.	— 1/8		— 1 20
N. N. W.	N. N. W. 1/8 N.	— 1/8		— 1 20
N. by W.	N. 7/8 W.	— 1/8		— 1 20
NORTH.				+ 0 10

A deviation of the North Point of the Compass to the East is designated by the sign + a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviations are obtained:

A = + 2° 25′.6 B = + 0° 58′.5 C = — 1° 54′.4
D = + 1° 47′.0 E = — 0° 20′.2

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD ALIDADE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Valparaiso, April 4, 1866.

Correction for Object = + 0° 1′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	0° 0′
N. by E.	N. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
N. N. E.	N. by E. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
N. E. by N.	N. E. by N. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 50
N. E.	N. E. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 50
N. E. by E.	N. E. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
E. N. E.	N. E. by E. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
E. by N.	E. by N. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 50
EAST.	E. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 50
E. by S.	E. $\frac{7}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
E. S. E.	E. S. E. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. E. by E.	S. E. by E. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. E.	S. E. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. E. by S.	S. E. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 2 50
S. S. E.	S. S. E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
S. by E.	S. by E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
SOUTH.	S. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
S. by W.	S. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 50
S. S. W.	S. by W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 50
S. W. by S.	S. W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 50
S. W.	S. W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 50
S. W. by W.	S. W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 50
W. S. W.	S. W. by W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 50
W. by S.	W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 50
WEST.	W. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
W. by N.	W. $\frac{7}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
W. N. W.	W. N. W.	0		0 0
N. W. by W.	N. W. by W.	0		0 0
N. W.	N. W.	0		0 0
N. W. by N.	N. W. by N.	0		0 0
N. N. W.	N. N. W.	0		0 0
N. by W.	N. by W.	0		0 0
NORTH.				0 0

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 1° 55′.2 B = + 0° 30′.0 C = — 0° 53′.9
D = + 1° 4′.2 E = — 0° 5′.2

Callao, April 29, 1866.

Correction for Object = + 0° 6′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{8}$ E.	— $\frac{1}{8}$	° ′	— 1° 20′
N. by E.	N. by E.	0		+ 0 10
N. N. E.	N. N. E.	0		+ 0 10
N. E. by N.	N. E. by N.	0		+ 0 10
N. E.	N. E. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
N. E. by E.	N. E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
E. N. E.	N. E. by E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
E. by N.	E. by N. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
EAST.	EAST.	0		+ 0 10
E. by S.	E. $\frac{7}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
E. S. E.	E. S. E.	0		+ 0 10
S. E. by E.	S. E. by E. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. E.	S. E.	0		+ 0 10
S. E. by S.	S. E. by S.	0		+ 0 10
S. S. E.	S. S. E. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. by E.	S. by E. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
SOUTH.	S. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. by W.	S. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 1 30
S. S. W.	S. by W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 3 0
S. W. by S.	S. W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 3 0
S. W.	S. W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 3 0
S. W. by W.	S. W. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 1 30
W. S. W.	S. W. by W. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 1 30
W. by S.	W. by S.	0		+ 0 10
WEST.	WEST.	0		+ 0 10
W. by N.	W. by N. $\frac{1}{8}$ N.	— $\frac{1}{8}$		— 1 20
W. N. W.	N. W. by W. $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 1 20
N. W. by W.	N. W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 40
N. W.	N. W. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 2 40
N. W. by N.	N. N. W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 40
N. N. W.	N. by W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 40
N. by W.	N. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 40
NORTH.				— 1 20

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 0° 21′.0 B = + 0° 40′.9 C = — 1° 36′.4
D = + 1° 29′.0 E = — 0° 6′.8

Observations for Determining the Deviations of the Forward Alidade Compass on the U. S. Iron Clad Monadnock.

Panama, May 20, 1866.

Correction for Object = + 0° 1′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	°	0° 0′
N. by E.	N. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
N. N. E.	N. by E. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
N. E. by N.	N. E. by N. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 50
N. E.	N. E. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 50
N. E. by E.	N. E. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
E. N. E.	N. E. by E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
E. by N.	E. by N. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 50
EAST.	E. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 50
E. by S.	E. $\frac{7}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
E. S. E.	E. by S. $\frac{7}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
S. E. by E.	S. E. by E. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. E.	S. E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
S. E. by S.	S. E. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 2 50
S. S. E.	S. S. E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
S. by E.	S. by E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
SOUTH.	S. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
S. by W.	S. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 10
S. S. W.	S. by W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 10
S. W. by S.	S. W. by S. $\frac{3}{8}$ S.	+ $\frac{3}{8}$		+ 4 10
S. W.	S. W. $\frac{3}{8}$ S.	+ $\frac{3}{8}$		+ 4 10
S. W. by W.	S. W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 10
W. S. W.	S. W. by W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 10
W. by S.	W. by S. $\frac{3}{8}$ S.	+ $\frac{3}{8}$		+ 4 10
WEST.	W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 50
W. by N.	W. $\frac{7}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
W. N. W.	W. N. W.	0		0 0
N. W. by W.	N. W. by W.	0		0 0
N. W.	N. W.	0		0 0
N. W. by N.	N. W. by N.	0		0 0
N. N. W.	N. N. W.	0		0 0
N. by W.	N. by W.	0		0 0
NORTH.				0 0

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 2° 15′.2 B = + 0° 1′.1 C = — 1° 22′.1
D = + 1° 21′.0 E = — 0° 6′.8

Acapulco, June 1, 1866.

Correction for Object = + 0° 6′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	+ 0° 10
N. by E.	N. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
N. N. E.	N. by E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
N. E. by N.	N. E. by N. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
N. E.	N. E. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
N. E. by E.	N. E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
E. N. E.	N. E. by E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
E. by N.	E. by N.	0		+ 0 10
EAST.	E. $\frac{1}{8}$ S.	— $\frac{1}{8}$		— 1 20
E. by S.	E. by S. $\frac{1}{8}$ S.	— $\frac{1}{8}$		— 1 20
E. S. E.	S. E. by E. $\frac{7}{8}$ E.	— $\frac{1}{8}$		— 1 20
S. E. by E.	S. E. $\frac{7}{8}$ E.	— $\frac{1}{8}$		— 1 20
S. E.	S. E. $\frac{1}{8}$ S.	— $\frac{1}{8}$		— 1 20
S. E. by S.	S. E. by S. $\frac{1}{8}$ S.	— $\frac{1}{8}$		— 1 20
S. S. E.	S. S. E.	0		+ 0 10
S. by E.	S. by E. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
SOUTH.	S. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. by W.	S. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 3 0
S. S. W.	S. by W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 3 0
S. W. by S.	S. W. by S. $\frac{3}{8}$ S.	+ $\frac{3}{8}$		+ 4 20
S. W.	S. W. $\frac{3}{8}$ S.	+ $\frac{3}{8}$		+ 4 20
S. W. by W.	S. W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 20
W. S. W.	S. W. by W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 20
W. by S.	W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 3 0
WEST.	W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 3 0
W. by N.	W. $\frac{7}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
W. N. W.	W. N. W.	0		+ 0 10
N. W. by W.	N. W. by W.	0		+ 0 10
N. W.	N. W.	0		+ 0 10
N. W. by N.	N. W. by N.	0		+ 0 10
N. N. W.	N. N. W.	0		+ 0 10
N. by W.	N. by W.	0		+ 0 10
NORTH.				+ 0 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 1° 8′.1 B = — 1° 28′.4 C = — 0° 33′.1
D = + 1° 52′.8 E = + 0° 10′.2

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD ALIDADE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Magdalena Bay, June 9, 1866.

Correction for Object = — 0° 41′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	— 0° 40′
N. by E.	N. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 0 50
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.				
E. by S.				
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.	S. W. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 0
S. W. by W.	S. W. $\frac{3}{8}$ W.	+ $\frac{5}{8}$		+ 6 10
W. S. W.	S. W. by W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 3 30
W. by S.	W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 10
WEST.	W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 10
W. by N.	W. $\frac{5}{8}$ N.	+ $\frac{3}{8}$		+ 3 30
W. N. W.	W. by N. $\frac{3}{4}$ N.	+ $\frac{1}{4}$		+ 2 10
N. W. by W.	N. W. by W. $\frac{1}{4}$ W.	+ $\frac{1}{4}$		+ 2 0
N. W.	N. W. $\frac{1}{8}$ W.	+ $\frac{1}{8}$		+ 0 40
N. W. by N.	N. W. $\frac{7}{8}$ N.	+ $\frac{1}{8}$		+ 0 40
N. N. W.	N. N. W.	0		— 0 40
N. by W.	N. by W.	0		— 0 40
NORTH.				— 0 40

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 1° 8′.8 B = — 2° 4′.1 C = — 1° 7′.6
D = + 1° 19′.2 E = 0° 0′.0

San Francisco, June 23, 1866.

Correction for Object = — 0° 45′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{8}$ E.	— $\frac{1}{8}$	° ′	— 2° 10′
N. by E.	N. by E. $\frac{1}{8}$ E.	— $\frac{1}{8}$		— 2 10
N. N. E.	N. N. E. $\frac{1}{8}$ E.	— $\frac{1}{8}$		— 2 0
N. E. by N.	N. E. by N.	0		— 0 40
N. E.	N. E.	0		— 0 40
N. E. by E.	N. E. by E.	0		— 0 40
E. N. E.	E. N. E.	0		— 0 50
E. by N.	E. $\frac{7}{8}$ N.	— $\frac{1}{8}$		— 2 10
EAST.	E. $\frac{1}{8}$ S.	— $\frac{1}{8}$		— 2 10
E. by S.	E. by S. $\frac{1}{8}$ S.	— $\frac{1}{8}$		— 2 0
E. S. E.	E. S. E.	0		— 0 40
S. E. by E.	S. E. by E.	0		— 0 40
S. E.	S. E.	0		— 0 40
S. E. by S.	S. E. $\frac{7}{8}$ S.	+ $\frac{1}{8}$		+ 0 50
S. S. E.	S. S. E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 10
S. by E.	S. by E. $\frac{3}{8}$ E.	+ $\frac{3}{8}$		+ 3 30
SOUTH.	S. $\frac{3}{8}$ E.	+ $\frac{3}{8}$		+ 3 30
S. by W.	S. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 3 30
S. S. W.	S. by W. $\frac{1}{2}$ W.	+ $\frac{1}{2}$		+ 4 50
S. W. by S.	S. W. by S. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 4 50
S. W.	S. W. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 4 50
S. W. by W.	S. W. $\frac{1}{2}$ W.	+ $\frac{1}{2}$		+ 4 50
W. S. W.	S. W. by W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 3 20
W. by S.	W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 0
WEST.	W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 0
W. by N.	W. $\frac{3}{4}$ N.	+ $\frac{1}{4}$		+ 1 50
W. N. W.	W. N. W.	0		— 0 30
N. W. by W.	N. W. by W. $\frac{1}{4}$ W.	+ $\frac{1}{4}$		+ 1 50
N. W.	N. W.	0		— 0 30
N. W. by N.	N. W. by N.	0		— 0 40
N. N. W.	N. N. W.	0		— 0 50
N. by W.	N. $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 2 10
NORTH.				— 2 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 0° 40′.6 B = — 1° 54′.2 C = — 2° 25′.1
D = + 0° 58′.0 E = + 0° 21′.5

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD BINNACLE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Hampton Roads, November 1, 1865.

Correction for Object = + 3° 57′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{2}$ E.	— $\frac{1}{2}$	° ′	— 1° 40′
N. by E.	N. by E. $\frac{1}{2}$ E.	— $\frac{1}{2}$		— 1 40
N. N. E.	N. E. by N. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 1 40
N. E. by N.	N. E. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 1 40
N. E.	N. E. $\frac{3}{8}$ E.	— $\frac{3}{8}$		— 0 50
N. E. by E.	N. E. by E. $\frac{3}{4}$ E.	— $\frac{3}{4}$		— 3 0
E. N. E.	E. by N. $\frac{1}{8}$ N.	— $\frac{7}{8}$		— 5 30
E. by N.	E. $\frac{1}{8}$ N.	— $\frac{7}{8}$		— 6 0
EAST.	E. $\frac{7}{8}$ S.	— $\frac{7}{8}$		— 6 0
E. by S.	E. S. E. $\frac{1}{4}$ E.	— $\frac{3}{4}$		— 5 0
E. S. E.	S. E. by E. $\frac{1}{4}$ E.	— $\frac{3}{4}$		— 4 30
S. E. by E.	S. E. $\frac{3}{8}$ E.	— $\frac{5}{8}$		— 3 40
S. E.	S. E. $\frac{5}{8}$ S.	— $\frac{5}{8}$		— 3 0
S. E. by S.	S. S. E. $\frac{1}{2}$ E.	— $\frac{1}{2}$		— 2 10
S. S. E.	S. by E. $\frac{5}{8}$ E.	— $\frac{3}{8}$		— 0 50
S. by E.	S. $\frac{7}{8}$ E.	— $\frac{1}{8}$		+ 1 30
SOUTH.	SOUTH.	0		+ 3 30
S. by W.	S. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 5 0
S. S. W.	S. by W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 6 20
S. W. by S.	S. W. by S. $\frac{3}{8}$ S.	+ $\frac{3}{8}$		+ 7 40
S. W.	S. W. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 9 10
S. W. by W.	S. W. $\frac{1}{2}$ W.	+ $\frac{1}{2}$		+ 9 30
W. S. W.	S. W. by W. $\frac{1}{2}$ W.	+ $\frac{1}{2}$		+ 9 30
W. by S.	W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 7 40
WEST.	W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 6 40
W. by N.	W. N. W. $\frac{7}{8}$ W.	— $\frac{1}{8}$		+ 4 0
W. N. W.	W. N. W.	0		+ 3 30
N. W. by W.	N. W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		+ 2 10
N. W.	N. W. $\frac{1}{4}$ N.	— $\frac{1}{4}$		+ 1 10
N. W. by N.	N. N. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 0 40
N. N. W.	N. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 40
N. by W.	N. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 40
NORTH.				— 1 40

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 0° 49′.0 B = — 5° 40′.8 C = — 2° 33′.4
D = + 2° 17′.7 E = + 0° 8′.2

St. Thomas, November 18, 1865.

Correction for Object = + 0° 16′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N.	0	° ′	— 0° 20′
N. by E.	N. by E.	0		— 0 20
N. N. E.	N. N. E.	0		— 0 20
N. E. by N.	N. E. by N.	0		— 0 20
N. E.	N. E.	0		— 0 20
N. E. by E.	N. E. by E.	0		— 0 20
E. N. E.	E. by N. $\frac{7}{8}$ N.	— $\frac{1}{8}$		— 1 40
E. by N.	E. $\frac{7}{8}$ N.	— $\frac{1}{8}$		— 1 40
EAST.	E. $\frac{1}{4}$ S.	— $\frac{1}{4}$		— 3 10
E. by S.	E. by S. $\frac{1}{4}$ S.	— $\frac{1}{4}$		— 3 10
E. S. E.	S. E. by E. $\frac{5}{8}$ E.	— $\frac{3}{8}$		— 4 30
S. E. by E.	S. E. $\frac{3}{4}$ E.	— $\frac{1}{4}$		— 3 10
S. E.	S. E. $\frac{1}{4}$ S.	— $\frac{1}{4}$		— 3 10
S. E. by S.	S. E. by S. $\frac{1}{4}$ S.	— $\frac{1}{4}$		— 3 10
S. S. E.	S. by E. $\frac{3}{4}$ E.	— $\frac{1}{4}$		— 3 10
S. by E.	S. $\frac{7}{8}$ E.	— $\frac{1}{8}$		— 1 40
SOUTH.	S.	0		— 0 20
S. by W.	S. by W.	0		— 0 20
S. S. W.	S. by W. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 1 10
S. W. by S.	S. W. by S. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 10
S. W.	S. W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 30
S. W. by W.	S. W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 0
W. S. W.	S. W. by W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 0
W. by S.	W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 30
WEST.	W. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 10
W. by N.	W. by N.	0		— 0 20
W. N. W.	W. N. W.	0		— 0 20
N. W. by W.	N. W. $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 1 40
N. W.	N. W. $\frac{1}{8}$ N.	— $\frac{1}{8}$		— 1 40
N. W. by N.	N. W. by N. $\frac{1}{8}$ N.	— $\frac{1}{8}$		— 1 40
N. N. W.	N. by W. $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 1 40
N. by W.	N $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 1 40
NORTH.				— 0 20

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 0° 44′.4 B = — 1° 56′.2 C = — 0° 12′.4
D = + 1° 59′.5 E = — 0° 7′.2

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD BINNACLE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Isle Royal, Salute Islands, November 30, 1865.

Correction for Object = — 0° 2′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.			°	° ′
N. by E.				
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.	EAST.	0		0 0
E. by S.				
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = B = C =
D = E =

Ceara, December 19, 1865.

Correction for Object = + 1° 51′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.			° ′	
N. by E.	N. by E.	0		+ 1 50
N. N. E.	N. N. E.	0		+ 1 50
N. E. by N.	N. E. by N.	0		+ 1 50
N. E.	N. E. $\frac{1}{8}$ N.	$+ \frac{1}{8}$		+ 3 0
N. E. by E.	N. E. by E.	0		+ 2 10
E. N. E.	E. N. E.	0		+ 1 50
E. by N.	E. $\frac{7}{8}$ N.	$— \frac{1}{8}$		+ 0 40
EAST.	E. $\frac{1}{4}$ S.	$— \frac{1}{4}$		— 0 40
E. by S.	E. by S. $\frac{3}{8}$ S.	$— \frac{3}{8}$		— 2 10
E. S. E.	S. E. by E. $\frac{5}{8}$ E.	$— \frac{3}{8}$		— 2 20
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 0° 54′.7 B = + 0° 24′.6 C = + 1° 26′.9
D = + 2° 7′.8 E = + 0° 3′.2

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD BINNACLE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Bahia, December 30, 1865.

Correction for Object = + 2° 30′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	+ 1° 50′
N. by E.	N. by E.	0		+ 2 30
N. N. E.	N. N. E.	0		+ 2 30
N. E. by N.	N. E. by N.	0		+ 2 30
N. E.	N. E.	0		+ 2 30
N. E. by E.	N. E. by E.	0		+ 2 30
E. N. E.	E. N. E.	0		+ 2 30
E. by N.	E. by N.	0		+ 2 30
EAST.	E. $\frac{1}{8}$ S.	— $\frac{1}{8}$		+ 1 30
E. by S.	E. by S. $\frac{1}{8}$ S.	— $\frac{1}{8}$		+ 1 10
E. S. E.	S. E. by E. $\frac{3}{4}$ E.	— $\frac{1}{4}$		0 0
S. E. by E.	S. E. $\frac{3}{4}$ E.	— $\frac{1}{4}$		— 0 20
S. E.	S. E. $\frac{1}{4}$ S.	— $\frac{1}{4}$		— 0 20
S. E. by S.	S. E. by S. $\frac{1}{4}$ S.	— $\frac{1}{4}$		— 0 20
S. S. E.	S. by E. $\frac{3}{4}$ E.	— $\frac{1}{4}$		— 0 20
S. by E.	S. $\frac{7}{8}$ E.	— $\frac{1}{8}$		+ 0 50
SOUTH.	SOUTH.	0		+ 2 10
S. by W.	S. by W.	0		+ 2 30
S. S. W.	S. S. W.	0		+ 2 30
S. W. by S.	S. W. by S.	0		+ 2 30
S. W.	S. W.	0		+ 2 30
S. W. by W.	S. W. by W.	0		+ 2 30
W. S. W.	W. S. W.	0		+ 2 30
W. by S.	W. $\frac{7}{8}$ S.	— $\frac{1}{8}$		+ 1 30
WEST.	W. $\frac{1}{4}$ N.	— $\frac{1}{4}$		0 0
W. by N.	W. by N. $\frac{1}{8}$ N.	— $\frac{1}{8}$		+ 0 50
W. N. W.	W. N. W.	0		+ 2 10
N. W. by W.	N. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 1 50
N. W.	N W. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 3 10
N. W. by N.	N. W. by N. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 3 10
N. N. W.	N. N. W. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 3 10
N. by W.	N. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 1 0
NORTH.				+ 1 50

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 0° .57′.9 B = + 0° 26′.5 C = — 0° 33′.8
D = + 2° 6′.5 E = — 0° 11′.2

Rio Janeiro, January 10, 1866.

Correction for Object = + 2° 44′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.			° ′	
N. by E.				
N. N. E.				
N. E. by N.	N. E. by N.	0		+ 2° 40′
N. E.	N. E.	0		+ 2 40
N. E. by E.	N. E. by E.	0		+ 2 40
E. N. E.	E. N. E.	0		+ 2 40
E. by N.	E. by N.	0		+ 2 40
EAST.	EAST.	0		+ 2 40
E. by S.	E. by S. $\frac{1}{8}$ S.	— $\frac{1}{8}$		+ 1 40
E. S. E.	E. S. E.	0		+ 2 20
S. E. by E.	S. E. $\frac{7}{8}$ E.	— $\frac{1}{8}$		+ 1 40
S. E.	S. E. $\frac{1}{4}$ S.	— $\frac{1}{4}$		+ 0 20
S. E. by S.	S. E. by S. $\frac{1}{8}$ S.	— $\frac{1}{8}$		+ 1 0
S. S. E.	S. by E. $\frac{7}{8}$ E.	— $\frac{1}{8}$		+ 1 20
S. by E.				+ 1 20
SOUTH.	SOUTH.	0		+ 2 20
S. by W.	S. by W. $\frac{1}{8}$ W.	— $\frac{1}{8}$		+ 1 40
S. S. W.	S. S. W. $\frac{1}{8}$ W.	— $\frac{1}{8}$		+ 1 20
S. W. by S.	S. W. $\frac{7}{8}$ S.	— $\frac{1}{8}$		+ 1 20
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N.W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviations are obtained:

A = — 0° 17′.1 B = + 2° 59′.8 C = — 1° 45′.5
D = + 2° 3′.7 E = + 0° 9′.3

Observations for Determining the Deviations of the Forward Binnacle Compass on the U. S. Iron Clad Monadnock.

Monte Video, January 24, 1866.

Correction for Object = $-0^\circ\ 13'$ Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	$-0^\circ\ 10'$
N. by E.	N. $\frac{7}{8}$ E.	$+\frac{1}{8}$		$+1$ 10
N. N. E.	N. by E. $\frac{3}{4}$ E.	$+\frac{1}{4}$		$+2$ 30
N. E. by N.	N. E. by N. $\frac{1}{4}$ N.	$+\frac{1}{4}$		$+2$ 30
N. E.	N. E. $\frac{3}{8}$ N.	$+\frac{3}{8}$		$+4$ 0
N. E. by E.	N. E. $\frac{5}{8}$ E.	$+\frac{3}{8}$		$+4$ 0
E. N. E.	E. N. E. $\frac{3}{8}$ N.	$+\frac{3}{8}$		$+4$ 0
E. by N.	E. by N. $\frac{3}{8}$ N.	$+\frac{3}{8}$		$+4$ 0
EAST.	E. $\frac{1}{4}$ N.	$+\frac{1}{4}$		$+2$ 30
E. by S.	E. $\frac{3}{4}$ S.	$+\frac{1}{4}$		$+2$ 30
E. S. E.	E. S. E. $\frac{1}{4}$ E.	$+\frac{1}{4}$		$+2$ 30
S. E. by E.	S. E. by E. $\frac{1}{8}$ E.	$+\frac{1}{8}$		$+1$ 10
S. E.	S. E. $\frac{1}{8}$ E.	$+\frac{1}{8}$		$+1$ 10
S. E. by S.	S. E. $\frac{7}{8}$ S.	$+\frac{1}{8}$		$+1$ 10
S. S. E.	S. S. E. $\frac{1}{8}$ E.	$+\frac{1}{8}$		$+1$ 10
S. by E.	S. by E. $\frac{1}{8}$ E.	$+\frac{1}{8}$		$+1$ 10
SOUTH.	SOUTH.	0		-0 10
S. by W.	S. $\frac{7}{8}$ W.	$+\frac{1}{8}$		$+1$ 10
S. S. W.	S. by W. $\frac{7}{8}$ W.	$+\frac{1}{8}$		$+1$ 10
S. W. by S.	S. W. by S. $\frac{1}{8}$ S.	$+\frac{1}{8}$		$+1$ 10
S. W.	S. W.	0		-0 10
S. W. by W.	S. W. by W.	0		-0 10
W. S. W.	W. S. W.	0		-0 10
W. by S.	W. $\frac{7}{8}$ S.	$-\frac{1}{8}$		-1 40
WEST.	W. $\frac{1}{4}$ N.	$-\frac{1}{4}$		-3 0
W. by N.	W. by N. $\frac{1}{4}$ N.	$-\frac{1}{4}$		-3 0
W. N. W.				-4 30
N. W. by W.	N. W. $\frac{5}{8}$ W.	$-\frac{3}{8}$		-4 30
N. W.	N. W. $\frac{1}{4}$ N.	$-\frac{1}{4}$		-3 0
N. W. by N.	N. W. by N. $\frac{1}{4}$ N.	$-\frac{1}{4}$		-3 0
N. N. W.	N. by W. $\frac{3}{4}$ W.	$-\frac{1}{4}$		-3 0
N. by W.	N. $\frac{3}{4}$ W.	$-\frac{1}{4}$		-3 0
NORTH.				-0 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

$$A = +0^\circ\ 17'.8 \quad B = +2^\circ\ 55'.4 \quad C = -0^\circ\ 41'.1$$
$$D = +1^\circ\ 45'.2 \quad E = -0^\circ\ 2'.2$$

Sandy Point, February 10, 1866.

Correction for Object = $+0^\circ\ 7'$. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{4}$ E.	$-\frac{1}{4}$	° ′	$-2^\circ\ 40'$
N. by E.	N. by E. $\frac{1}{8}$ E.	$-\frac{1}{8}$		-1 20
N. N. E.	N. N. E.	0		$+0$ 10
N. E. by N.	N. E. by N. $\frac{1}{8}$ N.	$+\frac{1}{8}$		$+1$ 30
N. E.	N. E. $\frac{1}{4}$ N.	$+\frac{1}{4}$		$+3$ 0
N. E. by E.	N. E. $\frac{3}{4}$ E.	$+\frac{1}{4}$		$+3$ 0
E. N. E.	N. E. by E. $\frac{5}{8}$ E.	$+\frac{3}{8}$		$+4$ 20
E. by N.	E. by N. $\frac{3}{8}$ N.	$+\frac{3}{8}$		$+4$ 20
EAST.	E. $\frac{3}{8}$ N.	$+\frac{3}{8}$		$+4$ 20
E. by S.	E. $\frac{3}{4}$ S.	$+\frac{1}{4}$		$+3$ 0
E. S. E.	E. by S. $\frac{3}{4}$ S.	$+\frac{1}{4}$		$+3$ 0
S. E. by E.	S. E. by E. $\frac{1}{4}$ E.	$+\frac{1}{4}$		$+3$ 0
S. E.	S. E. $\frac{1}{8}$ E.	$+\frac{1}{8}$		$+1$ 30
S. E. by S.	S. E. $\frac{5}{8}$ S.	$+\frac{3}{8}$		$+4$ 20
S. S. E.	S. S. E.	0		$+0$ 10
S. by E.	S. by E.	0		$+0$ 10
SOUTH.	SOUTH.	0		$+0$ 10
S. by W.	S. by W.	0		$+0$ 10
S. S. W.	S. S. W.	0		$+0$ 10
S. W. by S.	S. W. by S.	0		$+0$ 10
S. W.	S. W, $\frac{1}{8}$ W.	$-\frac{1}{8}$		-1 20
S. W. by W.	S. W. by W. $\frac{1}{4}$ W.	$-\frac{1}{4}$		-2 40
W. S. W.	W. by S. $\frac{3}{4}$ S.	$-\frac{1}{4}$		-2 40
W. by S.	W. $\frac{1}{2}$ S.	$-\frac{1}{2}$		-5 30
WEST.	W. $\frac{5}{8}$ N.	$-\frac{5}{8}$		-7 0
W. by N.	W. by N. $\frac{3}{4}$ N.	$-\frac{3}{4}$		-8 20
W. N. W.	N. W. by W. $\frac{1}{4}$ W.	$-\frac{3}{4}$		-8 20
N. W. by W.	N. W. $\frac{1}{4}$ W.	$-\frac{3}{4}$		-8 20
N. W.	N. W. $\frac{3}{4}$ N.	$-\frac{3}{4}$		-8 20
N. W. by N.	N. W. by N. $\frac{3}{4}$ N.	$-\frac{3}{4}$		-8 20
N. N. W.	N. by W. $\frac{3}{8}$ W.	$-\frac{5}{8}$		-7 0
N. by W.	N. $\frac{1}{2}$ W.	$-\frac{1}{2}$		-5 30
NORTH.				-2 40

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

$$A = -1^\circ\ 16'.5 \quad B = +5^\circ\ 16'.9 \quad C = -2^\circ\ 11'.0$$
$$D = +2^\circ\ 0'.5 \quad E = -0^\circ\ 3'.2$$

Observations for Determining the Deviations of the Forward Binnacle Compass on the U. S. Iron Clad Monadnock.

Valparaiso, April 4, 1866.

Correction for Object = + 0° 1′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{8}$ E.	— $\frac{1}{8}$	° ′	— 1° 20′
N. by E.	N. by E.	0		0 0
N. N. E.	N. N. E.	0		0 0
N. E. by N.	N. E. by N. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
N. E.	N. E. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 50
N. E. by E.	N. E. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
E. N. E.	N. E. by E. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
E. by N.	E. by N. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
EAST.	E. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
E. by S.	E. $\frac{7}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
E. S. E.	E. S. E.	0		0 0
S. E. by E.	S. E. by E.	0		0 0
S. E.	S. E.	0		0 0
S. E. by S.	S. E. by S.	0		0 0
S. S. E.	S. S. E.	0		0 0
S. by E.	S. by E.	0		0 0
SOUTH.	S. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. by W.	S. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 1 30
S. S. W.	S. S. W.	0		0 0
S. W. by S.	S. W. by S.	0		0 0
S. W.	S. W.	0		0 0
S. W. by W.	S. W. by W.	0		0 0
W. S. W.	W. S. W.	0		0 0
W. by S.	W. by S.	0		0 0
WEST.	W. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 2 50
W. by N.	W. by N. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 2 50
W. N. W.	W. N. W. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 2 50
N. W. by W.	N. W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 50
N. W.	N. W. $\frac{3}{8}$ N.	— $\frac{3}{8}$		— 4 10
N. W. by N.	N. W. by N. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 2 50
N. N. W.	N. by W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 50
N. by W.	N. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 50
NORTH.				— 1 20

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 0° 14′.6 B = + 1° 47′.9 C = — 0° 46′.1
D = + 1° 33′.7 E = — 0° 9′.0

Callao, April 29, 1866.

Correction for Object = + 0° 6′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{4}$ E.	— $\frac{1}{4}$	° ′	— 2° 40′
N. by E.	N. by E. $\frac{1}{8}$ E.	— $\frac{1}{8}$		— 1 20
N. N. E.	N. N. E. $\frac{1}{8}$ E.	— $\frac{1}{8}$		— 1 20
N. E. by N.	N. E. by N.	0		+ 0 10
N. E.	N. E.	0		+ 0 10
N. E. by E.	N. E. by E.	0		+ 0 10
E. N. E.	E. N. E.	0		+ 0 10
E. by N.	E. by N.	0		+ 0 10
EAST.	EAST.	0		+ 0 10
E. by S.	E. by S.	0		+ 0 10
E. S. E.	S. E. by E. $\frac{7}{8}$ E.	— $\frac{1}{8}$		— 1 20
S. E. by E.	S. E. $\frac{7}{8}$ E.	— $\frac{1}{8}$		— 1 20
S. E.	S. E. $\frac{1}{8}$ S.	— $\frac{1}{8}$		— 1 20
S. E. by S.	S. E. by S.	0		+ 0 10
S. S. E.	S. S. E.	0		+ 0 10
S. by E.	S. by E.	0		+ 0 10
SOUTH.	S. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. by W.	S. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 1 30
S. S. W.	S. by W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 3 0
S. W. by S.	S. W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 3 0
S. W.	S. W. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
S. W. by W.	S. W. by W.	0		+ 0 10
W. S. W.	W. S. W.	0		+ 0 10
W. by S.	W. $\frac{7}{8}$ S.	— $\frac{1}{8}$		— 1 20
WEST.	W. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 2 40
W. by N.	W. by N. $\frac{3}{8}$ N.	— $\frac{3}{8}$		— 4 10
W. N. W.	N. W. by W. $\frac{5}{8}$ W.	— $\frac{3}{8}$		— 4 10
N. W. by W.	N. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 5 30
N. W.	N. W. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 5 30
N. W. by N.	N. N. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 5 30
N. N. W.	N. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 5 30
N. by W.	N. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 40
NORTH.				— 2 40

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 1° 3′.4 B = + 1° 10′.2 C = — 2° 6′.8
D = + 2° 8′.2 E = + 0° 24′.7

Observations for Determining the Deviations of the Forward Binnacle Compass on the U. S. Iron Clad Monadnock.

Panama, May 20, 1866.

Correction for Object = + 0° 1′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{3}{8}$ E.	— $\frac{3}{8}$	° ′	— 4° 10′
N. by E.	N. by E. $\frac{1}{4}$ E.	— $\frac{1}{4}$		— 2 50
N. N. E.	N. E. by N. $\frac{3}{4}$ N.	— $\frac{1}{4}$		— 2 50
N. E. by N.	N. E. $\frac{3}{4}$ N.	— $\frac{1}{4}$		— 2 50
N. E.	N. E. $\frac{1}{4}$ E.	— $\frac{1}{4}$		— 2 50
N. E. by E.	N. E. by E. $\frac{1}{4}$ E.	— $\frac{1}{4}$		— 2 50
E. N. E.	E. by N. $\frac{3}{4}$ N.	— $\frac{1}{4}$		— 2 50
E. by N.	E. $\frac{3}{4}$ N.	— $\frac{1}{4}$		— 2 50
EAST.	E. $\frac{1}{4}$ S.	— $\frac{1}{4}$		— 2 50
E. by S.	E. by S. $\frac{1}{4}$ S.	— $\frac{1}{4}$		— 2 50
E. S. E.	S. E. by E. $\frac{5}{8}$ E.	— $\frac{3}{8}$		— 4 10
S. E. by E.	S. E. $\frac{5}{8}$ E.	— $\frac{3}{8}$		— 4 10
S. E.	S. E. $\frac{3}{8}$ S.	— $\frac{3}{8}$		— 4 10
S. E. by S.	S. E. by S. $\frac{3}{8}$ S.	— $\frac{3}{8}$		— 4 10
S. S. E.	S. by E. $\frac{3}{4}$ E.	— $\frac{1}{4}$		— 2 50
S. by E.	S. $\frac{3}{4}$ E.	— $\frac{1}{4}$		— 2 50
SOUTH.	S. $\frac{1}{8}$ W.	— $\frac{1}{8}$		— 1 20
S. by W.	S. by W.	0		0 0
S. S. W.	S. S. W.	0		0 0
S. W. by S.	S. W. by S.	0		0 0
S. W.	S. W. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
S. W. by W.	S. W. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 1 30
W. S. W.	S. W. by W. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 1 30
W. by S.	W. by S. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
WEST.	W. $\frac{1}{8}$ N.	— $\frac{1}{8}$		— 1 20
W. by N.	W. by N. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 2 50
W. N. W.	N. W. by W. $\frac{5}{8}$ W.	— $\frac{3}{8}$		— 4 10
N. W. by W.	N. W. $\frac{5}{8}$ W.	— $\frac{3}{8}$		— 4 10
N. W.	N. W. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 5 40
N. W. by N.	N. W. by N. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 5 40
N. N. W.	N. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 5 40
N. by W.	N. $\frac{5}{8}$ W.	— $\frac{3}{8}$		— 4 10
NORTH.				— 4 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 2° 31′.9 B = — 1° 1′.5 C = — 1° 33′.0
D = + 2° 6′.5 E = — 0° 23′.5

Acapulco, June 1, 1866.

Correction for Object = + 0° 6′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{3}{8}$ E.	— $\frac{3}{8}$	° ′	— 4° 10′
N. by E.	N. by E. $\frac{1}{4}$ E.	— $\frac{1}{4}$		— 2 40
N. N. E.	N. E. by N. $\frac{3}{4}$ N.	— $\frac{1}{4}$		— 2 40
N. E. by N.	N. E. $\frac{3}{4}$ N.	— $\frac{1}{4}$		— 2 40
N. E.	N. E. $\frac{1}{4}$ E.	— $\frac{1}{4}$		— 2 40
N. E. by E.	N. E. by E. $\frac{1}{4}$ E.	— $\frac{1}{4}$		— 2 40
E. N. E.	E. by N. $\frac{5}{8}$ N.	— $\frac{3}{8}$		— 4 10
E. by N.	E. $\frac{5}{8}$ N.	— $\frac{3}{8}$		— 4 10
EAST.	E. $\frac{3}{8}$ S.	— $\frac{3}{8}$		— 4 10
E. by S.	E. by S. $\frac{1}{2}$ S.	— $\frac{1}{2}$		— 5 30
E. S. E.	S. E. by E. $\frac{1}{2}$ E.	— $\frac{1}{2}$		— 5 30
S. E. by E.	S. E. $\frac{1}{2}$ E.	— $\frac{1}{2}$		— 5 30
S. E.	S. E. $\frac{1}{2}$ S.	— $\frac{1}{2}$		— 5 30
S. E. by S.	S. E. by S. $\frac{3}{8}$ S.	— $\frac{3}{8}$		— 4 10
S. S. E.	S. by E. $\frac{5}{8}$ E.	— $\frac{3}{8}$		— 4 10
S. by E.	S. $\frac{3}{4}$ E.	— $\frac{1}{4}$		— 2 40
SOUTH.	SOUTH.	0		+ 0 10
S. by W.	S. by W.	0		+ 0 10
S. S. W.	S. by W. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 1 30
S. W. by S.	S. W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 3 0
S. W.	S. W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 3 0
S. W. by W.	S. W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 3 0
W. S. W.	S. W. by W. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 1 30
W. by S.	W. by S.	0		+ 0 10
WEST.	W. $\frac{1}{8}$ N.	— $\frac{1}{8}$		— 1 20
W. by N.	W. by N. $\frac{1}{8}$ N.	— $\frac{1}{8}$		— 1 20
W. N. W.	N. W. by W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 40
N. W. by W.	N. W. $\frac{5}{8}$ W.	— $\frac{3}{8}$		— 4 10
N. W.	N. W. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 5 30
N. W. by N.	N. W. by N. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 5 30
N. N. W.	N. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 5 30
N. by W.	N. $\frac{5}{8}$ W.	— $\frac{3}{8}$		— 4 10
NORTH.				— 4 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 2° 31′.2 B = — 2° 2′.4 C = — 1° 41′.1
D = + 2° 39′.2 E = + 0° 10′.7

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD BINNACLE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Magdalena Bay, June 9, 1866.

Correction for Object = — 0° 41′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{2}$ E.	— $\frac{1}{2}$	° ′	— 6° 10′
N. by E.	N. by E. $\frac{3}{8}$ E.	— $\frac{3}{8}$		— 4 50
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.				
E. by S.				
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.	S. W. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 0
S. W. by W.	S. W. $\frac{1}{2}$ W.	+ $\frac{1}{2}$		+ 4 50
W. S. W.	S. W. by W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 3 30
W. by S.	W. by S. $\frac{3}{8}$ S.	+ $\frac{3}{8}$		+ 3 30
WEST.	W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 0
W. by N.	W. by N.	0		— 0 50
W. N. W.	N. W. by W. $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 2 10
N. W. by W.	N. W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 3 30
N. W.	N. W. $\frac{3}{8}$ N.	— $\frac{3}{8}$		— 5 0
N. W. by N.	N. W. by N. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 6 20
N. N. W.	N. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 6 20
N. by W.	N. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 6 20
NORTH.				— 6 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 1° 42′.6 B = — 2° 44′.3 C = — 4° 7′.3
D = + 2° 11′.8 E = — 0° 7′.9

San Francisco, June 23, 1866.

Correction for Object = — 0° 45′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{2}$ E.	— $\frac{1}{2}$	° ′	— 6° 20
N. by E.	N. by E. $\frac{1}{2}$ E.	— $\frac{1}{2}$		— 6 20
N. N. E.	N. E. by N. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 6 30
N. E. by N.	N. E. $\frac{3}{8}$ N.	— $\frac{5}{8}$		— 7 40
N. E.	N. E. $\frac{1}{2}$ E.	— $\frac{1}{2}$		— 6 20
N. E. by E.	N. E. by E. $\frac{1}{2}$ E.	— $\frac{1}{2}$		— 6 30
E. N. E.	E. by N. $\frac{3}{8}$ N.	— $\frac{5}{8}$		— 7 50
E. by N.	E. $\frac{3}{8}$ N.	— $\frac{5}{8}$		— 7 50
EAST.	E. $\frac{3}{4}$ S.	— $\frac{3}{4}$		— 9 10
E. by S.	E. by S. $\frac{3}{4}$ S.	— $\frac{3}{4}$		— 9 10
E. S. E.	S. E. by E. $\frac{3}{8}$ E.	— $\frac{5}{8}$		— 7 40
S. E. by E.	S. E. $\frac{1}{2}$ E.	— $\frac{1}{2}$		— 6 20
S. E.	S. E. $\frac{1}{2}$ S.	— $\frac{1}{2}$		— 6 10
S. E. by S.	S. E. by S. $\frac{1}{4}$ S.	— $\frac{1}{4}$		— 3 30
S. S. E.	S. by E. $\frac{3}{4}$ E.	— $\frac{1}{4}$		— 3 20
S. by E.	S. by E.	0		— 0 40
SOUTH.	S. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 0 50
S. by W.	S. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 10
S. S. W.	S. by W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 3 30
S. W. by S.	S. W. by S. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 4 50
S. W.	S. W. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 4 50
S. W. by W.	S. W. $\frac{1}{2}$ W.	+ $\frac{1}{2}$		+ 4 50
W. S. W.	S. W. by W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 3 20
W. by S.	W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 0
WEST.	W. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 0 40
W. by N.	W. by N.	0		— 0 50
W. N. W.	N. W. by W. $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 2 10
N. W. by W.	N. W. $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 2 10
N. W.	N. W. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 3 40
N. W. by N.	N. W. by N. $\frac{3}{8}$ N.	— $\frac{3}{8}$		— 5 0
N. N. W.	N. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 6 20
N. by W.	N. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 6 20
NORTH.				— 6 20

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = — 3° 9′.0 B = — 4° 41′.1 C = — 3° 34′.9
D = + 1° 56′.5 E = + 0° 30′.2

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD RITCHIE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Hampton Roads, November 1, 1865.

Correction for Object = + 3° 57′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. ¼ E.	— ¼	° ′	+ 1° 10′
N. by E.	N. by E. ⅛ E.	— ⅛		+ 2 0
N. N. E.	N. N. E.	0		+ 3 30
N. E. by N.	N. E. by N.	0		+ 4 0
N. E.	N. E. ⅛ N.	+ ⅛		+ 4 50
N. E. by E.	N. E. ⅞ E.	+ ⅛		+ 5 20
E. N. E.	N. E. by E. ¾ E.	+ ¼		+ 6 20
E. by N.	E. by N. ⅛ N.	+ ⅛		+ 5 50
EAST.	E. ⅛ N.	+ ⅛		+ 5 20
E. by S.	E. by S.	0		+ 4 30
E. S. E.	E. by S. ⅞ S.	+ ⅛		+ 4 50
S. E. by E.	S. E. by E. ⅛ E.	+ ⅛		+ 5 20
S. E.	S. E. ⅛ E.	+ ⅛		+ 5 20
S. E. by S.	S. E. ¾ S.	+ ¼		+ 6 10
S. S. E.	S. S. E. ¼ E.	+ ¼		+ 6 40
S. by E.	S. by E. ⅜ E.	+ ⅜		+ 7 40
SOUTH.	S. ½ E.	+ ½		+ 9 0
S. by W.	S. ½ W.	+ ½		+ 9 30
S. S. W.	S. by W. ⅝ W.	+ ⅜		+ 8 40
S. W. by S.	S. W. by S. ½ S.	+ ½		+ 9 0
S. W.	S. W. ⅜ S.	+ ⅜		+ 8 40
S. W. by W.	S. W. ¾ W.	+ ¼		+ 7 10
W. S. W.	W. S. W.	0		+ 5 0
W. by S.	W. by S.	0		+ 4 0
WEST.	W. ⅛ N.	— ⅛		+ 3 0
W. by N.	W. by N. ⅜ N.	— ⅜		+ 0 40
W. N. W.	N. W. by W. ¾ W.	— ¼		+ 0 40
N. W. by W.	N. W. ½ W.	— ½		— 0 40
N. W.	N. W. ½ N.	— ½		— 1 40
N. W. by N.	N. W. by N. ½ N.	— ½		— 1 40
N. N. W.	N. by W. ⅝ W.	— ⅜		— 0 50
N. by W.	N. ¾ W.	— ¼		+ 0 40
NORTH.				+ 1 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 4° 22′.5 B = + 1° 19′.2 C = — 3° 37′.2
D = + 2° 17′.2 E = + 0° 27′.5

St. Thomas, November 18, 1865.

Correction for Object = + 0° 16′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. ⅛ W.	+ ⅛	° ′	+ 1° 10′
N. by E.	N. by E.	0		— 0 10
N. N. E.	N. by E. ¾ E.	+ ¼		+ 2 40
N. E. by N.	N. E. by N. ½ N.	+ ½		+ 5 20
N. E.	N. E. ½ N.	+ ½		+ 5 20
N. E. by E.	N. E. ½ E.	+ ½		+ 5 20
E. N. E.	N. E. by E. ½ E.	+ ½		+ 5 20
E. by N.	E. by N. ¼ N.	+ ¼		+ 2 30
EAST.	E. ¼ N.	+ ¼		+ 2 30
E. by S.	E. ¾ S.	+ ¼		+ 2 30
E. S. E.	E. S. E.	0		— 0 10
S. E. by E.	S. E. by E. ¼ E.	+ ¼		+ 2 30
S. E.	S. E. ¼ E.	+ ¼		+ 2 30
S. E. by S.	S. E. ¾ S.	+ ¼		+ 2 30
S. S. E.	S. S. E.	0		— 0 10
S. by E.	S. by E.	0		— 0 20
SOUTH.	S.	0		— 0 20
S. by W.	S. ⅞ W.	+ ⅛		+ 1 10
S. S. W.	S. by W. ¾ W.	+ ¼		+ 2 40
S. W. by S.	S. W. by S. ½ S.	+ ½		+ 5 20
S. W.	S. W. ½ S.	+ ½		+ 5 20
S. W. by W.	S. W. ½ W.	+ ½		+ 5 20
W. S. W.	S. W. by W. ¾ W.	+ ¼		+ 2 40
W. by S.	W. ⅞ S.	— ⅛		— 1 40
WEST.	W. ⅛ N.	— ⅛		— 1 40
W. by N.	W. by N.	0		— 0 20
W. N. W.	N. W. by W. ¾ W.	— ¼		— 3 0
N. W. by W.	N. W. ½ W.	— ½		— 5 50
N. W.	N. W. ¼ N.	— ¼		— 3 10
N. W. by N.	N. W. by N. ½ N.	— ½		— 5 50
N. N. W.	N. by W. ¾ W.	— ¼		— 3 0
N. by W.	N. ¾ W.	— ¼		— 3 0
NORTH.				+ 1 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 1° 3′.7 B = + 2° 4′.0 C = — 1° 16′.6
D = + 3° 16′.0 E = — 0° 25′.5

Observations for Determining the Deviations of the Forward Ritchie Compass on the U. S. Iron Clad Monadnock.

Isle Royal, Salute Islands, November 30, 1865.

Correction for Object = — 0° 2′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
			° ′	° ′
NORTH.				
N. by E.				
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.	E. ½ N.	+ ½		+ 5 40
E. by S.				
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = B = C =
D = E =

Ceara, December 19, 1865.

Correction for Object = + 1° 51′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
			° ′	° ′
NORTH.				
N. by E.	N. ½ E.	+ ½		+ 7 10
N. N. E.	N. by E. ⅜ E.	+ ⅝		+ 8 40
N. E. by N.	N. E. by N. ¾ N.	+ ¾		+ 10 0
N. E.	N. E. ½ N.	+ ½		+ 8 0
N. E. by E.	N. E. ⅝ E.	+ ⅜		+ 6 20
E. N. E.	N. E. by E. ¾ E.	+ ¼		+ 5 0
E. by N.	E. by N ½ N.	+ ½		+ 7 0
EAST.	EAST.	0		+ 2 50
E. by S.	E. by S. ⅛ S.	— ⅛		+ 0 40
E. S. E.	S. E. by E. ⅞ E.	— ⅛		+ 0 30
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 3° 31′.0 B = — 0° 26′.1 C = + 3° 36′.9
D = + 2° 26′.6 E = — 0° 3′.9

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD RITCHIE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Bahia, December 30, 1865.

Correction for Object = + 2° 30′. Correction for Lubber Line = o.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH	N. $\frac{1}{4}$ E.	— $\frac{1}{4}$	° ′	— 0° 20′
N. by E.	N. by E. $\frac{1}{4}$ E.	— $\frac{1}{4}$		— 0 20
N. N. E.	N. N. E.	0		+ 1 50
N. E. by N.	N. E. by N. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 3 30
N. E.	N. E. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 7 10
N. E. by E.	N. E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 8 10
E. N. E.	N. E. by E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 8 10
E. by N.	E. by N. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 8 10
EAST.	E. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 4 50
E. by S.	E. $\frac{7}{8}$ S.	+ $\frac{1}{8}$		+ 4 0
E. S. E.	E. by S. $\frac{7}{8}$ S.	+ $\frac{1}{8}$		+ 4 0
S. F. by E.	S. E. by E.	0		+ 2 50
S. E.	S. E.	0		+ 2 30
S. E. by S.	S. E. by S.	0		+ 2 30
S. S. E.	S. S. E.	0		+ 2 30
S. by E.	S. by E. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 3 30
SOUTH.	S. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 4 0
S. by W.	S. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 5 0
S. S. W.	S. by W. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 4 10
S. W. by S.	S. W. by S. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 4 0
S. W.	S. W. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 4 0
S. W. by W.	S. W. by W.	0		+ 2 50
W. S. W.	W. by S. $\frac{7}{8}$ S.	— $\frac{1}{8}$		+ 1 30
W. by S.	W. $\frac{3}{4}$ S.	— $\frac{1}{4}$		0 0
WEST.	W. $\frac{5}{8}$ N.	— $\frac{5}{8}$		— 3 40
W. by N.	W. by N. $\frac{3}{4}$ N.	— $\frac{3}{4}$		— 5 40
W. N. W.	N. W. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 3 50
N. W. by W.	N. W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 1 0
N. W.	N W. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 2 30
N. W. by N.	N. W. by N. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 3 10
N. N. W.	N. by W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 1 0
N. by W.	N. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 0 20
NORTH.				— 0 20

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 2° 6′.2 B = + 3° 29′.1 C = — 1° 33′.9
D = + 2° 35′.7 E = — 0° 0′.5

Rio Janeiro, January 10, 1866.

Correction for Object = + 2° 44′. Correction for Lubber Line = o.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.			° ′	
N. by E.				
N. N. E.				
N. E. by N.	N. E. by N. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 8° 20′
N. E.	N. E. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 8 20
N. E. by E.	N. E. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		+ 6 10
E. N. E.	N. E. by E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 7 40
E. by N.	E. by N. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 8 20
EAST.	E. $\frac{3}{8}$ N.	+ $\frac{3}{8}$		+ 7 20
E. by S.	E. $\frac{5}{8}$ S.	+ $\frac{3}{8}$		+ 7 0
E. S. E.	E. by S. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 5 50
S. E. by E.	S. E. by E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 5 30
S. E.	S. E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 5 30
S. E. by S.	S. E. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 5 30
S. S. E.	S. E. by S. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 5 30
S. by E.				+ 4 30
SOUTH.	S. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 4 10
S. by W.	S. by W.	0		+ 3 0
S. S. W.	S. by W. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 3 50
S. W. by S.	S. W. by S. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 4 10
S. W.				
S. W. by W.				
W. S. W.				
W. by S.				
WEST.				
W. by N.				
W. N. W.				
N. W. by W.				
N. W.				
N. W. by N.				
N. N. W.				
N. by W.				
NORTH.				

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviations are obtained:

A = + 3° 14′.0 B = + 4° 23′.5 C = — 1° 10′.4
D = + 2° 10′.5 E = — 0° 0′.1

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD RITCHIE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Monte Video, January 24, 1866.

Correction for Object = — 0° 13′ Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{4}$ W.	+ $\frac{1}{4}$	° ′	+ 2° 30′
N. by E.	N. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 5 20
N. N. E.	N. by E. $\frac{3}{4}$ E.	+ $\frac{5}{8}$		+ 6 50
N. E. by N.	N. E. by N. $\frac{3}{4}$ N.	+ $\frac{3}{4}$		+ 8 10
N. E.	N. E. $\frac{3}{4}$ N.	+ $\frac{3}{4}$		+ 8 10
N. E. by E.	N. E. $\frac{1}{4}$ E.	+ $\frac{3}{4}$		+ 8 10
E. N. E.	N. E. by E. $\frac{1}{4}$ E.	+ $\frac{3}{4}$		+ 8 10
E. by N.	E. by N. $\frac{7}{8}$ N.	+ $\frac{7}{8}$		+ 9 30
EAST.	E. $\frac{3}{4}$ N.	+ $\frac{3}{4}$		+ 8 10
E. by S.	E. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 20
E. S. E.	E. by S. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 20
S. E. by E.	S. E. by E. $\frac{3}{8}$ E.	+ $\frac{3}{8}$		+ 4 0
S. E.	S. E. $\frac{3}{8}$ E.	+ $\frac{3}{8}$		+ 4 0
S. E. by S.	S. E. $\frac{5}{8}$ S.	+ $\frac{3}{8}$		+ 4 0
S. S. E.	S. S. E. $\frac{3}{8}$ E.	+ $\frac{3}{8}$		+ 4 0
S. by E.	S. by E. $\frac{3}{8}$ E.	+ $\frac{3}{8}$		+ 4 0
SOUTH.	S. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 30
S. by W.	S. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 30
S. S. W.	S. by W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 30
S. W. by S.	S. S. W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 30
S. W.	S. W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 30
S. W. by W.	S. W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 30
W. S. W.	S. W. by W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 30
W. by S.	W. by S. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 10
WEST.	WEST.	0		— 0 10
W. by N.	W. by N.	0		— 0 10
W. N. W.	W. N. W.	0		— 0 10
N. W. by W.	N. W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 3 0
N. W.	N. W. $\frac{1}{8}$ N.	— $\frac{1}{8}$		— 1 40
N. W. by N.	N. W. by N.	0		— 0 10
N. N. W.	N. N. W.	0		— 0 10
N. by W.	N. bv W.	0		— 0 10
NORTH.				+ 2 30

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 3° 23′.8 B = + 3° 48′.0 C = — 0° 0′.4
D = + 2° 11′.0 E = — 0° 28′.5

Sandy Point, February 10, 1866.

Correction for Object = + 0° 7′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{8}$ E.	— $\frac{1}{8}$	° ′	— 1° 20′
N. by E.	N. by E.	0		+ 0 10
N. N. E.	N. by E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
N. E. by N.				+ 3 0
N. E.	N. E. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 5 50
N. E. by E.	N. E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 5 50
E. N. E.	N. E. by E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 5 50
E. by N.	E. by N. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 5 50
EAST.	E. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 5 50
E. by S.	E. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 50
E. S. E.	E. by S. $\frac{5}{8}$ S.	+ $\frac{3}{8}$		+ 4 20
S. E. by E.	S. E. by E. $\frac{3}{8}$ E.	+ $\frac{3}{8}$		+ 4 20
S. E.	S. E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 3 0
S. E. by S.	S. E. $\frac{5}{8}$ S.	+ $\frac{3}{8}$		+ 4 20
S. S. E.	S. E. by S. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 50
S. by E.	S. by E. $\frac{3}{8}$ E.	+ $\frac{3}{8}$		+ 4 20
SOUTH.	S. $\frac{3}{8}$ E.	+ $\frac{3}{8}$		+ 4 20
S. by W.	S. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 20
S. S. W.	S. by W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 3 0
S. W. by S.	S. W. by S. $\frac{3}{8}$ S.	+ $\frac{3}{8}$		+ 4 20
S. W.	S. W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 3 0
S. W. by W.	S. W. $\frac{7}{8}$ W.	+ $\frac{1}{8}$		+ 1 30
W. S. W.	W. S. W. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
W. by S.	W. by S.	0		+ 0 10
WEST.	W. $\frac{1}{8}$ N.	— $\frac{1}{8}$		— 1 20
W. by N.	W. by N. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 2 40
W. N. W.	N. W. by W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 5 30
N. W. by W.	N. W. $\frac{1}{2}$ W.	— $\frac{1}{2}$		— 5 30
N. W.	N. W. $\frac{1}{2}$ N.	— $\frac{1}{2}$		— 5 30
N. W. by N.	N. W. by N. $\frac{3}{8}$ N.	— $\frac{3}{8}$		— 4 10
N. N. W.	N. by W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 40
N. by W.	N. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 40
NORTH.				— 1 20

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 1° 46′.2 B = + 3° 49′.5 C = — 2° 44′.2
D = + 2° 11′.2 E = — 0° 10′.0

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD RITCHIE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Valparaiso, April 4, 1866.

Correction for Object = + 0° 1′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. $\frac{1}{4}$ W.	+ $\frac{1}{4}$	° ′	+ 2° 50′
N. by E.	N. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
N. N. E.	N. by E. $\frac{5}{8}$ E.	+ $\frac{3}{8}$		+ 4 20
N. E. by N.	N. N. E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 5 40
N. E.	N. E. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 5 40
N. E. by E.	N. E. $\frac{3}{8}$ E.	+ $\frac{5}{8}$		+ 7 0
E. N. E.	E. N. E. $\frac{5}{8}$ N.	+ $\frac{5}{8}$		+ 7 0
E. by N.	E. by N. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 50
EAST.	E. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 50
E. by S.	E. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 2 50
E. S. E.	E. by S. $\frac{5}{8}$ S.	+ $\frac{3}{8}$		+ 4 20
S. E. by E.	S. E. by E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 5 40
S. E.	S. E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
S. E. by S.	S. E. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 2 50
S. S. E.	S. S. E. $\frac{3}{8}$ E.	+ $\frac{3}{8}$		+ 4 20
S. by E.	S. by E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 5 40
SOUTH.	S. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 5 40
S. by W.	S. $\frac{1}{2}$ W.	+ $\frac{1}{2}$		+ 5 40
S. S. W.	S. by W. $\frac{1}{2}$ W.	+ $\frac{1}{2}$		+ 5 40
S. W. by S.	S. W. by S. $\frac{5}{8}$ S.	+ $\frac{5}{8}$		+ 7 0
S. W.	S. W. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 40
S. W. by W.	S. W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 20
W. S. W.	W. S. W. $\frac{3}{8}$ S.	+ $\frac{3}{8}$		+ 4 20
W. by S.	W. by S. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 2 50
WEST.	W. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
W. by N.	W. $\frac{7}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
W. N. W.	W. N. W.	0		0 0
N. W. by W.	N. W. $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 1 20
N. W.	N. W.	0		0 0
N. W. by N.	N. W. by N.	0		0 0
N. N. W.	N. N. W.	0		0 0
N. by W.	N. by W. $\frac{1}{8}$ W.	+ $\frac{1}{8}$		+ 1 30
NORTH.				+ 2 50

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 3° 33′.4 B = + 1° 20′.2 C = — 1° 29′.0
D = + 2° 7′.8 E = + 0° 31′.2

Callao, April 29, 1866.

Correction for Object = + 0° 6′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	+ 0° 10′
N. by E.	N. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
N. N. E.	N. by E. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		+ 3 0
N. E. by N.	N. E. by N. $\frac{3}{8}$ N.	+ $\frac{3}{8}$		+ 4 20
N. E.	N. E. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 5 40
N. E. by E.	N. E. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 5 40
E. N. E.	E. N. E. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 5 40
E. by N.	E. by N. $\frac{1}{2}$ N.	+ $\frac{1}{2}$		+ 5 40
EAST.	E. $\frac{3}{8}$ N.	+ $\frac{3}{8}$		+ 4 20
E. by S.	E. $\frac{5}{8}$ S.	+ $\frac{3}{8}$		+ 4 20
E. S. E.	E. by S. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 3 0
S. E. by E.	S. E. by E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 3 0
S. E.	S. E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 3 0
S. E. by S.	S. E. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 3 0
S. S. E.	S. S. E $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 3 0
S. by E.	S. by E. $\frac{3}{8}$ E.	+ $\frac{3}{8}$		+ 4 20
SOUTH.	S. $\frac{1}{2}$ E.	+ $\frac{1}{2}$		+ 5 40
S. by W.	S. $\frac{1}{2}$ W.	+ $\frac{1}{2}$		+ 5 40
S. S. W.	S. by W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 20
S. W. by S.	S. W. by S. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 40
S. W.	S. W. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 40
S. W. by W.	S. W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 20
W. S. W.	W. S. W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 3 0
W. by S.	W. by S. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
WEST.	WEST.	0		+ 0 10
W. by N.	W. by N. $\frac{1}{8}$ N.	— $\frac{1}{8}$		— 1 20
W. N. W.	W. N. W. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 2 40
N. W. by W.	N. W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 40
N. W.	N. W. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 2 40
N. W. by N.	N. W. by N. $\frac{1}{8}$ N.	— $\frac{1}{8}$		— 1 20
N. N. W.	N. by W. $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 1 20
N. by W.	N. by W.	0		+ 0 10
NORTH.				+ 0 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 2° 37′.1 B = + 1° 52′.8 C = — 1° 58′.0
D = + 2° 30′.5 E = + 0° 12′.0

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD RITCHIE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Panama, May 20, 1866.

Correction for Object = + 0° 1′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	0° 0′
N. by E.	N. by E.	0		0 0
N. N. E.	N. by E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
N. E. by N.	N. E. by N. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
N. E.	N. E. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 50
N. E. by E.	N. E. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
E. N. E.	N. E. by E. $\frac{3}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
E. by N.	E. by N. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 2 50
EAST.	E. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
E. by S.	E. by S.	0		0 0
E. S. E.	E. by S. $\frac{7}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
S. E. by E.	S. E. by E. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. E.	S. E.	0		0 0
S. E. by S.	S. E. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 2 50
S. S. E.	S. S. E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
S. by E.	S. by E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 2 50
SOUTH.	S. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. by W.	S. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 10
S. S. W.	S. by W. $\frac{3}{4}$ W.	+ $\frac{1}{4}$		+ 2 50
S. W. by S.	S. W. by S. $\frac{3}{8}$ S.	+ $\frac{3}{8}$		+ 4 10
S. W.	S. W. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 40
S. W. by W.	S. W. $\frac{1}{2}$ W.	+ $\frac{1}{2}$		+ 5 40
W. S. W.	S. W. by W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 10
W. by S.	W. by S. $\frac{3}{8}$ S.	+ $\frac{3}{8}$		+ 4 10
WEST.	W. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
W. by N.	W. by N.	0		0 0
W. N. W.	N. W. by W. $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 1 20
N. W. by W.	N. W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 50
N. W.	N. W. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 2 50
N. W. by N.	N. W. by N. $\frac{1}{8}$ N.	— $\frac{1}{8}$		— 1 20
N. N. W.	N. by W. $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 1 20
N. by W.	N. $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 1 20
NORTH.				0 0

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 1° 34′.0 B = + 0° 12′.2 C = — 1° 53′.8
D = + 2° 10′.8 E = — 0° 14′.0

Acapulco, June 1, 1866.

Correction for Object = + 0° 6′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	NORTH.	0	° ′	+ 0° 10′
N. by E.	N. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
N. N. E.	N. by E. $\frac{7}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
N. E. by N.	N. E. by N. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 3 0
N. E.	N. E. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 3 0
N. E. by E.	N. E. $\frac{5}{8}$ E.	+ $\frac{3}{8}$		+ 4 20
E. N. E.	E. N. E. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 3 0
E. by N.	E. by N. $\frac{1}{4}$ N.	+ $\frac{1}{4}$		+ 3 0
EAST.	E. $\frac{1}{8}$ N.	+ $\frac{1}{8}$		+ 1 30
E. by S.	E. $\frac{7}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
E. S. E.	E. S. E.	0		+ 0 10
S. E. by E.	S. E. by E. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. E.	S. E. $\frac{1}{8}$ E.	+ $\frac{1}{8}$		+ 1 30
S. E. by S.	S. E. $\frac{3}{4}$ S.	+ $\frac{1}{4}$		+ 3 0
S. S. E.	S. S. E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 3 0
S. by E.	S. by E. $\frac{1}{4}$ E.	+ $\frac{1}{4}$		+ 3 0
SOUTH.	S. $\frac{3}{8}$ E.	+ $\frac{3}{8}$		+ 4 20
S. by W.	S. $\frac{1}{2}$ W.	+ $\frac{1}{2}$		+ 5 40
S. S. W.	S. by W. $\frac{1}{2}$ W.	+ $\frac{1}{2}$		+ 5 40
S. W. by S.	S. W. by S. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 40
S. W.	S. W. $\frac{1}{2}$ S.	+ $\frac{1}{2}$		+ 5 40
S. W. by W.	S. W. $\frac{5}{8}$ W.	+ $\frac{3}{8}$		+ 4 20
W. S. W.	W. S. W. $\frac{1}{4}$ S.	+ $\frac{1}{4}$		+ 3 0
W. by S.	W. by S. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
WEST.	W. $\frac{1}{8}$ S.	+ $\frac{1}{8}$		+ 1 30
W. by N.	W. by N.	0		+ 0 10
W. N. W.	W. N. W. $\frac{1}{8}$ N.	— $\frac{1}{8}$		— 1 20
N. W. by W.	N. W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 40
N. W.	N. W. $\frac{1}{4}$ N.	— $\frac{1}{4}$		— 2 40
N. W. by N.	N. W. by N. $\frac{1}{8}$ N.	— $\frac{1}{8}$		— 1 20
N. N. W.	N. by W. $\frac{3}{4}$ W.	— $\frac{1}{4}$		— 2 40
N. by W.	N. $\frac{7}{8}$ W.	— $\frac{1}{8}$		— 1 20
NORTH.				+ 0 10

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 1° 52′.8 B = + 0° 38′.2 C = — 2° 11′.8
D = + 2° 24′.2 E = + 0° 26′.2

OBSERVATIONS FOR DETERMINING THE DEVIATIONS OF THE FORWARD RITCHIE COMPASS ON THE U. S. IRON CLAD MONADNOCK.

Magdalena Bay, June 9, 1866.

Correction for Object = — 0° 41′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 1/4 E.	— 1/4	° ′	— 3° 30′
N. by E.	N. by E. 1/8 E.	— 1/8		— 2 0
N. N. E.				
N. E. by N.				
N. E.				
N. E. by E.				
E. N. E.				
E. by N.				
EAST.				
E. by S.				
E. S. E.				
S. E. by E.				
S. E.				
S. E. by S.				
S. S. E.				
S. by E.				
SOUTH.				
S. by W.				
S. S. W.				
S. W. by S.				
S. W.	S. W. 7/8 S.	+ 7/8		+ 9 0
S. W. by W.	S. W. 1/4 W.	+ 3/4		+ 7 40
W. S. W.	W. S. W. 5/8 S.	+ 5/8		+ 6 20
W. by S.	W. by S. 1/2 S.	+ 1/2		+ 4 50
WEST.	W. 3/8 S.	+ 3/8		+ 3 20
W. by N.	W. by N.	0		— 0 50
W. N. W.	W. N. W. 1/4 N.	— 1/4		— 3 30
N. W. by W.	N. W. 3/4 W.	— 1/4		— 3 30
N. W.	N. W. 1/4 N.	— 1/4		— 3 30
N. W. by N.	N. W. by N. 3/8 N.	— 3/8		— 5 0
N. N. W.	N. by W. 1/2 W.	— 1/2		— 6 10
N. by W.	N. 3/4 W.	— 1/4		— 3 30
NORTH.				— 3 30

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 2° 43′.8 B = + 0° 39′.9 C = — 6° 1′.3
D = + 2° 38′.7 E = — 0° 1′.3

San Francisco, June 23, 1866.

Correction for Object = — 0° 45′. Correction for Lubber Line = 0.

Assumed Magnetic Direction of Ship's Head.	Ship's Head by Compass.	Deviation of Compass in Points.	Deviation of Compass in Degrees.	Corrected Deviation of Compass.
NORTH.	N. 1/2 E.	— 1/2	° ′	— 6° 20′
N. by E.	N. by E. 3/8 E.	— 3/8		— 4 50
N. N. E.	N. N. E. 1/4 E.	— 1/4		— 3 30
N. E. by N.	N. E. 3/4 N.	— 1/4		— 3 30
N. E.	N. E. 1/8 E.	— 1/8		— 2 0
N. E. by E.	N. E. by E.	0		— 0 30
E. N. E.	E. N. E. 1/4 N.	+ 1/4		+ 2 0
E. by N.	E. by N. 1/8 N.	+ 1/8		+ 0 40
EAST.	EAST.	0		— 0 40
E. by S.	E. 7/8 S.	+ 1/8		+ 0 50
E. S. E.	E. by S. 3/4 S.	+ 1/4		+ 2 10
S. E. by E.	S. E. by E. 3/8 E.	+ 3/8		+ 3 40
S. E.	S. E. 1/2 E.	+ 1/2		+ 4 50
S. E. by S.	S. E. 1/2 S.	+ 1/2		+ 4 50
S. S. E.	S. S. E. 1/2 E.	+ 1/2		+ 5 0
S. by E.	S. by E. 5/8 E.	+ 5/8		+ 6 20
SOUTH.	S. 3/4 E.	+ 3/4		+ 7 40
S. by W.	S. 1/4 W.	+ 3/4		+ 7 40
S. S. W.	S. by W. 1/4 W.	+ 3/4		+ 7 40
S. W. by S.	S. W. by S. 7/8 S.	+ 7/8		+ 9 0
S. W.	S. W. 3/4 S.	+ 3/4		+ 7 30
S. W. by W.	S. W. 3/8 W.	+ 5/8		+ 6 20
W. S. W.	W. S. W. 5/8 S.	+ 5/8		+ 6 10
W. by S.	W. by S. 1/2 S.	+ 1/2		+ 4 40
WEST.	W. 1/8 S.	+ 1/8		+ 0 30
W. by N.	W. by N. 1/8 N.	+ 1/8		— 2 0
W. N. W.	W. N. W.	0		— 1 0
N. W. by W.	N. W. 3/4 W.	— 1/4		— 3 30
N. W.	N. W. 1/8 N.	— 1/8		— 2 20
N. W. by N.	N. W. by N. 1/2 N.	— 1/2		— 6 20
N. N. W.	N. by W. 1/2 W.	— 1/2		— 6 40
N. by W.	N. 1/8 W.	— 7/8		— 10 20
NORTH.				— 6 20

A deviation of the North Point of the Compass to the East is designated by the sign +; a deviation to the West by the sign —.

From the observations given above, the following values of the coefficients of the deviation are obtained:

A = + 1° 3′.8 B = — 0° 16′.2 C = — 6° 41′.6
D = + 1° 48′.5 E = — 0° 33′.5

The observations made at stations where the deviations had been determined on all of the thirty-two points were first discussed. For that purpose the values of the coefficients A_1, B_1, C_1, D_1, E_1, for each compass, at each station, were computed from the deviations on the true magnetic points by means of the equations given on pages 126 to 128. A specimen of the form employed in making these computations is appended. It sufficiently explains itself.

ADMIRALTY STANDARD COMPASS. COMPUTATION OF COEFFICIENTS B_1 AND C_1, FROM DEVIATIONS OBSERVED ON 32 POINTS, ON THE U. S. IRON CLAD MONADNOCK.

Bahia, December 30, 1865.

	I.		II.	III.	IV.	V. Computation of B_1.		VI. Computation of C_1.	
True Magnetic Direction of Ship's Head.	Observed Deviation of Compass.	True Magnetic Direction of Ship's Head.	Observed Deviation of Compass.	Half Sum of Quantities in Cols. I and II. — Unchanging Part of Deviation.	Half Sum of Cols. I and II, (changing Signs of Col. II.) — Semi-circular Deviation.	Multipliers.	Products of Col. IV by Multipliers.	Multipliers.	Products of Col. IV by Multipliers.
NORTH.	+ 1° 40′	SOUTH.	+ 1° 40′	+ 1° 40′	0° 0′	0	0° 0′	1	0° 0
N. by E.	+ 3 20	S. by W.	+ 1 20	+ 2 20	+ 1 0	S_1	+ 0 12	S_7	+ 0 59
N. N. E.	+ 3 40	S. S. W.	+ 1 00	+ 2 20	+ 1 20	S_2	+ 0 31	S_6	+ 1 14
N. E. by N.	+ 4 30	S. W. by S.	+ 0 30	+ 2 30	+ 2 0	S_3	+ 1 7	S_5	+ 1 40
N. E.	+ 4 40	S. W.	0 0	+ 2 20	+ 2 20	S_4	+ 1 39	S_4	+ 1 39
N. E. by E.	+ 5 0	S. W. by W.	— 0 40	+ 2 10	+ 2 50	S_5	+ 2 21	S_3	+ 1 34
E. N. E.	+ 5 30	W. S. W.	— 1 10	+ 2 10	+ 3 20	S_6	+ 3 5	S_2	+ 1 17
E. by N.	+ 5 40	W. by S.	— 1 50	+ 1 55	+ 3 ·45	S_7	+ 3 41	S_1	+ 0 44
EAST.	+ 5 20	WEST.	— 2 0	+ 1 40	+ 3 40	1	+ 3 40	0	0 0
E. by S.	+ 5 10	W. by N.	— 2 10	+ 1 30	+ 3 40	S_7	+ 3 36	$-S_1$	— 0 43
E. S. E.	+ 4 40	W. N. W.	— 2 0	+ 1 20	+ 3 20	S_6	+ 3 5	$-S_2$	— 1 17
S. E. by E.	+ 4 20	N. W. by W.	— 2 0	+ 1 10	+ 3 10	S_5	+ 2 38	$-S_3$	— 1 46
S. E.	+ 3 20	N. W.	— 2 0	+ 0 40	+ 2 40	S_4	+ 1 53	$-S_4$	— 1 53
S. E. by S.	+ 2 40	N. W. by N.	— 1 10	+ 0 45	+ 1 55	S_3	+ 1 4	$-S_5$	— 1 36
S. S. E.	+ 2 10	N. N. W.	— 0 10	+ 1 0	+ 1 10	S_2	+ 0 27	$-S_6$	— 1 5
S. by E.	+ 2 0	N. by W.	+ 0 30	+ 1 15	+ 0 45	S_1	+ 0 9	$-S_7$	— 0 44
					Sum of + terms =		+ 29 8	+	9 7
					Sum of — terms = —			—	9 4
					Divisor	8	+ 29 8	8	+ 0 3
							B_1 = + 3 38.5		C_1 = + 0 0.4

N. B.—Easterly deviations are to be entered in this table with the sign +; Westerly deviations with the sign —.

COMPUTATION OF COEFFICIENTS A_1, D_1, E_1, FROM DEVIATIONS OBSERVED ON 32 POINTS.

I.	II.	III.	IV.	V.		VI.	
		Half Sum of Quantities in Cols. I and II.	Half Sum of Cols. I and II, (changing Signs of Col. II.)	Computation of D_1.		Computation of E_1.	
Upper Half of Table A, Col. III.	Lower Half of Table A, Col. III.	Constant Part of Deviation.	Quadrantal Deviation.	Multipliers.	Products of Col. IV by Multipliers.	Multipliers.	Products of Col. IV by Multipliers.
+ 1° 40′	+ 1° 40′	+ 1° 40′	0° 0′	0	0° 0′	1	0° 0′
+ 2 20	+ 1 30	+ 1 55	+ 0 25	S_2	+ 0 10	S_6	+ 0 23
+ 2 20	+ 1 20	+ 1 50	+ 0 30	S_4	+ 0 21	S_4	+ 0 21
+ 2 30	+ 1 10	+ 1 50	+ 0 40	S_6	+ 0 37	S_2	+ 0 15
+ 2 20	+ 0 40	+ 1 30	+ 0 50	1	+ 0 50	0	0 0
+ 2 10	+ 0 45	+ 1 27	+ 0 43	S_6	+ 0 40	$-S_2$	— 0 16
+ 2 10	+ 1 0	+ 1 35	+ 0 35	S_4	+ 0 25	$-S_4$	— 0 25
+ 1 55	+ 1 15	+ 1 35	+ 0 20	S_2	+ 0 8	$-S_6$	— 0 18
Sum of + terms = +		13 22	Sum of + terms = +		3 11	+	59
Sum of — terms = —			Sum of — terms = —			—	59
	Divisor 8	+ 13 22	Divisor 4		+ 3 11	4	0 0
		$A_1 = + 1$ 40.2			$D_1 = + 0$ 47.8	$E_1 =$	0 0.0

NOTE.—$S_1 = .195$. $S_2 = .383$. $S_3 = .556$. $S_4 = .707$. $S_5 = .831$. $S_6 = .924$. $S_7 = .981$.

The resulting values of the coefficients for each compass, at each station, are given in the following tables:

COEFFICIENTS OF THE DEVIATIONS OF THE ADMIRALTY STANDARD COMPASS.

STATION.	DATE.	A_1	B_1	C_1	D_1	E_1
Hampton Roads . . .	November 1, 1865	+ 1° 37′.4	+ 9° 4′.6	— 0° 33′.1	+ 0° 29′.2	— 0° 7′.5
St. Thomas	November 18, 1865	+ 0 14.6	+ 5 45.5	+ 0 33.5	+ 0 3.2	— 0 48.2
Bahia	December 30, 1865	+ 1 40.2	+ 3 38.5	+ 0 0.4	+ 0 47.8	0 0.0
Monte Video	January 24, 1866	+ 1 32.8	+ 3 4.8	+ 0 5.8	+ 1 19.5	+ 0 14.5
Sandy Point	February 10, 1866	+ 0 35.9	+ 1 20.6	— 0 40.6	+ 0 53.5	+ 0 1.5
Valparaiso	April 4, 1866	+ 0 35.6	+ 1 20.2	— 0 6.9	+ 0 54.2	— 0 10.2
Callao	April 29, 1866	+ 0 9.1	+ 2 21.1	— 0 1.8	+ 0 52.5	+ 0 5.8
Panama	May 20, 1866	+ 0 31.6	+ 3 2.1	+ 0 1.9	+ 0 55.0	+ 0 8.0
Acapulco	June 1, 1866	— 0 36.9	+ 2 45.4	+ 0 5.5	+ 0 56.8	+ 0 8.0
San Francisco	June 23, 1866	— 0 39.6	+ 4 53.2	— 1 15.4	+ 0 51.2	+ 0 5.8

COEFFICIENTS OF THE DEVIATIONS OF THE AFTER BINNACLE COMPASS.

STATION.	DATE.	A_1	B_1	C_1	D_1	E_1
Hampton Roads . . .	November 1, 1865	+ 0° 27′.5	+ 7° 16′.8	— 1° 14′.1	+ 1° 39′.2	+ 0° 6′.2
St. Thomas	November 18, 1865	......	......	......	......	......
Bahia	December 30, 1865	+ 1 29.8	+ 5 43.6	— 0 6.9	+ 1 41.5	+ 0 7.8
Monte Video	January 24, 1866	+ 1 3.1	+ 5 30.6	+ 0 41.9	+ 1 57.5	— 0 42.5
Sandy Point	February 10, 1866	— 0 24.5	+ 5 44.4	— 0 14.6	+ 1 58.5	+ 0 0.2
Valparaiso	April 4, 1866	+ 0 4.9	+ 3 58.8	+ 0 7.9	+ 2 1.5	— 0 0.2
Callao	April 29, 1866	— 0 27.1	+ 4 12.5	— 0 3.9	+ 2 7.5	+ 0 9.0
Panama	May 20, 1866	— 0 50.0	+ 3 19.5	+ 0 22.0	+ 2 32.7	— 0 18.0
Acapulco	June 1, 1866	— 1 0.2	+ 3 4.4	— 0 17.1	+ 2 15.2	— 0 17.2
San Francisco	June 23, 1866	— 0 35.2	+ 3 28.2	— 2 13.9	+ 1 47.5	+ 0 10.2

COEFFICIENTS OF THE DEVIATIONS OF THE AFTER RITCHIE COMPASS.

STATION.	DATE.	A_1	B_1	C_1	D_1	E_1
Hampton Roads	November 1, 1865	+ 7° 40′.0	+ 11° 26′.5	— 1° 44′.1	+ 0° 15′.5	— 0° 54′.5
St. Thomas	November 18, 1865	+ 3 14.4	+ 8 26.9	+ 0 40.4	+ 1 54.2	— 0 37.2
Bahia	December 30, 1865	+ 8 47.1	+ 6 55.6	— 0 57.2	+ 1 59.7	+ 0 14.2
Monte Video	January 24, 1866	……	……	……	……	……
Sandy Point	February 10, 1866	+ 8 18.4	+ 4 3.2	— 3 25.6	+ 1 14.5	+ 0 58.5
Valparaiso	April 4, 1866	+ 4 21.9	+ 3 49.1	+ 0 12.4	+ 2 21.0	+ 0 7.5
Callao	April 29, 1866	+ 4 19.4	+ 5 50.1	+ 0 14.1	+ 1 30.5	+ 0 52.0
Panama	May 20, 1866	+ 5 20.6	+ 4 3.1	— 0 10.2	+ 1 17.0	— 1 33.0
Acapulco	June 1, 1866	+ 4 0.6	+ 4 29.1	+ 1 12.8	+ 1 12.2	+ 0 47.0
San Francisco	June 23, 1866	+ 4 11.6	+ 6 46.2	— 1 31.4	+ 2 28.5	+ 0 21.2

COEFFICIENTS OF THE DEVIATIONS OF THE AFTER AZIMUTH COMPASS.

STATION.	DATE.	A_1	B_1	C_1	D_1	E_1
Hampton Roads	November 1, 1865	— 1° 5′.0	— 4° 53′.0	— 0° 9′.1	+ 5° 35′.2	+ 0° 17′.0
St. Thomas	November 18, 1865	— 1 17.5	— 3 0.9	+ 1 20.0	+ 6 49.2	+ 0 12.2
Bahia	December 30, 1865	— 3 36.9	— 4 28.6	— 0 19.5	+ 7 22.0	— 1 5.5
Monte Video	January 24, 1866	……	……	……	……	……
Sandy Point	February 10, 1866	— 0 5.6	— 2 57.8	— 0 47.2	+ 7 10.2	— 0 25.5
Valparaiso	April 4, 1866	— 2 16.2	— 4 54.1	+ 0 20.9	+ 5 52.5	+ 0 37.5
Callao	April 29, 1866	— 3 56.2	— 2 0.6	— 0 49.6	+ 5 6.5	+ 0 35.7
Panama	May 20, 1866	— 2 6.9	— 3 47.2	+ 1 44.6	+ 6 21.2	— 0 34.0
Acapulco	June 1, 1866	— 3 11.2	— 3 25.8	— 0 0.8	+ 5 54.2	+ 0 23.8
San Francisco	June 23, 1866	……	……	……	……	……

COEFFICIENTS OF THE DEVIATIONS OF THE FORWARD ALIDADE COMPASS.

STATION.	DATE.	A_1	B_1	C_1	D_1	E_1
Hampton Roads	November 1, 1865	+ 2° 8′.1	— 2° 28′.4	— 1° 52′.0	+ 1° 4′.2	0° 0.0
St. Thomas	November 18, 1865	+ 0 50.9	— 0 35.1	— 0 46.2	+ 1 15.7	+ 0 20.5
Bahia	December 30, 1865	+ 2 9.4	— 0 6.0	— 0 34.1	+ 1 15.0	+ 0 14.5
Monte Video	January 24, 1866	+ 2 7.1	+ 0 57.2	— 1 5.0	+ 1 23.0	— 0 9.8
Sandy Point	February 10, 1866	+ 2 25.6	+ 0 58.5	— 1 54.4	+ 1 47.0	— 0 20.2
Valparaiso	April 4, 1866	+ 1 55.2	+ 0 30.0	— 0 53.9	+ 1 4.2	— 0 5.2
Callao	April 29, 1866	+ 0 21.0	+ 0 40.9	— 1 36.4	+ 1 29.0	— 0 6.8
Panama	May 20, 1866	+ 2 15.2	+ 0 1.1	— 1 22.1	+ 1 21.0	— 0 6.8
Acapulco	June 1, 1866	+ 1 8.1	— 1 28.4	— 0 33.1	+ 1 52.8	+ 0 10.2
San Francisco	June 23, 1866	+ 0 40.6	— 1 54.2	— 2 25.1	+ 0 58.0	+ 0 21.5

COEFFICIENTS OF THE DEVIATIONS OF THE FORWARD BINNACLE COMPASS.

STATION.	DATE.	A_1	B_1	C_1	D_1	E_1
Hampton Roads	November 1, 1865	+ 0° 49′.0	— 5° 40′.8	— 2° 33′.4	+ 2° 17′.7	+ 0° 8′.2
St. Thomas	November 18, 1865	— 0 44.4	— 1 56.2	— 0 12.4	+ 1 59.5	— 0 7.2
Bahia	December 30, 1865	+ 0 57.9	+ 0 26.5	— 0 33.8	+ 2 6.5	— 0 11.2
Monte Video	January 24, 1866	+ 0 17.8	+ 2 55.4	— 0 41.1	+ 1 45.2	— 0 2.2
Sandy Point	February 10, 1866	— 1 16.5	+ 5 16.9	— 2 11.0	+ 2 0.5	— 0 3.2
Valparaiso	April 4, 1866	— 0 14.6	+ 1 47.9	— 0 46.1	+ 1 33.7	— 0 9.0
Callao	April 29, 1866	— 1 3.4	+ 1 10.2	— 2 6.8	+ 2 8.2	+ 0 24.7
Panama	May 20, 1866	— 2 31.9	— 1 1.5	— 1 33.0	+ 2 6.5	— 0 23.5
Acapulco	June 1, 1866	— 2 31.2	— 2 2.4	— 1 41.1	+ 2 39.2	+ 0 10.7
San Francisco	June 23, 1866	— 3 9.0	— 4 41.1	— 3 34.9	+ 1 56.5	+ 0 30.2

COEFFICIENTS OF THE DEVIATIONS OF THE FORWARD RITCHIE COMPASS.

STATION.	DATE.	A_1	B_1	C_1	D_1	E_1
Hampton Roads . . .	November 1, 1865	$+4^\circ\ 22'.5$	$+1^\circ\ 19'.2$	$-3^\circ\ 37'.2$	$+2^\circ\ 17'.2$	$+0^\circ\ 27'.5$
St. Thomas	November 18, 1865	$+1\ \ 3.7$	$+2\ \ 4.0$	$-1\ \ 16.6$	$+3\ \ 16.0$	$-0\ \ 25.5$
Bahia	December 30, 1865	$+2\ \ 6.2$	$+3\ \ 29.1$	$-1\ \ 33.9$	$+2\ \ 35.7$	$-0\ \ 0.5$
Monte Video	January 24, 1866	$+3\ \ 23.8$	$+3\ \ 48.0$	$-0\ \ 0.4$	$+2\ \ 11.0$	$-0\ \ 28.5$
Sandy Point	February 10, 1866	$+1\ \ 46.2$	$+3\ \ 49.5$	$-2\ \ 44.2$	$+2\ \ 11.2$	$-0\ \ 10.0$
Valparaiso	April 4, 1866	$+3\ \ 33.4$	$+1\ \ 20.2$	$-1\ \ 29.0$	$+2\ \ 7.8$	$+0\ \ 31.2$
Callao	April 29, 1866	$+2\ \ 37.1$	$+1\ \ 52.8$	$-1\ \ 58.0$	$+2\ \ 30.5$	$+0\ \ 12.0$
Panama.	May 20, 1866	$+1\ \ 34.0$	$+0\ \ 12.2$	$-1\ \ 53.8$	$+2\ \ 10.8$	$-0\ \ 14.0$
Acapulco	June 1, 1866	$+1\ \ 52.8$	$+0\ \ 38.2$	$-2\ \ 11.8$	$+2\ \ 24.2$	$+0\ \ 26.2$
San Francisco. . . .	June 23, 1866	$+1\ \ 3.8$	$-0\ \ 16.2$	$-6\ \ 41.6$	$+1\ \ 48.5$	$-0\ \ 33.5$

In the case of the Admiralty Standard Compass, for some not very evident reason, the variations in the value of the coefficient A_1 are greater than might have been expected. The After Binnacle, Forward Alidade, and Forward Binnacle Compasses were frequently removed from their places, and the fittings were not sufficiently exact to give any certainty of replacing them with their lubber lines always precisely in the same position. This source of error sufficiently accounts for the variations in the values of the A_1s belonging to them. The Forward and After Ritchie Compasses were firmly fixed in their places, and were not removed during the cruise, except at Valparaiso; but the arrangements for reading off their cards were such that an improper position of the eye of the observer might easily introduce a large parallax, which accounts for the changes in the values of the A_1s belonging to them. The After Azimuth Compass was always taken down after each swing, and as there was no fixed mark by which to adjust its lubber line, the changes in the value of its A_1 are not surprising.

It now becomes necessary to determine the probable errors of the values of the coefficients which have just been given. To do this for any compass, at any particular station, the value of δ at each of the thirty-two points must be computed from the coefficients for that station. Comparing the values thus found with the corrected observed values, a series of thirty-two residuals are obtained, from which the probable error of δ for that station is deduced by means of the formula

$$r = 0.6745 \sqrt{\frac{[vv]}{m - \mu}}$$

where r is the probable error of a single observed value of δ; $[vv]$ the sum of the squares of the thirty-two residuals; m the number of the residuals, in this case thirty-two; and μ the number of the coefficients, in the present instance five. Then, letting p_A, p_B, p_C, p_D, p_E, represent respectively the weights, and r_A, r_B, r_C, r_D, r_E, the probable errors, of the values of A_1, B_1, C_1, D_1, E_1, when determined from a set of deviations observed on each of the thirty-two true magnetic points; we have

$$r_A = \frac{r}{\sqrt{p_A}} \qquad r_B = \frac{r}{\sqrt{p_B}}, \qquad \text{\&c.}$$

From the normal equations on page 126, we also have,

$$p_A = 32 \qquad p_D = 16$$
$$p_B = 16 \qquad p_E = 16$$
$$p_C = 16$$

It is therefore evident that the probable errors of B_1, C_1, D_1, and E_1, will all be equal to each other.

The probable error of a single observed value of δ has been computed in this way, for each compass, at three stations; namely, Bahia, Sandy Point, and Panama, and the results are given in the following table. The column headed "mean value of r" was obtained by adding together, for each compass, the sum of the squares of the residuals at Bahia, Sandy Point, and Panama; dividing the result by three; and then computing the value of r from the mean value of $[vv]$ thus found. The column headed "$\frac{r}{\sqrt{32}}$" gives the probable error of A_1; and the column headed "$\frac{r}{\sqrt{16}}$" gives the probable error of B_1, C_1, D_1, and E_1, for each compass, when these coefficients have been computed from a set of deviations observed on thirty-two points.

Compass.	Value of r.			Mean value of r.	$\frac{r}{\sqrt{32}}$	$\frac{r}{\sqrt{16}}$
	Bahia.	Sandy Point.	Panama.			
Admiralty Standard . .	± 9′.8	± 12′.2	± 11′.3	± 11′.1	± 2′.0	± 2′.8
After Binnacle	± 25.8	± 20.1	± 26.2	± 24.2	± 4.3	± 6.1
After Ritchie	± 30.6	± 56.6	± 38.8	± 43.4	± 7.7	± 10.8
After Azimuth	± 39.3	± 51.1	± 32.6	± 41.7	± 7.4	± 10.4
Forward Alidade . . .	± 19.0	± 24.5	± 23.6	± 22.5	± 4.0	± 5.6
Forward Binnacle . . .	± 40.2	± 31.2	± 25.3	± 32.8	± 5.8	± 8.2
Forward Ritchie . . .	± 59.7	± 30.2	± 37.8	± 44.4	± 7.8	± 11.1

As an incidental result, this table shows that for ordinary steering compasses (such as the Forward Alidade, Forward Binnacle, and After Binnacle) when read to the nearest eighth of a point, the probable accidental error of a single reading is about half a degree; for Ritchie Monitor Compasses (such as the Forward and After Ritchie) when read to the nearest eighth of a point, the probable accidental error of a single reading is about three-quarters of a degree; and for Admiralty Standard Compasses, read to the nearest ten minutes, the probable accidental error of a single reading is about eleven minutes.

From the mathematical theory of the deviations of the compass, given in a preceding part of this section, we have

$$\mathfrak{B} = B_1 - A_1 C_1$$

and also

$$\mathfrak{B} = \frac{c}{\lambda} \tan \theta + \frac{P}{\lambda} \times \frac{1}{H}$$

Hence

$$0 = - B_1 + A_1 C_1 + \frac{c}{\lambda} \tan \theta + \frac{P}{\lambda} \times \frac{1}{H}$$

But as P is liable to undergo a slow change, we introduce a term depending upon the time, and the equation becomes

$$0 = -B_1 + A_1 C_1 + \frac{c}{\lambda} \tan \theta + \frac{P}{\lambda} \times \frac{1}{H} + \frac{\Delta P}{\lambda} \times \frac{t}{H} \tag{17}$$

where ΔP is the change of the value of P in one day, and t is the elapsed time in days, counted from November 1st, 1865.

We have further

$$\mathfrak{C} = C_1 + A_1 B_1$$

and also

$$\mathfrak{C} = \frac{f}{\lambda} \tan \theta + \frac{Q}{\lambda} \times \frac{1}{H}$$

Hence

$$0 = -C_1 - A_1 B_1 + \frac{f}{\lambda} \tan \theta + \frac{Q}{\lambda} \times \frac{1}{H}$$

But as Q is liable to undergo a slow change, we introduce a term depending upon the time, in the same manner as above, and the equation becomes

$$0 = -C_1 - A_1 B_1 + \frac{f}{\lambda} \tan \theta + \frac{Q}{\lambda} \times \frac{1}{H} + \frac{\Delta Q}{\lambda} \times \frac{t}{H} \tag{18}$$

Each observed value of B_1 and C_1 gives two equations of condition; one of the same form as (17), the other of the same form as (18); and from all the equations of condition thus obtained for any compass, the values of A_1, $\frac{c}{\lambda}$, $\frac{P}{\lambda}$, $\frac{\Delta P}{\lambda}$, $\frac{f}{\lambda}$, $\frac{Q}{\lambda}$, and $\frac{\Delta Q}{\lambda}$, for that compass, have been computed by the method of least squares.

The value of A_1 thus found we will designate as the "true A_1" in order to distinguish it from the "apparent A_1" obtained directly from the corrected observed values of the deviations. The value of the true A_1 depends only upon the value of the constants a, b, d, and e, in equations (1) and (2); but the apparent A_1 is made up of the true A_1, together with any errors that may exist in the placing of the lubber line of the compass, or in the determination of the true magnetic bearing of the distant object used as an azimuth mark in swinging the ship.

The equations of condition, formed in the manner just explained; the normal equations derived from them by the method of least squares; and the resulting values of the constants, A_1, $\frac{c}{\lambda}$, $\frac{P}{\lambda}$, $\frac{\Delta P}{\lambda}$, $\frac{f}{\lambda}$, $\frac{Q}{\lambda}$, and $\frac{\Delta Q}{\lambda}$, for each compass are as follows: the values of B_1 and C_1 being expressed in parts of radius.

ADMIRALTY STANDARD COMPASS.

Equations of Condition.

Absolute Terms.	A_1	$\frac{c}{\lambda}$	$\frac{P}{\lambda}$	$\frac{\Delta P}{\lambda}$	$\frac{f}{\lambda}$	$\frac{Q}{\lambda}$	$\frac{\Delta Q}{\lambda}$
0 = — 0.158	— 0.010	+ 2.694	+ 0.212				
0 = — 0.100	+ 0.010	+ 1.176	+ 0.148	+ 2.520			
0 = — 0.064	0.000	+ 0.077	+ 0.161	+ 9.516			
0 = — 0.054	+ 0.002	— 0.603	+ 0.166	+ 13.933			
0 = — 0.023	— 0.012	— 1.426	+ 0.164	+ 16.522			
0 = — 0.023	— 0.002	— 0.710	+ 0.158	+ 24.375			
0 = — 0.041	— 0.001	— 0.113	+ 0.143	+ 25.608			
0 = — 0.053	+ 0.001	+ 0.623	+ 0.132	+ 26.316			
0 = — 0.048	+ 0.002	+ 0.836	+ 0.129	+ 27.440			
0 = — 0.085	— 0.022	+ 1.910	+ 0.177	+ 41.519			
0 = + 0.010	— 0.158				+ 2.694	+ 0.212	
0 = — 0.010	— 0.100				+ 1.176	+ 0.148	+ 2.520
0 = 0.000	— 0.064				+ 0.077	+ 0.161	+ 9.516
0 = — 0.002	— 0.054				— 0.603	+ 0.166	+ 13.933
0 = + 0.012	— 0.023				— 1.426	+ 0.164	+ 16.522
0 = + 0.002	— 0.023				— 0.710	+ 0 158	+ 24.375
0 = + 0.001	— 0.041				— 0.113	+ 0.143	+ 25.608
0 = — 0.001	— 0.053				+ 0.623	+ 0.132	+ 26.316
0 = — 0.002	— 0.048				+ 0.836	+ 0.129	+ 27.440
0 = + 0.022	— 0.085				+ 1.910	+ 0.177	+ 41.519

Normal Equations.

0 = 0.000	+ 0.058						
0 = — 0.699	— 0.037	+ 16.294					
0 = — 0.109	— 0.006	+ 0.826	+ 0.258				
0 = — 9.869	— 1.057	+ 70.177	+ 28.825	+ 4983.3			
0 = + 0.037	— 0.699				+ 16.294		
0 = + 0.006	— 0.109				+ 0.826	+ 0.258	
0 = + 1.057	— 9.869				+ 70.177	+ 28.825	+ 4983.3

Hence

$$A_1 = 0.000 \qquad \frac{P}{\lambda} = +0.460 \qquad \frac{f}{\lambda} = -0.0016$$

$$\frac{c}{\lambda} = +0.0240 \qquad \frac{\Delta P}{\lambda} = +0.00102 \qquad \frac{Q}{\lambda} = +0.006$$

$$\frac{\Delta Q}{\lambda} = -0.00023$$

AFTER BINNACLE COMPASS.

Equations of Condition.

Absolute Terms.	A_1	$\frac{c}{\lambda}$	$\frac{P}{\lambda}$	$\frac{\Delta P}{\lambda}$	$\frac{f}{\lambda}$	$\frac{Q}{\lambda}$	$\frac{\Delta Q}{\lambda}$
0 = — 0.127	— 0.022	+ 2.694	+ 0.212				
0 = — 0.100	— 0.002	+ 0.077	+ 0.161	+ 9.516			
0 = — 0.096	+ 0.012	— 0.603	+ 0.166	+ 13.933			
0 = — 0.100	— 0.004	— 1.426	+ 0.164	+ 16.522			
0 = — 0.070	+ 0.002	— 0.710	+ 0.158	+ 24.375			
0 = — 0.073	— 0.001	— 0.113	+ 0.143	+ 25.608			
0 = — 0.058	+ 0.006	+ 0.623	+ 0.132	+ 26.316			
0 = — 0.054	— 0.005	+ 0.836	+ 0.129	+ 27.440			
0 = — 0.061	— 0.039	+ 1.910	+ 0.177	+ 41.519			
0 = + 0.022	— 0.127				+ 2.694	+ 0.212	
0 = + 0.002	— 0.100				+ 0.077	+ 0.161	+ 9.516
0 = — 0.012	— 0.096				— 0.603	+ 0.166	+ 13.933
0 = + 0.004	— 0.100				— 1.426	+ 0.164	+ 16.522
0 = — 0.002	— 0.070				— 0.710	+ 0 158	+ 24.375
0 = + 0.001	— 0.073				— 0.113	+ 0.143	+ 25 608
0 = — 0.006	— 0.058				+ 0.623	+ 0.132	+ 26.316
0 = + 0.005	— 0.054				+ 0.836	+ 0.129	+ 27.440
0 = + 0.039	— 0.061				+ 1.910	+ 0.177	+ 41.519

AFTER BINNACLE COMPASS.

Normal Equations.

Absolute Terms.	A_1	$\frac{c}{\lambda}$	$\frac{P}{\lambda}$	$\frac{\Delta P}{\lambda}$	$\frac{f}{\lambda}$	$\frac{Q}{\lambda}$	$\frac{\Delta Q}{\lambda}$
0 = 0.000	+ 0.068						
0 = − 0.288	− 0.136	+ 14.910					
0 = − 0.122	− 0.010	+ 0.652	+ 0.236				
0 = − 13.033	− 1.478	+ 67.212	+ 28.451	+ 4977.0			
0 = + 0.136	− 0.288				+ 14.910		
0 = + 0.010	− 0.122				+ 0.652	+ 0.236	
0 = + 1.478	− 13.033				+ 67.212	+ 28.451	+ 4977.0

Hence

$$A_1 = -0.010 \qquad \frac{P}{\lambda} = +0.664 \qquad \frac{f}{\lambda} = -0.0084$$

$$\frac{c}{\lambda} = -0.0048 \qquad \frac{\Delta P}{\lambda} = -0.00112 \qquad \frac{Q}{\lambda} = +0.002$$

$$\frac{\Delta Q}{\lambda} = -0.00022$$

AFTER RITCHIE COMPASS.

Equations of Condition.

Absolute Terms.	A_1	$\frac{c}{\lambda}$	$\frac{P}{\lambda}$	$\frac{\Delta P}{\lambda}$	$\frac{f}{\lambda}$	$\frac{Q}{\lambda}$	$\frac{\Delta Q}{\lambda}$
0 = − 0.200	− 0.030	+ 2.694	+ 0.212				
0 = − 0.148	+ 0.012	+ 1.176	+ 0.148	+ 2.520			
0 = − 0.121	− 0.017	+ 0.077	+ 0.161	+ 9.516			
0 = − 0.071	− 0.060	− 1.426	+ 0.164	+ 16.522			
0 = − 0.067	+ 0.004	− 0.710	+ 0.158	+ 24.375			
0 = − 0.102	+ 0.004	− 0.113	+ 0.143	+ 25.608			
0 = − 0.071	− 0.003	+ 0.623	+ 0.132	+ 26.316			
0 = − 0.078	+ 0.021	+ 0.836	+ 0.129	+ 27.440			
0 = − 0.118	− 0.027	+ 1.910	+ 0.177	+ 41.519			
0 = + 0.030	− 0.200				+ 2.694	+ 0.212	
0 = − 0.012	− 0.148				+ 1.176	+ 0.148	+ 2.520
0 = + 0.017	− 0.121				+ 0.077	+ 0.161	+ 9.516
0 = + 0.060	− 0.071				− 1.426	+ 0.164	+ 16.522
0 = − 0.004	− 0.067				− 0.710	+ 0.158	+ 24.375
0 = − 0.004	− 0.102				− 0.113	+ 0.143	+ 25.608
0 = + 0.003	− 0.071				+ 0.623	+ 0.132	+ 26.316
0 = − 0.021	− 0.078				+ 0.836	+ 0.129	+ 27.440
0 = + 0.027	− 0.118				+ 1.910	+ 0.177	+ 41.519

Normal Equations.

0 = 0.000	+ 0.127						
0 = − 0.896	− 0.022	+ 15.930					
0 = − 0.161	− 0.018	+ 0.926	+ 0.231				
0 = − 15.837	− 1.525	+ 78.581	+ 26.514	+ 4789.2			
0 = + 0.022	− 0.896				+ 15.930		
0 = + 0.018	− 0.161				+ 0.926	+ 0.231	
0 = + 1.525	− 15.837				+ 78.581	+ 26.514	+ 4789.2

Hence

$$A_1 = 0.000 \qquad \frac{P}{\lambda} = +0.766 \qquad \frac{f}{\lambda} = +0.0052$$

$$\frac{c}{\lambda} = +0.0178 \qquad \frac{\Delta P}{\lambda} = -0.00122 \qquad \frac{Q}{\lambda} = -0.149$$

$$\frac{\Delta Q}{\lambda} = +0.00042$$

AFTER AZIMUTH COMPASS.

Equations of Condition.

Absolute Terms.	A_1	$\frac{c}{\lambda}$	$\frac{P}{\lambda}$	$\frac{\Delta P}{\lambda}$	$\frac{f}{\lambda}$	$\frac{Q}{\lambda}$	$\frac{\Delta Q}{\lambda}$
o = + 0.085	— 0.003	+ 2.694	+ 0.212				
o = + 0.053	+ 0.023	+ 1.176	+ 0.148	+ 2.520			
o = + 0.078	— 0.006	+ 0.077	+ 0.161	+ 9.516			
o = + 0.052	— 0.014	— 1.426	+ 0.164	+ 16.522			
o = + 0.086	+ c.006	— 0.710	+ 0.158	+ 24.375			
o = + 0.035	— 0.014	— 0.113	+ 0.143	+ 25.608			
o = + 0.066	+ 0.030	+ 0.623	+ 0.132	+ 26.316			
o = + 0.060	0.000	+ 0.836	+ 0.129	+ 27.440			
o = + 0.003	+ 0.085				+ 2.694	+ 0.212	
o = — 0.023	+ 0.053				+ 1.176	+ 0.148	+ 2.520
o = + 0.006	+ 0.078				+ 0.077	+ 0.161	+ 9.516
o = + 0.014	+ 0.052				— 1.426	+ 0.164	+ 16.522
o = — 0.006	+ 0.086				— 0.710	+ 0.158	+ 24.375
o = + 0.014	+ 0.035				— 0.113	+ 0.143	+ 25.608
o = — 0.030	+ 0.066				+ 0.623	+ 0.132	+ 26.316
o = 0.000	+ 0.060				+ 0.836	+ 0.129	+ 27.440

Normal Equations.

o = 0.000	+ 0.037						
o = + 0.250	+ 0.055	+ 12.282					
o = + 0.082	+ 0.003	+ 0.588	+ 0.200				
o = + 8.100	+ 0.352	— 0.725	+ 19.147	+ 3065.3			
o = — 0.055	+ 0.250				+ 12.282		
o = — 0.003	+ 0.082				+ 0.588	+ 0.200	
o = — 0.352	+ 8.100				— 0.725	+ 19.147	+ 3065.3

Hence

$A_1 =$ 0.000 $\frac{P}{\lambda} = - 0.373$ $\frac{f}{\lambda} = + 0.0066$

$\frac{c}{\lambda} = - 0.0026$ $\frac{\Delta P}{\lambda} = - 0.00032$ $\frac{Q}{\lambda} = - 0.044$

$\frac{\Delta Q}{\lambda} = + 0.00039$

FORWARD ALIDADE COMPASS.

Equations of Condition.

Absolute Terms.	A_1	$\frac{c}{\lambda}$	$\frac{P}{\lambda}$	$\frac{\Delta P}{\lambda}$	$\frac{f}{\lambda}$	$\frac{Q}{\lambda}$	$\frac{\Delta Q}{\lambda}$
o = + 0.043	— 0.033	+ 2.694	+ 0.212				
o = + 0.010	— 0.013	+ 1.176	+ 0.148	+ 2.520			
o = + 0.002	— 0.010	+ 0.077	+ 0.161	+ 9.516			
o = — 0.017	— 0.019	— 0.603	+ 0.166	+ 13.933			
o = — 0.017	— 0.033	— 1.426	+ 0.164	+ 16.522			
o = — 0.009	— 0.016	— 0.710	+ 0.158	+ 24.375			
o = — 0.012	— 0.028	— 0.113	+ 0.143	+ 25.608			
o = 0.000	— 0.024	+ 0.623	+ 0.132	+ 26.316			
o = + 0.026	— 0.010	+ 0.836	+ 0.129	+ 27.440			
o = + 0.033	— 0.042	+ 1.910	+ 0.177	+ 41.519			
o = + 0.033	+ 0.043				+ 2.694	+ 0.212	
o = + 0.013	+ 0.010				+ 1.176	+ 0.148	+ 2.520
o = + 0.010	+ 0.002				+ 0.077	+ 0.161	+ 9.516
o = + 0.019	— 0.017				— 0.603	+ 0.166	+ 13.933
o = + 0.033	— 0.017				— 1.426	+ 0.164	+ 16.522
o = + 0.016	— 0.009				— 0.710	+ 0.158	+ 24.375
o = + 0.028	— 0.012				— 0.113	+ 0.143	+ 25.608
o = + 0.024	0.000				+ 0.623	+ 0.132	+ 26.316
o = + 0.010	+ 0.026				+ 0.836	+ 0.129	+ 27.440
o = + 0.042	+ 0.033				+ 1.910	+ 0.177	+ 41.519

FORWARD ALIDADE COMPASS.

Normal Equations.

Absolute Terms.	A_1	$\frac{c}{\lambda}$	$\frac{P}{\lambda}$	$\frac{\Delta P}{\lambda}$	$\frac{f}{\lambda}$	$\frac{Q}{\lambda}$	$\frac{\Delta Q}{\lambda}$
0 = 0.000	+ 0.011						
0 = + 0.255	— 0.135	+ 16.294					
0 = + 0.012	— 0.037	+ 0.826	+ 0.258				
0 = + 1.089	— 4.686	+ 70.177	+ 28.825	+ 4983.3			
0 = + 0.135	+ 0.255				+ 16.294		
0 = + 0.037	+ 0.012				+ 0.826	+ 0.258	
0 = + 4.686	+ 1.089				+ 70.177	+ 28.825	+ 4983.3

Hence

$$A_1 = -0.025 \qquad \frac{P}{\lambda} = +0.014 \qquad \frac{f}{\lambda} = -0.0012$$

$$\frac{c}{\lambda} = -0.0162 \qquad \frac{\Delta P}{\lambda} = -0.00010 \qquad \frac{Q}{\lambda} = -0.106$$

$$\frac{\Delta Q}{\lambda} = -0.00031$$

FORWARD BINNACLE COMPASS.

Equations of Condition.

Absolute Terms.	A	$\frac{c}{\lambda}$	$\frac{P}{\lambda}$	$\frac{\Delta P}{\lambda}$	$\frac{f}{\lambda}$	$\frac{Q}{\lambda}$	$\frac{\Delta Q}{\lambda}$
0 = + 0.099	— 0.045	+ 2.694	+ 0.212				
0 = + 0.034	— 0.004	+ 1.176	+ 0.148	+ 2.520			
0 = — 0.008	— 0.010	+ 0.077	+ 0.161	+ 9.516			
0 = — 0.051	— 0.012	— 0.603	+ 0.166	+ 13.933			
0 = — 0.092	— 0.038	— 1.426	+ 0.164	+ 16.522			
0 = — 0.031	— 0.013	— 0.710	+ 0.158	+ 24.375			
0 = — 0.020	— 0.037	— 0.113	+ 0.143	+ 25.608			
0 = + 0.018	— 0.027	+ 0.623	+ 0.132	+ 26.316			
0 = + 0.036	— 0.029	+ 0 836	+ 0.129	+ 27.440			
0 = + 0.082	— 0.062	+ 1.910	+ 0.177	+ 41.519			
0 = + 0.045	+ 0.099				+ 2.694	+ 0.212	
0 = + 0.004	+ 0.034				+ 1.176	+ 0.148	+ 2.520
0 = + 0.010	— 0.008				+ 0.077	+ 0.161	+ 9.516
0 = + 0.012	— 0.051				— 0.603	+ 0.166	+ 13.933
0 = + 0.038	— 0.092				— 1.426	+ 0.164	+ 16.522
0 = + 0.013	— 0.031				— 0.710	+ 0.158	+ 24.375
0 = + 0.037	— 0.020				— 0.113	+ 0.143	+ 25.608
0 = + 0.027	+ 0.018				+ 0.623	+ 0.132	+ 26.316
0 = + 0.029	+ 0.036				+ 0.836	+ 0.129	+ 27.440
0 = + 0.062	+ 0.082				+ 1.910	+ 0.177	+ 41.519

Normal Equations.

0 = 0.000	+ 0.043						
0 = + 0.690	— 0.211	+ 16.294					
0 = + 0.015	— 0.046	+ 0.826	+ 0.258				
0 = + 1.334	— 6.283	+ 70.177	+ 28.825	+ 4983.3			
0 = + 0.211	+ 0.690				+ 16.294		
0 = + 0.046	+ 0.015				+ 0.826	+ 0.258	
0 = + 6.283	+ 1.334				+ 70.177	+ 28.825	+ 4983.3

Hence

$$A_1 = 0.000 \qquad \frac{P}{\lambda} = +0.140 \qquad \frac{f}{\lambda} = -0.0059$$

$$\frac{c}{\lambda} = -0.0477 \qquad \frac{\Delta P}{\lambda} = -0.00041 \qquad \frac{Q}{\lambda} = -0.075$$

$$\frac{\Delta Q}{\lambda} = -0.00074$$

FORWARD RITCHIE COMPASS.

Equations of Condition.

Absolute Terms.	A_1	$\frac{c}{\lambda}$	$\frac{P}{\lambda}$	$\frac{\Delta P}{\lambda}$	$\frac{f}{\lambda}$	$\frac{Q}{\lambda}$	$\frac{\Delta Q}{\lambda}$
o = — 0.023	— 0.063	+ 2.694	+ 0.212				
o = — 0.036	— 0.022	+ 1.176	+ 0.148	+ 2.520			
o = — o 061	— 0.027	+ 0.077	+ 0.161	+ 9.516			
o = — 0.066	0.000	— 0.603	+ 0.166	+ 13.933			
o = — 0.067	— 0.048	— 1.426	+ 0.164	+ 16.522			
o = — 0.023	— 0.026	— 0.710	+ 0.158	+ 24.375			
o = — 0.033	— 0.034	— 0.113	+ 0.143	+ 25.608			
o = — 0.004	— 0.033	+ 0.623	+ 0.132	+ 26.316			
o = — 0.011	— 0.038	+ 0.836	+ 0.129	+ 27.440			
o = + 0.005	— 0.117	+ 1.910	+ 0.177	+ 41.519			
o = + 0.063	— 0.023				+ 2.694	+ 0.212	
o = + 0.022	— 0.036				+ 1.176	+ 0.148	+ 2.520
o = + 0.027	— 0.061				+ 0.077	+ 0.161	+ 9.516
o = 0.000	— 0.066				— 0.603	+ 0.166	+ 13.933
o = + 0.048	— 0.067				— 1.426	+ 0.164	+ 16.522
o = + 0.026	— 0.023				— 0.710	+ 0.158	+ 24.375
o = + 0.034	— 0.033				— 0.113	+ 0.143	+ 25.608
o = + 0.033	— 0.004				+ 0.623	+ 0.132	+ 26.316
o = + 0.038	— 0.011				+ 0.836	+ 0.129	+ 27.440
o = + 0.117	+ 0.005				+ 1.910	+ 0.177	+ 41.519

Normal Equations.

Absolute Terms.	A_1	$\frac{c}{\lambda}$	$\frac{P}{\lambda}$	$\frac{\Delta P}{\lambda}$	$\frac{f}{\lambda}$	$\frac{Q}{\lambda}$	$\frac{\Delta Q}{\lambda}$
o = 0.000	+ 0.042						
o = + 0.044	— 0.384	+ 16.294					
o = — 0.052	— 0.068	+ 0.826	+ 0.258				
o = — 4.306	— 9.388	+ 70.177	+ 28.825	+ 4983.3			
o = + 0.384	+ 0.044				+ 16.294		
o = + 0.068	— 0.052				+ 0.826	+ 0.258	
o = + 9.388	— 4.306				+ 70.177	+28.825	+ 4983.3

Hence

$$A_1 = \quad 0.000 \qquad \frac{P}{\lambda} = +0.367 \qquad \frac{f}{\lambda} = -0.0141$$

$$\frac{c}{\lambda} = -0.0169 \qquad \frac{\Delta P}{\lambda} = -0.00102 \qquad \frac{Q}{\lambda} = -0.083$$

$$\frac{\Delta Q}{\lambda} = -0.00120$$

The value of the true A_1 having thus become known for each compass, the values of the coefficients 𝔅, ℭ, 𝔇, and 𝔈, for each compass, at each station, were next computed by means of the formulæ (16). The results, expressed in parts of radius, are as follows:

COEFFICIENTS OF THE DEVIATIONS OF THE ADMIRALTY STANDARD COMPASS.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865	0.000	+ 0.158	— 0.010	+ 0.021	— 0.004
St. Thomas	November 18, 1865	0.000	+ 0.100	+ 0.010	+ 0.006	— 0.013
Bahia	December 30, 1865	0.000	+ 0.064	0.000	+ 0.016	0.000
Monte Video	January 24, 1866	0.000	+ 0.054	+ 0.002	+ 0.024	+ 0.004
Sandy Point	February 10, 1866	0.000	+ 0.023	— 0.012	+ 0.016	0.000
Valparaiso	April 4, 1866	0.000	+ 0.023	— 0.002	+ 0.016	— 0.003
Callao	April 29, 1866	0.000	+ 0.041	0.000	+ 0.016	+ 0.002
Panama	May 20, 1866	0.000	+ 0.053	+ 0.001	+ 0.017	+ 0.002
Acapulco	June 1, 1866	0.000	+ 0.048	+ 0.002	+ 0.018	+ 0.002
San Francisco	June 23, 1866	0.000	+ 0.085	— 0.022	+ 0.018	0.000
Means					+ 0.017	— 0.001

COEFFICIENTS OF THE DEVIATIONS OF THE AFTER BINNACLE.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865	— 0.010	+ 0.127	— 0.023	+ 0.037	— 0.001
St. Thomas	November 18, 1865	— 0.010	......	......	......	......
Bahia	December 30, 1865	— 0.010	+ 0.100	— 0.003	+ 0.034	+ 0.002
Monte Video	January 24, 1866	— 0.010	+ 0.096	+ 0.011	+ 0.039	— 0.012
Sandy Point	February 10, 1866	— 0.010	+ 0.100	— 0.005	+ 0.040	— 0.001
Valparaiso	April 4, 1866	— 0.010	+ 0.070	+ 0.002	+ 0.038	0.000
Callao	April 29, 1866	— 0.010	+ 0.073	— 0.002	+ 0.040	+ 0.002
Panama.	May 20, 1866	— 0.010	+ 0.058	+ 0.006	+ 0.046	— 0.005
Acapulco	June 1, 1866	— 0.010	+ 0.054	— 0.006	+ 0.041	— 0.006
San Francisco. . . .	June 23, 1866	— 0.010	+ 0.060	— 0.040	+ 0.032	0.000
Means					+ 0.038	— 0.002

COEFFICIENTS OF THE DEVIATIONS OF THE AFTER RITCHIE COMPASS.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865	0.000	+ 0.200	— 0.030	+ 0.024	— 0.022
St. Thomas	November 18, 1865	0.000	+ 0.148	+ 0.012	+ 0.044	— 0.009
Bahia	December 30, 1865	0.000	+ 0.121	— 0.017	+ 0.042	+ 0.002
Monte Video	January 24, 1866	......	......	......	......	......
Sandy Point	February 10, 1866	0.000	+ 0.071	— 0.060	+ 0.022	+ 0.013
Valparaiso	April 4, 1866	0.000	+ 0.067	+ 0.004	+ 0.043	+ 0.002
Callao	April 29, 1866	0.000	+ 0.102	+ 0.004	+ 0.032	+ 0.016
Panama.	May 20, 1866	0.000	+ 0.071	— 0.003	+ 0.025	— 0.027
Acapulco	June 1, 1866	0.000	+ 0.078	+ 0.021	+ 0.024	+ 0.015
San Francisco. . . .	June 23, 1866	0.000	+ 0.118	— 0.027	+ 0.050	+ 0.003
Means					+ 0.034	— 0.001

COEFFICIENTS OF THE DEVIATIONS OF THE AFTER AZIMUTH COMPASS.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865	0.000	— 0.085	— 0.003	+ 0.101	+ 0.005
St. Thomas	November 18, 1865	0.000	— 0.053	+ 0.023	+ 0.120	+ 0.002
Bahia	December 30, 1865	0.000	— 0.078	— 0.006	+ 0.132	— 0.019
Monte Video	January 24, 1866	......	......	......	......	......
Sandy Point	February 10, 1866	0.000	— 0.052	— 0.014	+ 0.126	— 0.007
Valparaiso	April 4, 1866	0.000	— 0.086	+ 0.006	+ 0.106	+ 0.010
Callao	April 29, 1866	0.000	— 0.035	— 0.014	+ 0.090	+ 0.011
Panama.	May 20, 1866	0.000	— 0.066	+ 0.030	+ 0.113	— 0.012
Acapulco	June 1, 1866	0.000	— 0.060	0.000	+ 0.105	+ 0.007
San Francisco. . . .	June 23, 1866	......	......	......	......	......
Means					+ 0.112	0.000

COEFFICIENTS OF THE DEVIATIONS OF THE FORWARD ALIDADE COMPASS.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865	— 0.025	— 0.044	— 0.032	+ 0.019	+ 0.001
St. Thomas	November 18, 1865	— 0.025	— 0.010	— 0.013	+ 0.022	+ 0.006
Bahia	December 30, 1865	— 0.025	— 0.002	— 0.010	+ 0.022	+ 0.004
Monte Video	January 24, 1866	— 0.025	+ 0.016	— 0.019	+ 0.024	— 0.004
Sandy Point	February 10, 1866	— 0.025	+ 0.017	— 0.034	+ 0.031	— 0.007
Valparaiso	April 4, 1866	— 0.025	+ 0.008	— 0.016	+ 0.019	— 0.002
Callao	April 29, 1866	— 0.025	+ 0.012	— 0.029	+ 0.026	— 0.003
Panama.	May 20, 1866	— 0.025	— 0.001	— 0.024	+ 0.023	— 0.003
Acapulco	June 1, 1866	— 0.025	— 0.026	— 0.009	+ 0.033	+ 0.002
San Francisco. . . .	June 23, 1866	— 0.025	— 0.034	— 0.041	+ 0.017	+ 0.007
Means					+ 0.024	0.000

COEFFICIENTS OF THE DEVIATIONS OF THE FORWARD BINNACLE COMPASS.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865	0.000	— 0.099	— 0.045	+ 0.044	+ 0.007
St. Thomas	November 18, 1865	0.000	— 0.034	— 0.004	+ 0.035	— 0.002
Bahia	December 30, 1865	0.000	+ 0.008	— 0.010	+ 0.037	— 0.003
Monte Video	January 24, 1866	0.000	+ 0.051	— 0.012	+ 0.032	— 0.001
Sandy Point	February 10, 1866	0.000	+ 0.092	— 0.038	+ 0.039	— 0.004
Valparaiso	April 4, 1866	0.000	+ 0.031	— 0.013	+ 0.028	— 0.003
Callao	April 29, 1866	0.000	+ 0.020	— 0.037	+ 0.037	+ 0.006
Panama.	May 20, 1866	0.000	— 0.018	— 0.027	+ 0.037	— 0.006
Acapulco	June 1, 1866	0.000	— 0.036	— 0.029	+ 0.046	+ 0.004
San Francisco	June 23, 1866	0.000	— 0.082	— 0.062	+ 0.035	+ 0.014
Means					+ 0.037	+ 0.001

COEFFICIENTS OF THE DEVIATIONS OF THE FORWARD RITCHIE COMPASS.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865	0.000	+ 0.023	— 0.063	+ 0.038	+ 0.006
St. Thomas	November 18, 1865	0.000	+ 0.036	— 0.022	+ 0.057	— 0.008
Bahia	December 30, 1865	0.000	+ 0.061	— 0.027	+ 0.047	— 0.002
Monte Video	January 24, 1866	0.000	+ 0.066	0.000	+ 0.040	— 0.008
Sandy Point	February 10, 1866	0.000	+ 0.067	— 0.048	+ 0.039	— 0.006
Valparaiso	April 4, 1866	0.000	+ 0.023	— 0.026	+ 0.037	+ 0.008
Callao	April 29, 1866	0.000	+ 0.033	— 0.034	+ 0.044	+ 0.002
Panama.	May 20, 1866	0.000	+ 0.004	— 0.033	+ 0.038	— 0.004
Acapulco	June 1, 1866	0.000	+ 0.011	— 0.038	+ 0.041	+ 0.007
San Francisco. . . .	June 23, 1866	0.000	— 0.005	— 0.117	+ 0.025	— 0.009
Means					+ 0.041	— 0.001

The values of the coefficients 𝔇 and 𝔈 for any compass should be constant. Therefore the mean of all the observed values has been assumed as the truth, and is given on the line marked "means" in the case of each compass.

The constants thus far determined furnish the data with which to compute the values of the coefficients 𝔄, 𝔅, ℭ, 𝔇, 𝔈, in any part of the world, for any of the compasses under discussion. For convenience of reference these constants are collected in the following table:

Compass.	A_1=𝔄	$\frac{c}{\lambda}$	$\frac{P}{\lambda}$	$\frac{P}{\lambda}$	$\frac{f}{\lambda}$	$\frac{Q}{\lambda}$	$\frac{\Delta Q}{\lambda}$	𝔇	𝔈
Admiralty Standard .	0.000	+ 0.0240	+ 0.460	— 0.00102	— 0.0016	+ 0.006	— 0.00023	+ 0.017	— 0.001
After Binnacle . . .	— 0.010	— 0.0048	+ 0.664	— 0.00112	— 0.0084	+ 0.002	— 0.00022	+ 0.038	— 0.002
After Ritchie . . .	0.000	+ 0.0178	+ 0.766	— 0.00122	+ 0.0052	— 0.149	+ 0.00042	+ 0.034	— 0.001
After Azimuth . . .	0.000	— 0.0026	— 0.373	— 0.00032	+ 0.0066	— 0.044	+ 0.00039	+ 0.112	0.000
Forward Alidade . .	— 0.025	— 0.0162	+ 0.014	— 0.00010	— 0.0012	— 0.106	— 0.00031	+ 0.024	0.000
Forward Binnacle . .	0.000	— 0.0477	+ 0.140	— 0.00041	— 0.0059	— 0.075	— 0.00074	+ 0.037	+ 0.001
Forward Ritchie . .	0.000	— 0.0169	+ 0.367	— 0.00102	— 0.0141	— 0.083	— 0.00120	+ 0.041	— 0.001

The values of the coefficients 𝔄, 𝔅, ℭ, 𝔇, 𝔈, for each compass at each station, were next computed from the quantities given in this table, in the following manner. The coefficients 𝔄, 𝔇, and 𝔈 are constant for each compass, and were taken directly from the table; while the coefficients $\mathfrak{B}$ and $\mathfrak{C}$ were obtained by means of the formulæ

$$\mathfrak{B}=\frac{c}{\lambda}\tan\theta+\frac{P}{\lambda}\times\frac{1}{H}+\frac{\Delta P}{\lambda}\times\frac{t}{H}$$

$$\mathfrak{C}=\frac{f}{\lambda}\tan\theta+\frac{Q}{\lambda}\times\frac{1}{H}+\frac{\Delta Q}{\lambda}\times\frac{t}{H}$$

where θ is the true magnetic dip; H the earth's magnetic horizontal force, expressed in English units, namely, in feet, grains, and seconds; and t the time in days, counted from November 1st, 1865. The results, expressed in parts of radius, are as follows:

COEFFICIENTS OF THE DEVIATIONS OF THE ADMIRALTY STANDARD COMPASS.

STATION.	DATE.	$\mathfrak{A}$	$\mathfrak{B}$	$\mathfrak{C}$	$\mathfrak{D}$	$\mathfrak{E}$
Hampton Roads	November 1, 1865	0.000	+ 0.162	— 0.003	+ 0.017	— 0.001
St. Thomas	November 18, 1865	0.000	+ 0.094	— 0.002	+ 0.017	— 0.001
Bahia	December 30, 1865	0.000	+ 0.066	— 0.001	+ 0.017	— 0.001
Monte Video	January 24, 1866	0.000	+ 0.048	— 0.001	+ 0.017	— 0.001
Sandy Point	February 10, 1866	0.000	+ 0.024	0.000	+ 0.017	— 0.001
Valparaiso	April 4, 1866	0.000	+ 0.031	— 0.003	+ 0.017	— 0.001
Callao	April 29, 1866	0.000	+ 0.037	— 0.005	+ 0.017	— 0.001
Panama	May 20, 1866	0.000	+ 0.049	— 0.006	+ 0.017	— 0.001
Acapulco	June 1, 1866	0.000	+ 0.052	— 0.007	+ 0.017	— 0.001
San Francisco	June 23, 1866	0.000	+ 0.085	— 0.011	+ 0.017	— 0.001

COEFFICIENTS OF THE DEVIATIONS OF THE AFTER BINNACLE COMPASS.

STATION.	DATE.	$\mathfrak{A}$	$\mathfrak{B}$	$\mathfrak{C}$	$\mathfrak{D}$	$\mathfrak{E}$
Hampton Roads	November 1, 1865	— 0.010	+ 0.128	— 0.022	+ 0.038	— 0.002
St. Thomas	November 18, 1865	......	......	......	......	......
Bahia	December 30, 1865	— 0.010	+ 0.096	— 0.002	+ 0.038	— 0.002
Monte Video	January 24, 1866	— 0.010	+ 0.098	+ 0.002	+ 0.038	— 0.002
Sandy Point	February 10, 1866	— 0.010	+ 0.097	+ 0.009	+ 0.038	— 0.002
Valparaiso	April 4, 1866	— 0.010	+ 0.081	+ 0.001	+ 0.038	— 0.002
Callao	April 29, 1866	— 0.010	+ 0.067	— 0.004	+ 0.038	— 0.002
Panama	May 20, 1866	— 0.010	+ 0.055	— 0.011	+ 0.038	— 0.002
Acapulco	June 1, 1866	— 0.010	+ 0.051	— 0.013	+ 0.038	— 0.002
San Francisco	June 23, 1866	— 0.010	+ 0.062	— 0.025	+ 0.038	— 0.002

COEFFICIENTS OF THE DEVIATIONS OF THE AFTER RITCHIE COMPASS.

STATION.	DATE.	$\mathfrak{A}$	$\mathfrak{B}$	$\mathfrak{C}$	$\mathfrak{D}$	$\mathfrak{E}$
Hampton Roads	November 1, 1865	0.000	+ 0.211	— 0.018	+ 0.034	— 0.001
St. Thomas	November 18, 1865	0.000	+ 0.131	— 0.015	+ 0.034	— 0.001
Bahia	December 30, 1865	0.000	+ 0.113	— 0.020	+ 0.034	— 0.001
Monte Video	January 24, 1866	......	......	......	......	......
Sandy Point	February 10, 1866	0.000	+ 0.080	— 0.025	+ 0.034	— 0.001
Valparaiso	April 4, 1866	0.000	+ 0.079	— 0.017	+ 0.034	— 0.001
Callao	April 29, 1866	0.000	+ 0.076	— 0.011	+ 0.034	— 0.001
Panama	May 20, 1866	0.000	+ 0.080	— 0.005	+ 0.034	— 0.001
Acapulco	June 1, 1866	0.000	+ 0.080	— 0.003	+ 0.034	— 0.001
San Francisco	June 23, 1866	0.000	+ 0.119	+ 0.001	+ 0.034	— 0.001

Coefficients of the Deviations of the After Azimuth Compass.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865	0.000	— 0.086	+ 0.008	+ 0.112	0.000
St. Thomas	November 18, 1865	0.000	— 0.059	+ 0.002	+ 0.112	0.000
Bahia	December 30, 1865	0.000	— 0.063	— 0.003	+ 0.112	0.000
Monte Video	January 24, 1866	......	......	......	......	......
Sandy Point	February 10, 1866	0.000	— 0.062	— 0.010	+ 0.112	0.000
Valparaiso	April 4, 1866	0.000	— 0.065	— 0.002	+ 0.112	0.000
Callao	April 29, 1866	0.000	— 0.061	+ 0.003	+ 0.112	0.000
Panama.	May 20, 1866	0.000	— 0.059	+ 0.009	+ 0.112	0.000
Acapulco	June 1, 1866	0.000	— 0.059	+ 0.011	+ 0.112	0.000
San Francisco. . . .	June 23, 1866	......	......	......	......	......

Coefficients of the Deviations of the Forward Alidade Compass.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865	— 0.025	— 0.041	— 0.026	+ 0.024	0.000
St. Thomas	November 18, 1865	— 0.025	— 0.017	— 0.018	+ 0.024	0.000
Bahia	December 30, 1865	— 0.025	0.000	— 0.020	+ 0.024	0.000
Monte Video	January 24, 1866	— 0.025	+ 0.011	— 0.021	+ 0.024	0.000
Sandy Point	February 10, 1866	— 0.025	+ 0.024	— 0.021	+ 0.024	0.000
Valparaiso	April 4, 1866	— 0.025	+ 0.011	— 0.023	+ 0.024	0.000
Callao	April 29, 1866	— 0.025	+ 0.001	— 0.023	+ 0.024	0.000
Panama.	May 20, 1866	— 0.025	— 0.011	— 0.023	+ 0.024	0.000
Acapulco	June 1, 1866	— 0.025	— 0.014	— 0.023	+ 0.024	0.000
San Francisco. . . .	June 23, 1866	— 0.025	— 0.032	— 0.034	+ 0.024	0.000

Coefficients of the Deviations of the Forward Binnacle Compass.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865	0.000	— 0.099	— 0.032	+ 0.037	+ 0.001
St. Thomas	November 18, 1865	0.000	— 0.036	— 0.020	+ 0.037	+ 0.001
Bahia	December 30, 1865	0.000	+ 0.015	— 0.020	+ 0.037	+ 0.001
Monte Video	January 24, 1866	0.000	+ 0.046	— 0.019	+ 0.037	+ 0.001
Sandy Point	February 10, 1866	0.000	+ 0.084	— 0.016	+ 0.037	+ 0.001
Valparaiso	April 4, 1866	0.000	+ 0.046	— 0.026	+ 0.037	+ 0.001
Callao	April 29, 1866	0.000	+ 0.015	— 0.029	+ 0.037	+ 0.001
Panama.	May 20, 1866	0.000	— 0.022	— 0.033	+ 0.037	+ 0.001
Acapulco	June 1, 1866	0.000	— 0.033	— 0.035	+ 0.037	+ 0.001
San Francisco. . . .	June 23, 1866	0.000	— 0.083	— 0.056	+ 0.037	+ 0.001

Coefficients of the Deviations of the Forward Ritchie Compass.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865	0.000	+ 0.032	— 0.056	+ 0.041	— 0.001
St. Thomas	November 18, 1865	0.000	+ 0.032	— 0.032	+ 0.041	— 0.001
Bahia	December 30, 1865	0.000	+ 0.048	— 0.026	+ 0.041	— 0.001
Monte Video	January 24, 1866	0.000	+ 0.057	— 0.022	+ 0.041	— 0.001
Sandy Point	February 10, 1866	0.000	+ 0.067	— 0.013	+ 0.041	— 0.001
Valparaiso	April 4, 1866	0.000	+ 0.045	— 0.032	+ 0.041	— 0.001
Callao	April 29, 1866	0.000	+ 0.028	— 0.041	+ 0.041	— 0.001
Panama.	May 20, 1866	0.000	+ 0.011	— 0.051	+ 0.041	— 0.001
Acapulco	June 1, 1866	0.000	+ 0.005	— 0.056	+ 0.041	— 0.001
San Francisco. . . .	June 23, 1866	0.000	— 0.010	— 0.092	+ 0.041	— 0.001

Comparing these computed values with the values before found directly from the observations, the following residuals are obtained:

VALUE OF THE COMPUTED MINUS THE OBSERVED COEFFICIENTS OF THE DEVIATIONS OF THE ADMIRALTY STANDARD COMPASS.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865		+ 0.004	+ 0.007	— 0.004	+ 0.003
St. Thomas	November 18, 1865		— 0.006	— 0.012	+ 0.011	+ 0.012
Bahia	December 30, 1865		+ 0.002	— 0.001	+ 0.001	— 0.001
Monte Video	January 24, 1866		— 0.006	— 0.003	— 0.007	— 0.005
Sandy Point	February 10, 1866		+ 0.001	+ 0.012	+ 0.001	— 0.001
Valparaiso	April 4, 1866		+ 0.008	— 0.001	+ 0.001	+ 0.002
Callao	April 29, 1866		— 0.004	— 0.005	+ 0.001	— 0.003
Panama.	May 20, 1866		— 0.004	— 0.007	0.000	— 0.003
Acapulco	June 1, 1866		+ 0.004	— 0.009	— 0.001	— 0.003
San Francisco. . . .	June 23, 1866		0.000	+ 0.011	— 0.001	— 0.001

VALUE OF THE COMPUTED MINUS THE OBSERVED COEFFICIENTS OF THE DEVIATIONS OF THE AFTER BINNACLE COMPASS.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865		+ 0.001	+ 0.001	+ 0.001	— 0.001
St. Thomas	November 18, 1865		......	......	......	......
Bahia	December 30, 1865		— 0.004	+ 0.001	+ 0.004	— 0.004
Monte Video	January 24, 1866		+ 0.002	— 0.009	— 0.001	+ 0.010
Sandy Point	February 10, 1866		— 0.003	+ 0.014	— 0 002	— 0.001
Valparaiso	April 4, 1866		+ 0.011	— 0.001	0.000	— 0.002
Callao	April 29, 1866		— 0.006	— 0.002	— 0.002	— 0.004
Panama.	May 20, 1866		— 0.003	— 0.017	— 0.008	+ 0.003
Acapulco	June 1, 1866		— 0.003	— 0.007	— 0.003	+ 0.004
San Francisco. . . .	June 23, 1866		+ 0.002	+ 0.015	+ 0.006	— 0.002

VALUE OF THE COMPUTED MINUS THE OBSERVED COEFFICIENTS OF THE DEVIATIONS OF THE AFTER RITCHIE COMPASS.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865		+ 0.011	+ 0.012	+ 0.010	+ 0.021
St. Thomas	November 18, 1865		— 0.017	— 0.027	— 0.010	+ 0.008
Bahia	December 30, 1865		— 0.008	— 0.003	— 0.008	— 0.003
Monte Video	January 24, 1866		......	......	......	......
Sandy Point	February 10, 1866		+ 0.009	+ 0.035	+ 0.012	— 0.014
Valparaiso	April 4, 1866		+ 0.012	— 0.021	— 0.009	— 0.003
Callao	April 29, 1866		— 0.026	— 0.015	+ 0.002	— 0.017
Panama.	May 20, 1866		+ 0.009	— 0.002	+ 0.009	+ 0.026
Acapulco	June 1, 1866		+ 0.002	— 0.024	+ 0.010	— 0.016
San Francisco. . . .	June 23, 1866		+ 0.001	+ 0.028	— 0.016	— 0.004

VALUE OF THE COMPUTED MINUS THE OBSERVED COEFFICIENTS OF THE DEVIATIONS OF THE AFTER AZIMUTH COMPASS.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865		— 0.001	+ 0.011	+ 0.011	— 0.005
St. Thomas	November 18, 1865		— 0.006	— 0.021	— 0.008	— 0.002
Bahia	December 30, 1865		+ 0.015	+ 0.003	— 0.020	+ 0.019
Monte Video	January 24, 1866		……	……	……	……
Sandy Point	February 10, 1866		— 0.010	+ 0.004	— 0.014	+ 0.007
Valparaiso	April 4, 1866		+ 0.021	— 0.008	+ 0.006	— 0.010
Callao	April 29, 1866		— 0.026	+ 0.017	+ 0.022	— 0.011
Panama.	May 20, 1866		+ 0.007	— 0.021	— 0.001	+ 0.012
Acapulco	June 1, 1866		+ 0.001	+ 0.011	+ 0.007	— 0.007
San Francisco. . . .	June 23, 1866		……	……	……	……

VALUE OF THE COMPUTED MINUS THE OBSERVED COEFFICIENTS OF THE DEVIATIONS OF THE FORWARD ALIDADE COMPASS.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865		+ 0.003	+ 0.006	+ 0.005	— 0.001
St. Thomas	November 18, 1865		— 0.007	— 0.005	+ 0.002	— 0.006
Bahia	December 30, 1865		+ 0.002	— 0.010	+ 0.002	— 0.004
Monte Video	January 24, 1866		— 0.005	— 0.002	0.000	+ 0.004
Sandy Point	February 10, 1866		+ 0.007	+ 0.013	— 0.007	+ 0.007
Valparaiso	April 4, 1866		+ 0.003	— 0.007	+ 0.005	+ 0.002
Callao	April 29, 1866		— 0.011	+ 0.006	— 0.002	+ 0.003
Panama.	May 20, 1866		— 0.010	+ 0.001	+ 0.001	+ 0.003
Acapulco	June 1, 1866		+ 0.012	— 0.014	— 0.009	— 0.002
San Francisco. . . .	June 23, 1866		+ 0.002	+ 0.007	+ 0.007	— 0.007

VALUE OF THE COMPUTED MINUS THE OBSERVED COEFFICIENTS OF THE DEVIATIONS OF THE FORWARD BINNACLE COMPASS.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865		0.000	+ 0.013	— 0.007	— 0.006
St. Thomas	November 18, 1865		— 0.002	— 0.016	+ 0.002	+ 0.003
Bahia	December 30, 1865		+ 0.007	— 0.010	0.000	+ 0.004
Monte Video	January 24, 1866		— 0.005	— 0.007	+ 0.005	+ 0.002
Sandy Point	February 10, 1866		— 0.008	+ 0.022	— 0.002	+ 0.005
Valparaiso	April 4, 1866		+ 0.015	— 0.013	+ 0.009	+ 0.004
Callao	April 29, 1866		— 0.005	+ 0.008	0.000	— 0.005
Panama.	May 20, 1866		— 0.004	— 0.006	0.000	+ 0.007
Acapulco	June 1, 1866		+ 0.003	— 0.006	— 0.009	— 0.003
San Francisco. . . .	June 23, 1866		— 0.001	+ 0.006	+ 0.002	— 0.013

VALUE OF THE COMPUTED MINUS THE OBSERVED COEFFICIENTS OF THE DEVIATIONS OF THE FORWARD RITCHIE COMPASS.

STATION.	DATE.	𝔄	𝔅	ℭ	𝔇	𝔈
Hampton Roads . . .	November 1, 1865		+ 0.009	+ 0.007	+ 0.003	— 0.007
St. Thomas	November 18, 1865		— 0.004	— 0.010	— 0.016	+ 0.007
Bahia	December 30, 1865		— 0.013	+ 0.001	— 0.006	+ 0.001
Monte Video	January 24, 1866		— 0.009	— 0.022	+ 0.001	+ 0.007
Sandy Point	February 10, 1866		0.000	+ 0.035	+ 0.002	+ 0.005
Valparaiso	April 4, 1866		+ 0.022	— 0.006	+ 0.004	— 0.009
Callao	April 29, 1866		— 0.005	— 0.007	— 0.003	— 0.003
Panama.	May 20, 1866		+ 0.007	— 0.018	+ 0.003	+ 0.003
Acapulco	June 1, 1866		— 0.006	— 0.018	0.000	— 0.008
San Francisco. . . .	June 23, 1866		— 0.005	+ 0.025	+ 0.016	+ 0.008

In the following table the columns headed $r_{\mathfrak{B}}$, $r_{\mathfrak{C}}$, $r_{\mathfrak{D}}$, $r_{\mathfrak{E}}$, contain respectively the probable errors of a single observed value of $\mathfrak{B}$, $\mathfrak{C}$, $\mathfrak{D}$, and $\mathfrak{E}$, for each compass, computed from the residuals just given. But as these residuals were got by subtracting the computed from the observed values of the coefficients, and as each observed value was found from a set of deviations observed on all the thirty-two points, it follows that the probable errors here given belong to the coefficients when they have been computed from a set of deviations observed on all the thirty-two points. For convenience of reference we will designate these as the probable errors derived from all the observations of the cruise.

Compass.	$r_{\mathfrak{B}}$	$r_{\mathfrak{C}}$	$r_{\mathfrak{D}}$	$r_{\mathfrak{E}}$	$\frac{r}{\sqrt{16}}$
Admiralty Standard. .	± 0.0033	± 0.0053	± 0.0032	± 0.0033	± 0.0008
After Binnacle . . .	± 0.0036	± 0.0069	± 0.0026	± 0.0028	± 0.0018
After Ritchie	± 0.0090	± 0.0153	± 0.0072	± 0.0106	± 0.0031
After Azimuth . . .	± 0.0100	± 0.0100	± 0.0094	± 0.0074	± 0.0030
Forward Alidade . .	± 0.0050	± 0.0059	± 0.0035	± 0.0031	± 0.0016
Forward Binnacle . .	± 0.0046	± 0.0084	± 0.0036	± 0.0043	± 0.0024
Forward Ritchie. . .	± 0.0070	± 0.0127	± 0.0056	± 0.0047	± 0.0032
Means . . .	± 0.0061	± 0.0092	± 0.0050	± 0.0052	± 0.0023

But we have before found the probable errors of B_1, C_1, D_1, and E_1, when computed from observations made at a single station on each of the thirty-two points, by a totally different process, namely, from the thirty-two observed deviations the values of A_1, B_1, C_1, D_1, and E_1, were computed; next, with the values of A_1, B_1, C_1, D_1, and E_1, thus found, the deviations were computed for each point; then, comparing these computed values of the deviation with the observed values, a series of residuals were obtained from which the probable errors in question (which are given in the table on page 185) were easily got. These we will designate as the probable errors obtained from observations at a single station; and it will be remembered that it was shown that, no matter what their numerical values might be, the probable errors of B_1, C_1, D_1, and E_1 must all be equal to each other. Although the difference between the probable errors of B_1, C_1, D_1, E_1, and those of $\mathfrak{B}$, $\mathfrak{C}$, $\mathfrak{D}$, $\mathfrak{E}$, can never be great, yet, in general, it would not be rigorously correct to assume that they are equal to each other. However, in the case of the compasses under discussion we will make this assumption, for by so doing no error greater than the uncertainty of the probable errors themselves will be introduced. In order to facilitate the comparison of the two sets of probable errors, those of B_1, C_1, D_1, E_1 are given in the table above, in the column headed $\frac{r}{\sqrt{16}}$. This column is identical with the column headed in the same manner in the table on page 185, except that the quantities are here expressed in parts of radius instead of minutes of arc.

Now, comparing the probable errors derived from all the observations of the cruise with those derived from observations at any single station, we see that, taking the mean of the results for all the compasses, $r_{\mathfrak{D}}$ and $r_{\mathfrak{E}}$ are almost identical, as they should be, but they are each more than twice as great as $\frac{r}{\sqrt{16}}$. On the other hand,

$r_{\mathfrak{B}}$ and $r_{\mathfrak{C}}$ are neither equal to each other, nor yet to $r_{\mathfrak{D}}$ and $r_{\mathfrak{E}}$, but are, the one nearly three, and the other four, times as great as $\frac{r}{\sqrt{16}}$. Assuming the theory employed in this discussion to be correct, we should have expected to find $r_{\mathfrak{B}}$, $r_{\mathfrak{C}}$, $r_{\mathfrak{D}}$, $r_{\mathfrak{E}}$ sensibly equal to each other, and all sensibly equal to $\frac{r}{\sqrt{16}}$. Such, however, is not the case; and, as the results for each compass all tend in precisely the same direction as the mean result, a doubt naturally arises whether or not the theory really represents the semi-circular deviation as accurately as it does the quadrantal. As this doubt is founded upon observations which may possibly have been affected by some unknown cause of constant error—as they were all made on a single vessel during a single cruise—perhaps it would not be well to insist upon it too strongly; but at all events, it shows the necessity for further investigation of the subject, and especially the great want of more observations.

The probable errors of the coefficients $\mathfrak{B}$, $\mathfrak{C}$, $\mathfrak{D}$, $\mathfrak{E}$, for each compass, when computed from the values of A_1, $\frac{c}{\lambda}$, $\frac{P}{\lambda}$, $\frac{\Delta P}{\lambda}$, $\frac{f}{\lambda}$, $\frac{Q}{\lambda}$, $\frac{\Delta Q}{\lambda}$, $\mathfrak{D}$, and $\mathfrak{E}$, given in the table on page 193, are as follows:

Compass.	$r^{\circ}_{\mathfrak{B}}$	$r^{\circ}_{\mathfrak{C}}$	$r^{\circ}_{\mathfrak{D}}$	$r^{\circ}_{\mathfrak{E}}$
Admiralty Standard	± 0.0010	± 0.0017	± 0.0010	± 0.0010
After Binnacle	± 0.0012	± 0.0023	± 0.0009	± 0.0009
After Ritchie	± 0.0030	± 0.0051	± 0.0024	± 0.0035
After Azimuth	± 0.0035	± 0.0035	± 0.0033	± 0.0026
Forward Alidade	± 0·0016	± 0.0019	± 0.0011	± 0-0010
Forward Binnacle	± 0.0014	± 0.0026	± 0.0012	± 0.0014
Forward Ritchie.	± 0.0022	± 0.0040	± 0.0018	± 0-0015

The following table shows, for each compass, the place at which the maximum value of its deviation, δ, was the greatest, together with the point on which that maximum value occurred, and its amount. Also, the place at which the maximum value of its deviation was the least, together with the point on which that maximum occurred, and its amount. These deviations are given on the compass points, and in computing them the true A was used.

Compass and Station.	Point.	δ
Admiralty Standard.		
Hampton Roads	E. by N.	+ 9° 29′
Sandy Point	N. E. by E.	+ 2 3
After Binnacle.		
Hampton Roads	N. W. by W.	— 9 15
Acapulco.	N. W. by W.	— 5 21
After Ritchie.		
Hampton Roads	W. N. W.	— 12 45
Panama	N. W. by W.	— 5 41
After Azimuth.		
Hampton Roads	S. E. by E.	— 10 5
St. Thomas	S. E.	— 8 45

Compass and Station.	Point.	δ
Forward Alidade.		
Bahia	N. W. by N.	— 3° 39′
Sandy Point	N. W.	— 4 34
Forward Binnacle.		
Bahia	N. W.	— 3 31
San Francisco	S. W.	+ 7 43
Forward Ritchie.		
St. Thomas	N. W.	— 4 55
San Francisco	S. W. by S.	+ 6 53

The following table shows, for each compass, the maximum change, $\Delta\delta$, in its deviation, which occurred on any single point, together with the azimuth at which, and the places between which that change occurred.

Compass and Station.	Azimuth.	Δδ
Admiralty Standard.		
Hampton Roads and Sandy Point . .	S. 88° 52′ E.	7° 53′
After Binnacle.		
Hampton Roads and Acapulco . . .	S. 82 43 E.	4 23
After Ritchie.		
Hampton Roads and Panama . . .	S. 84 27 E.	7 28
After Azimuth.		
Hampton Roads and Sandy Point . .	S. 48 31 E.	1 43
Forward Alidade.		
Hampton Roads and Sandy Point . .	N. 85 20 E.	3 39
Forward Binnacle.		
Sandy Point and San Francisco . .	N. 76 17 E.	9 42
Forward Ritchie.		
Sandy Point and San Francisco . .	N. 43 16 E.	6 18

In order to show the difference between the values of the deviation computed from observations made at a single station, and those computed from all the observations of the cruise, or, in other words, the difference between the theory and the observations, let δ be the deviation of a compass on any point, ζ, at a given station, as computed from values of A_1, B_1, C_1, D_1, E_1, derived from all the observations of that compass made during the cruise; and also let δ' be the deviation of the same compass, on the same point, at the same station, as computed from values of A_1, B_1, C_1, D_1, E_1, derived from observations of that compass made on each of the thirty-two points at the station in question. Then the following table shows, for each compass, the maximum value attained by $\delta - \delta'$ during the cruise, together with the point on which, and the station at which, that maximum occurred.

Compass.	Station.	Point.	δ — δ′
Admiralty Standard	St. Thomas	S. S. W.	+ 1° 41′
After Binnacle	Panama	S. S. E.	+ 1 14
After Ritchie	Sandy Point	S. by E.	— 2 51
After Azimuth	Callao	S. E. by S.	— 3 4
Forward Alidade	Acapulco	S. E.	+ 1 36
Forward Binnacle . . .	Valparaiso	N. W. by W.	— 1 41
Forward Ritchie	San Francisco	N. N. E.	+ 2 11

As the After Azimuth Compass was a very poor instrument, the descrepancy between theory and observation in the case of its deviations is not surprising. In the case of all the other compasses, except perhaps the Forward and After Ritchie, the agreement of the observed and computed values of the deviations is much more satisfactory; and indeed the differences between them are so small as to be of very little consequence for the ordinary purposes of navigation; still, viewed from a purely scientific stand-point, they are larger than might have been expected.

The hard and soft iron forces involved in the production of the semi-circular deviation were next examined in order to ascertain whether or not their relations to each other were such as to render it possible, in the case of a vessel swung for the first time, to predict from the observed deviations of her standard compass what the deviations would be at any other place. The coefficients of the semi-circular deviation are $\mathfrak{B}$ and $\mathfrak{C}$, and the components of the hard iron force involved in their production are $\frac{P}{\lambda}$ and $\frac{Q}{\lambda}$; while the components of the soft iron force are $\frac{c}{\lambda}$ and $\frac{f}{\lambda}$. As these components act at right angles to each other, the total hard iron force will be

$$\sqrt{\frac{P^2}{\lambda^2}+\frac{Q^2}{\lambda^2}},$$

and if we let α represent the direction in which it acts, measured from the ship's head toward the right hand, we have

$$\tan \alpha = \frac{\frac{Q}{\lambda}}{\frac{P}{\lambda}}$$

In the same way the total soft iron force will be

$$\sqrt{\frac{c^2}{\lambda^2}+\frac{f^2}{\lambda^2}}$$

and to determine its direction we have

$$\tan \alpha' = \frac{\frac{f}{\lambda}}{\frac{c}{\lambda}}$$

By means of these formulæ the following table was computed. It shows the amount and direction of the hard and soft iron forces acting on each compass on November 1, 1865, and June 23, 1866.

Compass.	Hard Iron Force.				Soft Iron Force.	
	November 1, 1865.		June 23, 1866.			
	Amount.	Direction.	Amount.	Direction.	Amount.	Direction.
Admiralty Standard	0.460	000°.8	0.226	348°.0	0.024	356°.1
After Binnacle	0.664	000.2	0.639	353.0	0.010	240.4
After Ritchie	0.780	349.0	0.481	354.0	0.018	16.3
After Azimuth	0.375	186.8	0.449	173.9	0.007	111.2
Forward Alidade	0.107	277.6	0.178	267.3	0.016	184.2
Forward Binnacle	0.159	331.9	0.254	280.1	0.048	187.1
Forward Ritchie	0.376	347.2	0.387	289.1	0.022	219.9

The following table shows the change, in amount and direction, of the hard iron force between November 1, 1865, and June 23, 1866; the ratio of the hard to the soft iron force on each of these dates; and also the mean ratio of the same forces.

Compass.	Change of Hard Iron Force.		Ratio of Hard to Soft Iron Force.		
	Amount.	Direction.	Nov. 1, 1865.	June 23, 1866.	Mean.
Admiralty Standard . .	— 0.234	— 12°.8	19.2	9.4	14 3
After Binnacle . .	— 0.025	— 7.2	68.8	66.1	67.4
After Ritchie . . .	— 0.299	+ 5.0	42.1	26.0	34.0
After Azimuth. . .	+ 0.074	— 12.9	52.6	62.8	57.7
Forward Alidade . .	+ 0.071	— 10.3	6.6	11.0	8.8
Forward Binnacle . .	+ 0.095	— 51.8	3.3	5.3	4.3
Forward Ritchie . .	+ 0.011	— 58.1	17.1	17.6	17.3

An examination of the last two tables shows that during the whole cruise the hard iron force was changing in a very remarkable manner, both in amount and direction. In the case of the three compasses mounted above the forward turret, the force was increasing: while in the case of those mounted above the after turret, it was decreasing. In other words, there seems to have been a transfer of hard iron force from aft forward. Now, looking at the change in direction of the force, we see that in every case, excepting only that of the After Ritchie, it took place in such a manner as to correspond to a rotation from right to left. Further, the ratio of the hard to the soft iron force was slowly varying at each compass; and for the different compasses it ranged between 4.3 and 67.4. Finally, there was not a single compass on board at which the direction of the hard and soft iron force coincided; from which it follows that in no case was the ratio of the hard and soft iron forces the same in the coefficient 𝔅 as it was in the coefficient ℭ. Under these circumstances we are forced to conclude that, so far as can be judged from the observations here given, in the case of a vessel swung for the first time it is impossible to make any reliable estimate of the ratio of the hard to the soft iron force in the coefficients 𝔅 and ℭ; and, therefore, it is also impossible to make any reliable estimate as to what changes her deviations will undergo upon a change of magnetic latitude. As a further proof of this, we see that the After Azimuth Compass, with a maximum deviation of 10° 5′, changed its deviation during the cruise by only 1° 43′, that is, by about one-sixth of its whole amount; while the Forward Binnacle Compass, with a maximum deviation of only 7° 43′ changed its deviation during the cruise by 9° 42′, that is, by about one and a quarter times its whole amount.

In the beginning of this section it was stated that, at the positions occupied by the Admiralty Standard and After Azimuth Compasses, observations of deflection and dip were made in order to determine the absolute magnetic force; and the details of the method followed in taking these observations were explained. We will now proceed to reduce and discuss the observations themselves, and for that purpose the first thing necessary to be known is the magnetic moment of the deflecting magnets. For its determination we have the observations recorded in the following table, which were all made on shore. The first and second columns of the table give the place where, and the date when, each observation was made. The third and fourth columns give respectively the observed deflections when the north ends of the deflecting magnets were directed towards the west and towards the east; the distance of their centres from the centre of the compass needle being in both cases eleven inches. The fifth column gives the mean of the four observed deflections recorded in the third and fourth columns. The sixth, seventh, and eighth columns contain, in precisely the same manner, the observed deflections, and their mean, when the centres of the deflecting magnets were at a distance of fifteen inches from the centre of the compass needle. Now, let r be the distance, expressed in feet, between the centres of the deflecting magnets and the centre of the compass needle; u, the observed angle of deflection given for each value of r in the column headed "mean"; m, the combined magnetic moment of the two deflecting magnets; and H, the earth's horizontal force at the place where the observation was made, taken from the table on page 61. Then we shall have

$$\tfrac{1}{2}r^3 \tan u = \frac{m}{H}$$

and the ninth column contains the mean of the two values of log. $\frac{m}{H}$ computed respectively from the angles of deflection observed with $r = 11$ inches $= 0.917$ foot, and $r = 15$ inches $= 1.250$ feet. The tenth column contains the value of log. m, found by adding to log. $\frac{m}{H}$ the known value of log. H.

Station.	Date.	Deflections.						Log. $\frac{m}{H}$.	Log. m.
		$r = 11$ inches.			$r = 15$ inches.				
		West.	East.	Mean.	West.	East.	Mean.		
Gosport.	Oct. 30, 1865	19° 30′	22° 40′		14° 30′	17° 30′			
		19 0	22 20	20° 52′	14 20	17 40	*16° 0′	9.1617	9.8344
St. Thomas	Nov. 13, 1865	15 20	14 50		4 20	6 40			
		15 30	14 40	15 5	4 30	6 40	5 32	8.9961	9.8251
Salute Islands . . .	Nov. 28, 1865	14 35	15 0		5 20	5 20			
		14 35	15 5	14 49	4 55	5 20	5 14	8.9799	9.8079
Bahia.	Dec. 27, 1865	15 40	16 10		6 10	5 30			
		16 40	16 10	16 10	5 40	5 30	5 42	9.0184	9.8108
Rio Janeiro	Jan. 6, 1866	17 0	17 0		6 40	6 0			
		17 0	17 10	17 2	6 0	6 0	6 10	9.0476	9.8216
Monte Video . . .	Jan. 18, 1866	16 40	16 40		6 20	5 30			
		17 0	16 40	16 45	6 10	5 30	5 52	9.0328	9.8130
Sandy Point . . .	Feb. 7, 1866	16 30	16 20		5 40	6 40			
		16 40	16 20	16 27	6 0	6 30	6 12	9.0408	9.8270
Valparaiso	March 2, 1866	17 0	15 0		7 20	5 0			
		16 40	14 40	15 50	7 30	5 0	6 12	9.0320	9.8326
Valparaiso	April 7, 1866	14 40	17 40		4 30	7 30			
		14 30	17 30	16 5	4 20	7 40	6 0	9.0284	9.8290
Callao	April 26, 1866	14 30	14 30		5 20	5 10			
		14 30	14 30	14 30	5 10	5 30	5 18	8.9777	9.8222
Panama	May 14, 1866	12 50	13 30		4 30	5 20			
		13 10	13 30	13 15	4 40	5 0	4 52	8.9387	9.8195
Acapulco	May 30, 1866	12 30	12 20		4 40	4 30			
		12 40	12 10	12 25	5 30	4 40	4 50	8.9227	9.8107
San Francisco . . .	June 26, 1866	17 40	17 0		7 0	6 10			
		18 0	16 40	17 20	7 10	6 30	6 42	9.0698	9.8208

* In this observation $r = 12$ inches.

The observed values of log. m show no trace whatever of any change depending upon the time, and therefore the indiscriminate mean of them all has been taken as the truth, and we have

$$\text{Log. } m = 9.8211 \pm 0.0016.$$

The probable error of a single observed value of log. m is ± 0.0058.

The following table contains all the observations which were made at the position occupied by the Admiralty Standard Compass on board the Monadnock, for the determination of absolute force. The first nine columns contain quantities precisely similar to those in the columns headed in the same manner in the table last given. The column headed "Log. H'" gives the logarithm of the combined horizontal force of the earth and ship, obtained by subtracting log. $\frac{m}{H'}$ from the value of log. m given above. The column "θ'" contains the dip, which was observed immediately after the deflections. The column "Log. Z'" contains the logarithm of the combined vertical force of the earth and ship, computed from the quantities in the tenth and eleventh columns by the formula $Z' = H' \tan \theta'$. The columns "Log. $\frac{H'}{H}$," and "Log. $\frac{Z'}{Z}$", explain themselves when it is stated that H represents the horizontal force of the earth; H' the combined horizontal force of the earth and ship; Z the earth's vertical force; and Z' the combined vertical force of the earth and ship. The column "ζ'" contains the azimuth of the ship's head as read off from the compass card at the time the deflections were observed; and the column "ζ" contains the same azimuth, counted from the true magnetic north.

ADMIRALTY STANDARD COMPASS.

Station.	Date.	Deflection.						$\text{Log.}\frac{m}{H'}$	$\text{Log.}H'$	θ'	$\text{Log.}Z'$	$\text{Log.}\frac{H'}{H}$	$\text{Log.}\frac{Z'}{Z}$	ζ'	ζ
		$r = 11$ inches.			$r = 15$ inches.										
		West.	East.	Mean.	West.	East.	Mean.								
Hampton Roads	Nov. 1, 1865	22° 20′ 21 20 21 0 23 0	26° 0′ 26 30 26 0 23 40	23° 44′				9.2288	0.5923			9.9196		W. (?)	
St. Thomas . .	Nov. 15, 1865	17 10 17 20	15 40 15 50	16 30	6° 30′ 6 40	7° 10 7 0	6° 50′	9.0628	0.7583			9.9293		East.	
Salute Islands .	Nov. 30, 1865	16 20 16 30	16 0 16 0	16 12	6 20 6 40	5 40 6 0	6 10	9.0361	0.7850	+ 41° 30′	0.7318	9.9570	0.0644	N. 85° E.	N. 89° 41′ E.
Ceara	Dec. 18, 1865	18 0 17 0	16 20 16 0	16 50	7 0 6 30	6 0 6 0	6 22	9.0519	0.7692			9.9566		N. 70 E.	N. 74 30 E.
Bahia	Dec. 29, 1865	16 20 16 0	16 0 16 0	16 5	6 20 6 30	6 0 6 20	6 17	9.0385	0.7826	+ 8 30	9.9571	9.9902	0.2786	N. 35 E.	N. 38 2 E.
Rio Janeiro . .	Jan. 4, 1866	16 30 16 40	16 40 16 40	16 37	6 20 6 20	6 0 6 10	6 12	9.0431	0.7780	— 8 0	9.9258	0.0040	9.8324	N. 4 W.	N. 4 30 W.
Rio Janeiro . .	Jan. 4, 1866	18 40 18 30	18 40 18 40	18 37	7 0 7 0	7 10 7 10	7 5	9.0985	0.7226	— 15 0	0.1506	9.9486	0.0572	S. 2 W.	S. 1 58 W.
Monte Video . .	Jan. 24, 1866	18 0 18 0	18 20 18 20	18 10	7 10 6 40	6 40 7 0	6 52	9.0861	0.7350	— 36 30	0.6042	9.9548	0.0435	S. 20 E.	S. 19 40 E.
Sandy Point . .	Feb. 9, 1866	16 0 16 40	18 20 18 30	17 22	6 20 6 20	7 20 7 30	6 52	9.0757	0.7454	— 60 30	0.9928	9.9592	0.0526	S. 39 W.	S. 39 4 W.
Valparaiso . . .	March 20, 1866	16 40 16 30	17 20 17 10	16 55	6 30 6 20	7 0 6 50	6 40	9.0631	0.7580	— 42 0	0.7124	9.9574	0.0604	S. 20 W.	S. 20 9 W.
Valparaiso . . .	April 4, 1866	17 20 17 20	14 40 14 40	16 0	7 0 7 20	4 40 5 0	6 0	9.0273	0.7938	— 36 15	0.6590	9.9932	0.0070	N. 5 W.	N. 5 34 W.
Callao	April 30, 1866	16 30 15 40	16 0 15 0	15 48	6 20 6 30	5 30 6 0	6 5	9.0274	0.7937	— 7 45	9.9275	9.9492	0.0288	South.	S. 0 13 W.
Panama	May 17, 1866	14 0 14 0	12 40 13 0	13 25	5 20 5 20	5 0 4 30	5 2	8.9489	0.8722	+ 36 45	0.7454	9.9914	0.0699	N. 42 W.	N. 45 6 W.
Acapulco	May 31, 1866	13 30 13 30	14 40 14 40	14 5	5 0 5 0	5 40 5 50	5 22	8.9739	0.8472	+ 45 45	0.8586	9.9592	0.0484	S. 30 E.	S. 29 2 E.
San Francisco .	June 23, 1866	20 0 19 40	20 0 20 20	20 0	6 40 5 30	9 0 10 0	7 48	9.1366	0.6845	+ 67 0	1.0567	9.9335	0.0247	S. 20 E.	S. 18 22 E.

The following table contains, in precisely the same manner, all the observations which were made for the determination of absolute force at the position occupied by the After Azimuth Compass on board the Monadnock.

AFTER AZIMUTH COMPASS.

Station.	Date.	Deflection.						$\text{Log.}\frac{m}{H'}$	Log. H'	θ'	Log. Z'	$\text{Log.}\frac{H'}{H}$	$\text{Log.}\frac{Z'}{Z}$	ζ'	ζ
		$r = 11$ inches.			$r = 15$ inches.										
		West.	East.	Mean.	West.	East.	Mean.								
Hampton Roads	Nov. 1, 1865	25° 20′ 26 0 25 20 23 40	25° 30′ 27 0 28 20 28 20	26° 11′				9.2774	0.5437			9.8710		West (?)	
St. Thomas . .	Nov. 15, 1865	19 10 18 40	19 40 19 20	19 12	6° 40′ 6 20	7° 30′ 7 40	7° 2′	9.1042	0.7169			9.8879		East	
Salute Islands .	Nov. 30, 1865	19 40 19 30	21 40 21 20	20 32	7 20 7 0	8 20 8 30	7 48	9.1428	0.6783	+ 40° 12′	0.6052	9.8503	9.9378		
Ceara	Dec. 18, 1865	25 40 27 0	16 40 18 40	22 0	7 0 8 40	7 20 6 30	7 23	9.1471	0.6740			9.8614			
Bahia	Dec. 29, 1865	21 20 21 10	20 20 20 10	20 45	8 10 8 30	7 10 8 0	7 57	9.1494	0.6717	+ 9 30	9.8953	9.8793	0.2168		
Rio Janeiro . .	Jan. 4, 1866	19 10 19 0	18 10 18 10	18 37	6 40 6 40	6 50 6 40	6 42	9.0864	0.7347	— 6 30	9.7914	9.9607	9.6980	N. 2° E.	N. 2° 4′ E.
Rio Janeiro . .	Jan. 4, 1866	17 20 17 30	16 20 16 0	16 47	5 40 5 50	6 0 6 10	5 55	9.0351	0.7860	— 18 15	0.3042	0.0120	0.2108	S. 10 W.	S. 13 26 W.
Monte Video . .	Jan. 24, 1866	20 20 21 40	17 50 18 30	19 35	8 40 9 40	6 20 5 40	7 35	9.1254	0.6957	— 39 15	0.6079	9.9155	0.0472	S. 45 E.	S. 53 48 E.
Sandy Point . .	Feb. 9, 1866	21 0 21 20	16 50 16 40	18 57	7 0 7 40	9 0 8 50	8 7	9.1327	0.6884	— 59 15	0.9139	9.9022	9.9737	S. 50 W.	S. 59 17 W.
Valparaiso . . .	March 20, 1866	16 20 15 20	16 0 16 50	16 8	7 0 7 30	4 40 4 40	5 58	9.0279	0.7932	— 38 30	0.6938	9.9926	0.0418	S. 10 W.	S. 13 18 W.
Valparaiso . . .	April 4, 1866	19 0 19 40	16 20 16 40	17 55	6 30 7 0	6 0 5 0	6 7	9.0575	0.7636	— 33 15	0.5803	9.9630	9.9283	N. 7 W.	N. 8 23 W.
Callao	April 30, 1866	13 0 13 0	15 0 15 30	14 8	7 0 5 20	5 40 5 40	5 55	8.9960	0.8251	— 10 45	0.1035	9.9806	0.2048	South	S. 0 12 E.
Panama	May 17, 1866	15 20 16 0	15 20 15 30	15 32	6 10 6 0	5 40 5 30	5 50	9.0144	0.8067	+ 40 45	0.7420	9.9259	0.0665	N. 35 W.	N. 38 49 W.
Acapulco. . . .	May 31, 1866	18 20 17 30	15 40 16 0	16 52	7 20 6 30	5 20 7 30	6 40	9.0624	0.7587	+ 49 45	0.8310	9.8707	0.0208	N. 75 W.	N. 74 47 W.
San Francisco .	June 23, 1866	19 20 17 30	19 30 19 0	18 50	7 30 7 30	7 0 7 0	7 15	9.1063	0.7148	+ 62 0	0.9891	9.9638	9.9571	S. 50 E.	S. 60 37 E.

From the data already given, the value of λ was next computed by means of the formulæ

$$\sin\delta = \frac{1}{1 - \mathfrak{D}\cos 2\zeta'}\left[\mathfrak{A} + \mathfrak{B}\sin\zeta' + \mathfrak{C}\cos\zeta' + \mathfrak{D}\sin 2\zeta' + \mathfrak{E}\cos 2\zeta'\right]$$

$$\lambda = \frac{H'}{H} \times \frac{\sin\delta}{\mathfrak{A} + \mathfrak{B}\sin\zeta + \mathfrak{C}\cos\zeta + \mathfrak{D}\sin 2\zeta + \mathfrak{E}\cos 2\zeta}$$

The individual results obtained from the observed values of $\frac{H'}{H}$ are as follows:

Station.	Value of λ	
	Admiralty Standard Compass.	After Azimuth Compass.
Salute Islands . . .	0.918	
Ceara	0.896	
Bahia	0.922	
Rio Janeiro. . . .	0.939	0.942
Rio Janeiro. . . .	0.904	0.884
Monte Video . . .	0.913	0.814
Sandy Point . . .	0.914	0.821
Valparaiso	0.954	0.848
Valparaiso	0.934	0.886
Callao	0.905	0.820
Panama	0.952	0.861
Acapulco	0.947	0.816
San Francisco . . .	0.914	0.947

Taking the means, for the Admiralty Standard Compass, we have finally

$$\lambda = 0.924 \pm 0.0036$$

and the probable error of a single observed value of λ is $\pm$ 0.013. For the After Azimuth compass we have finally

$$\lambda = 0.864 \pm 0.0107$$

and the probable error of a single observed value of λ is $\pm$ 0.034.

In order to determine these coefficients which depend upon the value of $\frac{Z'}{Z}$, we have equation (6 a), which is

$$0 = 1 - \frac{Z'}{Z} + g \times \frac{\cos\zeta}{\tan\theta} - h \times \frac{\sin\zeta}{\tan\theta} + k + R \times \frac{1}{Z}$$

But as R is liable to a slow change, a term depending upon the time is introduced, and then we get

$$0 = 1 - \frac{Z'}{Z} + g \times \frac{\cos\zeta}{\tan\theta} - h \times \frac{\sin\zeta}{\tan\theta} + k + R \times \frac{1}{Z} + \Delta R \times \frac{t}{Z} \qquad \text{(6 b)}$$

where ΔR is the daily change in the value of R, and t is the time in days, counted from November 1, 1865. Each observed value of $\frac{Z'}{Z}$ furnishes an equation of condition of the same form as (6 b), and from all the equations of condition thus obtained the most probable values of g, h, k, R, and ΔR, can be found by the method of least squares.

The following are the equations of condition, formed in the manner just explained, for the Admiralty Standard Compass.

Absolute Term.	g	h	k	R	ΔR
0 = − 0.160	+ 0.008	− 1.448	+ 1.000	+ 0.215	+ 6.24
0 = − 0.899	+ 10.23	− 8.007	+ 1.000	+ 2.097	+ 125.8
0 = + 0.320	− 4.779	− 0.376	+ 1.000	− 0.806	− 51.61
0 = − 0.141	+ 4.791	− 0.164	+ 1.000	− 0.806	− 51.61
0 = − 0.108	+ 1.561	+ 0.558	+ 1.000	− 0.275	− 23.10
0 = − 0.129	+ 0.545	− 0.442	+ 1.000	− 0.115	− 11.48
0 = − 0.149	+ 1.322	− 0.485	+ 1.000	− 0.223	− 30.76
0 = − 0.016	− 1.401	− 0.140	+ 1.000	− 0.223	− 34.32
0 = − 0.068	+ 8.822	− 0.033	+ 1.000	− 1.263	− 227.3
0 = − 0.175	+ 1.132	+ 1.136	+ 1.000	+ 0.211	+ 41.59
0 = − 0.118	− 1.046	− 0.580	+ 1.000	+ 0.155	+ 32.66
0 = − 0.058	− 0.497	− 0.165	+ 1.000	+ 0.093	+ 21.74

From these equations of condition, the following normal equations have been obtained by the method of least squares.

Absolute Term.	g	h	k	R	$100\Delta R$
0 = − 12.462	+ 237.337				
0 = + 7.286	− 79.068	+ 68.794			
0 = − 1.701	+ 20.688	− 10.147	+ 12.000		
0 = − 1.957	+ 9.858	− 16.451	− 0.941	+ 7.605	
0 = − 1.112	− 7.513	− 9.444	− 2.022	+ 6.735	+ 7.892

Solving, we find

$$g = +\,0.04070 \qquad k = +\,0.1006$$
$$h = +\,0.00504 \qquad R = +\,0.1665$$
$$100\Delta R = +\,0.0694$$

Substituting these results in the equations of condition, we find that the probable error of a single observed value of $\frac{Z'}{Z}$ is $\pm\,0.024$, and the probable error of a computed value of $\frac{Z'}{Z}$ is $\pm\,0.007$.

In a precisely similar manner, from the values of $\frac{Z'}{Z}$ observed at the position of the After Azimuth Compass, we obtain the following equations of condition.

Absolute Term.	g	h	k	R	ΔR
0 = + 0.501	− 4.790	+ 0.173	+ 1.000	− 0.806	− 51.61
0 = − 0.625	+ 4.663	− 1.114	+ 1.000	− 0.806	− 51.61
0 = − 0.115	+ 0.979	+ 1.338	+ 1.000	− 0.275	− 23.10
0 = + 0.059	+ 0.358	− 0.603	+ 1.000	− 0.115	− 11.48
0 = − 0.101	+ 1.370	− 0.324	+ 1.000	− 0.223	− 30.76
0 = + 0.152	− 1.393	− 0.205	+ 1.000	− 0.223	− 34.32
0 = − 0.602	+ 8.823	+ 0.031	+ 1.000	− 1.263	− 227.3
0 = − 0.165	+ 1.250	+ 1.006	+ 1.000	+ 0.211	+ 41.59
0 = − 0.049	+ 0.314	+ 1.154	+ 1.000	+ 0.155	+ 32.66
0 = + 0.094	− 0.257	− 0.456	+ 1.000	+ 0.093	+ 21.74

And the resulting normal equations are

Absolute Term.	g	h	k	R	$100\Delta R$
$0 = - 11.313$	$+ 129.164$				
$0 = + 0.311$	$- 3.078$	$+ 6.125$			
$0 = - 0.851$	$+ 11.317$	$+ 1.000$	$+ 10.000$		
$0 = + 0.840$	$- 11.053$	$+ 0.888$	$- 3.253$	$+ 3.161$	
$0 = + 1.367$	$- 19.634$	$+ 1.042$	$- 3.342$	$+ 4.084$	$+ 6.305$

Solving, we find

$$g = + 0.11398 \qquad k = - 0.0509$$
$$h = + 0.00981 \qquad R = - 0.3918$$
$$100\Delta R = + 0.3634$$

Substituting these results in the equations of condition, the probable error of a single observed value of $\frac{Z'}{Z}$ comes out $\pm$ 0.030, and the probable error of a computed value of $\frac{Z'}{Z}$ comes out $\pm$ 0.010.

For the Admiralty Standard Compass we found $\mathfrak{A} = 0.000$, $\mathfrak{D} = + 0.017$, and $\mathfrak{E} = - 0.001$. We have also

$$a = \lambda\,(1 + \mathfrak{D}) - 1$$
$$e = \lambda\,(1 - \mathfrak{D}) - 1$$
$$b = \lambda\,(\mathfrak{E} - \mathfrak{A})$$
$$d = \lambda\,(\mathfrak{E} + \mathfrak{A})$$

Hence

$$a = - 0.0605 \qquad e = - 0.0917$$
$$b = - 0.0008 \qquad d = - 0.0008$$

For the After Azimuth Compass we found $\mathfrak{A} = 0.000$, $\mathfrak{D} = + 0.112$, and $\mathfrak{E} = 0.000$. Hence, in the same manner,

$$a = - 0.0396 \qquad e = - 0.2324$$
$$b = 0.0000 \qquad d = 0.0000$$

Collecting our results, we have the following final values of the coefficients of the

ADMIRALTY STANDARD COMPASS.

$$\mathfrak{A} = 0.000$$
$$\mathfrak{B} = + 0.0240 \tan\theta + 0.460 \frac{1}{H} - 0.00102 \frac{t}{H} \pm 0.001$$
$$\mathfrak{C} = - 0.0016 \tan\theta + 0.006 \frac{1}{H} - 0.00023 \frac{t}{H} \pm 0.002$$
$$\mathfrak{D} = + 0.017 \pm 0.001$$
$$\mathfrak{E} = - 0.001 \pm 0.001$$
$$\frac{Z'}{Z} = 1 + 0.0407 \frac{\cos\zeta}{\tan\theta} - 0.0050 \frac{\sin\zeta}{\tan\theta} + 0.1006 + 0.1665 \frac{1}{Z} + 0.000694 \frac{t}{Z} \pm 0.007$$

$\lambda = +0.924 \pm 0.004$

$\frac{c}{\lambda} = +0.0240$

$\frac{P}{\lambda} = +0.460$

$\frac{\Delta P}{\lambda} = -0.00102$

$\frac{f}{\lambda} = -0.0016$

$\frac{Q}{\lambda} = +0.006$

$\frac{\Delta Q}{\lambda} = -0.00023$

$c = +0.0221$

$P = +0.425$

$\Delta P = +0.00094$

$f = -0.0015$

$Q = +0.006$

$\Delta Q = -0.00021$

$a = -0.0605$

$b = -0.0008$

$d = -0.0008$

$e = -0.0917$

$g = +0.0407$

$h = +0.0050$

$k = +0.1006$

$R = +0.166$

$\Delta R = +0.00069$

Hence, the general equations for the determination of the deviations of this compass are

$$X' = X - 0.0605\,X - 0.0008\,Y + 0.0221\,Z + 0.425 - 0.00094\,t$$
$$Y' = Y - 0.0008\,X - 0.0917\,Y - 0.0015\,Z + 0.006 - 0.00021\,t$$
$$Z' = Z + 0.0407\,X + 0.0050\,Y + 0.1006\,Z + 0.166 + 0.00069\,t$$

The following are the final values of the coefficients of the

After Azimuth Compass.

$$\mathfrak{A} = 0.000$$
$$\mathfrak{B} = -0.0026\tan\theta - 0.373\frac{1}{H} - 0.00032\frac{t}{H} \pm 0.004$$
$$\mathfrak{C} = +0.0066\tan\theta - 0.044\frac{1}{H} + 0.00039\frac{t}{H} \pm 0.004$$
$$\mathfrak{D} = +0.112 \pm 0.003$$
$$\mathfrak{E} = 0.000 \pm 0.003$$
$$\frac{Z'}{Z} = 1 + 0.1140\frac{\cos\zeta}{\tan\theta} - 0.0098\frac{\sin\zeta}{\tan\theta} - 0.0509 - 0.3918\frac{1}{Z} + 0.00363\frac{t}{Z} \pm 0.010$$

$\lambda = +0.864 \pm 0.011$

$\frac{c}{\lambda} = -0.0026$

$\frac{P}{\lambda} = -0.373$

$\frac{\Delta P}{\lambda} = -0.00032$

$\frac{f}{\lambda} = +0.0066$

$\frac{Q}{\lambda} = -0.044$

$\frac{\Delta Q}{\lambda} = +0.00039$

$c = -0.0022$

$P = -0.322$

$\Delta P = -0.00027$

$f = +0.0058$

$Q = -0.038$

$\Delta Q = +0.00034$

$a = -0.0396$

$b = 0.0000$

$d = 0.0000$

$e = -0.2324$

$g = +0.1140$

$h = +0.0098$

$k = -0.0509$

$R = -0.392$

$\Delta R = +0.00363$

Hence, the general equations for the determination of the deviations of this compass are

$$X' = X - 0.0396\,X - 0.0000\,Y - 0.0022\,Z - 0.322 - 0.00027\,t$$
$$Y' = Y - 0.0000\,X - 0.2324\,Y - 0.0058\,Z - 0.038 + 0.00034\,t$$
$$Z' = Z + 0.1140\,X + 0.0098\,Y - 0.0509\,Z - 0.392 + 0.00363\,t$$

The constants P, Q, R, are the resolved values of the hard iron magnetism of the ship; and in order to show as clearly as possible how it varied during the cruise, at the positions occupied by the two compasses under discussion, the following table is appended. The columns headed "F" contain the values of the total hard iron force, computed by means of the formula

$$F = \sqrt{P^2 + Q^2 + R^2}$$

Date.	Admiralty Standard Compass.				After Azimuth Compass.			
	P.	*Q.*	*R.*	*F.*	*P.*	*Q.*	*R.*	*F.*
November 1, 1865	+0.425	+ 0.006	+0.166	0.456	— 0.322	— 0.038	— 0.392	0.509
June 23, 1866	+0.205	— 0.043	+0.327	0.388	— 0.385	+ 0.042	+ 0.457	0.599

Thus it appears that in the interval between November 1, 1865, and June 23, 1866, the total hard iron force had decreased fifteen per centum at the position of the Admiralty Standard Compass, while it had increased eighteen per centum at the position of the After Azimuth Compass; and in both cases the changes in the direction of the force were very great. On the whole, the so-called permanent and sub-permanent magnetism of the Monadnock seem to have been in a very unstable condition.

There were some places where observations of the deviations of the compasses were obtained on a number of points less than thirty-two, because the ship could not be made to swing completely around. In order to deduce from these observations the corresponding values of the coefficients A_1, B_1, C_1, D_1, E_1, we remark that each observed deviation furnishes an equation of condition of the form

$$0 = -\delta + A_1 + B_1 \sin\zeta + C_1 \cos\zeta + D_1 \sin 2\zeta + E_1 \cos 2\zeta$$

and from all the equations thus obtained the values of the coefficients must be found by the method of least squares. As all the compasses were observed simultaneously; the deviations at each place are given on the same points in the case of each compass. Hence, although the absolute terms in the equations of condition will be different, the numerical coefficients of the unknown quantities A_1, B_1, C_1, D_1, E_1, will be identical for all the compasses at any one station. Advantage has been taken of this circumstance in forming the following table, which gives the equations of condition for all the compasses at Ceara. The absolute terms of the equations of condition belonging to any compass will be found in the column headed with the name of that compass, while the coefficients of the remaining terms of the equations will be found in the columns headed A_1, B_1, C_1, D_1, E_1. For example, the first equation of condition for the Admiralty Standard Compass is

$$0 = -170 + A_1 + 0.195\,B_1 + 0.981\,C_1 + 0.383\,D_1 + 0.924\,E_1.$$

In the same way, the first equation of condition for the After Binnacle Compass is

$$0 = -220 + A_1 + 0.195\, B_1 + 0.981\, C_1 + 0.383\, D_1 + 0.924\, E_1.$$

EQUATIONS OF CONDITION AT CEARA.

Absolute Terms.						Coefficients of the Unknown Quantities.				
Admiralty Standard.	After Binnacle.	After Ritchie.	Forward Alidade.	Forward Binnacle.	Forward Ritchie.	A_1	B_1	C_1	D_1	E_1
— 170′	— 220′	— 820′	— 180′	— 110′	— 430′	+ 1.000	+ 0.195	+ 0.981	+ 0.383	+ 0.924
— 210	— 310	— 820	— 270	— 110	— 520	+ 1.000	+ 0.383	+ 0.924	+ 0.707	+ 0.707
— 260	— 390	— 820	— 280	— 110	— 600	+ 1.000	+ 0.556	+ 0.831	+ 0.924	+ 0.383
— 350	— 470	— 970	— 280	— 180	— 480	+ 1.000	+ 0.707	+ 0.707	+ 1.000	0.000
— 340	— 420	— 990	— 211	— 130	— 380	+ 1.000	+ 0.831	+ 0.556	+ 0.924	— 0.383
— 330	— 410	— 1140	— 200	— 110	— 300	+ 1.000	+ 0.924	+ 0.383	+ 0.707	— 0.707
— 310	— 410	— 1020	— 130	— 40	— 420	+ 1.000	+ 0.981	+ 0.195	+ 0.383	— 0.924
— 230	— 260	— 850	— 110	+ 40	— 170	+ 1.000	+ 1.000	0.000	0.000	— 1.000
— 210	— 240	— 690	— 110	+ 130	— 40	+ 1.000	+ 0.981	— 0.195	— 0.383	— 0.924
— 170	— 170	— 660	— 40	+ 140	— 30	+ 1.000	+ 0.924	— 0.383	— 0.707	— 0.707

From these equations of condition five normal equations were obtained for each compass by the method of least squares; but on attempting to solve them the numerical coefficients of D_1 and E_1 came out so small that no confidence could be placed in the resulting values of these quantities; and moreover, the uncertainty of them vitiated the values of A_1, B_1, and C_1. It was therefore considered best to reject the normal equations in D_1 and E_1, and to employ in their stead the equations

$$0 = -\mathfrak{D} + \mathrm{D}_1 + \tfrac{1}{2}(B_1^2 - C_1^2)$$
$$0 = -\mathfrak{E} + \mathrm{E}_1 + B_1\, C_1 + A_1\, D_1$$

using for $\mathfrak{D}$ and $\mathfrak{E}$ the numerical values already found. The following are the normal equations thus formed, and the resulting values of A_1, B_1, C_1 D_1, and E_1, for each compass. For convenience of computation, the unit of the absolute terms of the normal equations has been changed from minutes of arc to radius.

ADMIRALTY STANDARD COMPASS.

$$0 = -0.7505 + 10.000\, A_1 + 7.482\, B_1 + 3.999\, C_1 + 3.938\, D_1 - 2.631\, E_1$$
$$0 = -0.5789 + 7.482\, A_1 + 6.317\, B_1 + 1.969\, C_1 + 2.334\, D_1 - 3.774\, E_1$$
$$0 = -0.3183 + 3.999\, A_1 + 1.969\, B_1 + 3.685\, C_1 + 3.708\, D_1 + 1.665\, E_1$$
$$0 = -0.0169 + D_1 + \tfrac{1}{2}(B_1^2 - C_1^2)$$
$$0 = +0.0009 + E_1 + B_1\, C_1$$

Hence

$$A_1 = -0.0102 = -0^\circ\ 35'.1$$
$$B_1 = +0.0833 = +4\ \ 46.3$$
$$C_1 = +0.0405 = +2\ \ 19.2$$
$$D_1 = +0.0142 = +0\ \ 48.8$$
$$E_1 = -0.0043 = -0\ \ 14.8$$

AFTER BINNACLE COMPASS.

$$\begin{aligned}
0 &= -0.9599 + 10.000\,A_1 + 7.482\,B_1 + 3.999\,C_1 + 3.938\,D_1 - 2.631\,E_1\\
0 &= -0.7253 + 7.482\,A_1 + 6.317\,B_1 + 1.969\,C_1 + 2.334\,D_1 - 3.774\,E_1\\
0 &= -0.4413 + 3.999\,A_1 + 1.969\,B_1 + 3.685\,C_1 + 3.708\,D_1 + 1.665\,E_1\\
0 &= -0.0385 + D_1 + \tfrac{1}{2}\,(B_1^2 - C_1^2)\\
0 &= +0.0018 + E_1 + B_1\,C_1 + 0.0047\,(B_1^2 - C_1^2)
\end{aligned}$$

Hence

$$\begin{aligned}
A_1 &= +0.0062 = +0^\circ\ 21'.3\\
B_1 &= +0.0801 = +4\ \ 35.2\\
C_1 &= +0.0362 = +2\ \ \ 4.6\\
D_1 &= +0.0360 = +2\ \ \ 3.6\\
E_1 &= -0.0048 = -0\ \ 16.3
\end{aligned}$$

AFTER RITCHIE COMPASS.

$$\begin{aligned}
0 &= -2.5540 + 10.000\,A_1 + 7.482\,B_1 + 3.999\,C_1 + 3.938\,D_1 - 2.631\,E_1\\
0 &= -1.9282 + 7.482\,A_1 + 6.317\,B_1 + 1.969\,C_1 + 2.334\,D_1 - 3.774\,E_1\\
0 &= -1.0844 + 3.999\,A_1 + 1.969\,B_1 + 3.685\,C_1 + 3.708\,D_1 + 1.665\,E_1\\
0 &= -0.0340 + D_1 + \tfrac{1}{2}\,(B_1^2 - C_1^2)\\
0 &= +0.0008 + E_1 + B_1\,C_1
\end{aligned}$$

Hence

$$\begin{aligned}
A_1 &= +0.1030 = +5^\circ\ 54'.2\\
B_1 &= +0.1385 = +7\ \ 56.0\\
C_1 &= +0.0859 = +4\ \ 55.4\\
D_1 &= +0.0281 = +1\ \ 36.6\\
E_1 &= -0.0127 = -0\ \ 43.7
\end{aligned}$$

FORWARD ALIDADE COMPASS.

$$\begin{aligned}
0 &= -0.5265 + 10.000\,A_1 + 7.482\,B_1 + 3.999\,C_1 + 3.938\,D_1 - 2.631\,E_1\\
0 &= -0.3589 + 7.482\,A_1 + 6.317\,B_1 + 1.969\,C_1 + 2.334\,D_1 - 3.774\,E_1\\
0 &= -0.3022 + 3.999\,A_1 + 1.969\,B_1 + 3.685\,C_1 + 3.708\,D_1 + 1.665\,E_1\\
0 &= -0.0235 + D_1 + \tfrac{1}{2}\,(B_1^2 - C_1^2)\\
0 &= -0.0007 + E_1 + B_1\,C_1 + 0.0125\,(B_1^2 - C_1^3)
\end{aligned}$$

Hence

$$\begin{aligned}
A_1 &= +0.0359 = +2^\circ\ \ 3'.5\\
B_1 &= +0.0001 = +0\ \ \ 0.2\\
C_1 &= +0.0188 = +1\ \ \ 4.8\\
D_1 &= +0.0237 = +1\ \ 21.4\\
E_1 &= +0.0007 = +0\ \ \ 2.4
\end{aligned}$$

FORWARD BINNACLE COMPASS.

$$\begin{aligned}
0 &= -0.1396 + 10.000\,A_1 + 7.482\,B_1 + 3.999\,C_1 + 3.938\,D_1 - 2.631\,E_1\\
0 &= -0.0593 + 7.482\,A_1 + 6.317\,B_1 + 1.969\,C_1 + 2.334\,D_1 - 3.774\,E_1\\
0 &= -0.1831 + 3.999\,A_1 + 1.969\,B_1 + 3.685\,C_1 + 3.708\,D_1 + 1.665\,E_1\\
0 &= -0.0369 + D_1 + \tfrac{1}{2}\,(B_1^2 - C_1^2)\\
0 &= -0.0011 + E_1 + B_1\,C_1
\end{aligned}$$

Hence

$$\begin{aligned}
A_1 &= -0.0159 = -0^\circ\ 54'.7\\
B_1 &= +0.0072 = +0\ \ 24.6\\
C_1 &= +0.0253 = +1\ \ 26.9\\
D_1 &= +0.0372 = +2\ \ \ 7.8\\
E_1 &= +0.0009 = +0\ \ \ 3.2
\end{aligned}$$

FORWARD RITCHIE COMPASS.

$$0 = -\,0.9803 + 10.000\,A_1 + 7.482\,B_1 + 3.999\,C_1 + 3.938\,D_1 - 2.631\,E_1$$
$$0 = -\,0.6394 + 7.482\,A_1 + 6.317\,B_1 + 1.969\,C_1 + 2.334\,D_1 - 3.774\,E_1$$
$$0 = -\,0.6193 + 3.999\,A_1 + 1.969\,B_1 + 3.685\,C_1 + 3.708\,D_1 + 1.665\,E_1$$
$$0 = -\,0.0407 + D_1 + \tfrac{1}{2}\,(B_1^2 - C_1^2)$$
$$0 = +\,0.0013 + E_1 + B_1\,C_1$$

Hence

$$A_1 = +\,0.0614 = +\,3^\circ\ 31'.0$$
$$B_1 = -\,0.0076 = -\,0\ \ 26.1$$
$$C_1 = +\,0.0631 = +\,3\ \ 36.9$$
$$D_1 = +\,0.0427 = +\,2\ \ 26.6$$
$$E_1 = -\,0.0011 = -\,0\ \ 3.9$$

The following are the equations of condition, together with the resulting normal equations, and the values of the coefficients A_1, B_1, C_1, D_1, E_1, as determined for each compass from the observations made at Rio Janeiro.

EQUATIONS OF CONDITION AT RIO JANEIRO.

Absolute Terms.							Coefficients of the Unknown Quantities.				
Admiralty Standard.	After Binnacle.	After Ritchie.	After Azimuth.	Forward Alidade.	Forward Binnacle.	Forward Ritchie.	A_1	B_1	C_1	D_1	E_1
+ 290′	— 320′	— 840′	— 160′	— 250′	— 160′	— 500′	+ 1.000	+ 0.556	+ 0.831	+ 0.924	+ 0.383
+ 360	— 410	— 840	— 120	— 250	— 160	— 500	+ 1.000	+ 0.707	+ 0.707	+ 1.000	0.000
+ 390	— 430	— 840	— 20	— 250	— 160	— 370	+ 1.000	+ 0.831	+ 0.556	+ 0.924	— 0.383
+ 350	— 430	— 970	+ 130	— 180	— 160	— 460	+ 1.000	+ 0.924	+ 0.383	+ 0.707	— 0.707
+ 330	— 360	— 1010	+ 160	— 160	— 160	— 500	+ 1.000	+ 0.981	+ 0.195	+ 0.383	— 0.924
+ 320	— 340	— 880	+ 280	— 160	— 160	— 440	+ 1.000	+ 1.000	0.000	0.000	— 1.000
+ 300	— 340	— 720	+ 390	— 160	— 100	— 420	+ 1.000	+ 0.981	— 0.195	— 0.383	— 0.924
+ 280	— 280	— 610	+ 410	— 160	— 140	— 350	+ 1.000	+ 0.924	— 0.383	— 0.707	— 0.707
+ 260	— 260	— 590	+ 440	— 160	— 100	— 330	+ 1.000	+ 0.831	— 0.556	— 0.924	— 0.383
+ 240	— 190	— 590	+ 400	— 160	— 20	— 330	+ 1.000	+ 0.707	— 0.707	— 1.000	0.000
+ 200	— 170	— 510	+ 320	— 160	— 60	— 330	+ 1.000	+ 0.556	— 0.831	— 0.924	+ 0.383
+ 210	— 110	— 510	+ 200	— 230	— 80	— 330	+ 1.000	+ 0.383	— 0.924	— 0.707	+ 0.707
+ 170	— 90	— 510	+ 70	— 250	— 80	— 270	+ 1.000	+ 0.195	— 0.981	— 0.383	+ 0.924
+ 150	— 90	— 510	— 20	— 250	— 140	— 250	+ 1.000	0.000	— 1.000	0.000	+ 1.000
+ 140	— 20	— 510	— 190	— 310	— 100	— 180	+ 1.000	— 0.195	— 0.981	+ 0.383	+ 0.924
+ 120	— 10	— 510	— 290	— 330	— 80	— 230	+ 1.000	— 0.383	— 0.924	+ 0.707	+ 0.707
+ 90	— 10	— 510	— 310	— 330	— 80	— 250	+ 1.000	— 0.556	— 0.831	+ 0.924	+ 0.383

Normal Equations.

ADMIRALTY STANDARD COMPASS.

$$0 = -\,1.2217 + 17.000\,A_1 + 8.442\,B_1 - 5.641\,C_1 + 0.924\,D_1 + 0.383\,E_1$$
$$0 = -\,0.7991 + 8.442\,A_1 + 8.310\,B_1 + 0.462\,C_1 - 1.205\,D_1 - 4.543\,E_1$$
$$0 = +\,0.1662 - 5.641\,A_1 + 0.462\,B_1 + 8.691\,C_1 + 3.900\,D_1 - 4.438\,E_1$$
$$0 = -\,0.0169 + D_1 + \tfrac{1}{2}\,(B_1^2 - C_1^2)$$
$$0 = +\,0.0009 + E_1 + B_1\,C_1$$

Hence

$$A_1 = +\,0.0453 = +\,2^\circ\ 35'.7$$
$$B_1 = +\,0.0519 = +\,2\ \ 58.5$$
$$C_1 = +\,0.0001 = +\,0\ \ 0.2$$
$$D_1 = +\,0.0156 = +\,0\ \ 53.5$$
$$E_1 = -\,0.0009 = -\,0\ \ 3.1$$

AFTER BINNACLE COMPASS.

$$\begin{aligned}
0 &= -1.1228 + 17.000\,A_1 + 8.442\,B_1 - 5.641\,C_1 + 0.924\,D_1 + 0.383\,E_1 \\
0 &= -0.8724 + 8.442\,A_1 + 8.310\,B_1 + 0.462\,C_1 - 1.205\,D_1 - 4.543\,E_1 \\
0 &= -0.0346 - 5.641\,A_1 + 0.462\,B_1 + 8.691\,C_1 + 3.900\,D^1 - 4.438\,E_1 \\
0 &= -0.0385 + D_1 + \tfrac{1}{2}(B_1^2 - C_1^2) \\
0 &= +0.0018 + E_1 + B_1\,C_1 + 0.0047\,(B_1^2 - C_1^2)
\end{aligned}$$

Hence

$$\begin{aligned}
A_1 &= +0.0148 = +0^\circ\ 50'.8 \\
B_1 &= +0.0947 = +5\ \ 25.4 \\
C_1 &= -0.0073 = -0\ \ 25.2 \\
D_1 &= +0.0340 = +1\ \ 57.1 \\
E_1 &= -0.0012 = -0\ \ 4.1
\end{aligned}$$

AFTER RITCHIE COMPASS.

$$\begin{aligned}
0 &= -3.3336 + 17.000\,A_1 + 8.442\,B_1 - 5.641\,C_1 + 0.924\,D_1 + 0.383\,E_1 \\
0 &= -1.9499 + 8.442\,A_1 + 8.310\,B_1 + 0.462\,C_1 - 1.205\,D_1 - 4.543\,E_1 \\
0 &= +0.6086 - 5.641\,A_1 + 0.462\,B_1 + 8.691\,C_1 + 3.900\,D_1 - 4.438\,E_1 \\
0 &= -0.0340 + D_1 + \tfrac{1}{2}(B_1^2 - C_1^2) \\
0 &= +0.0008 + E_1 + B_1\,C_1
\end{aligned}$$

Hence

$$\begin{aligned}
A_1 &= +0.1684 = +9^\circ\ 39'.0 \\
B_1 &= +0.0659 = +3\ \ 46.6 \\
C_1 &= +0.0203 = +1\ \ 9.8 \\
D_1 &= +0.0320 = +1\ \ 50.1 \\
E_1 &= -0.0021 = -0\ \ 7.4
\end{aligned}$$

AFTER AZIMUTH COMPASS.

$$\begin{aligned}
0 &= +0.4916 + 17.000\,A_1 + 8.442\,B_1 - 5.641\,C_1 + 0.924\,D_1 + 0.383\,E_1 \\
0 &= +0.6880 + 8.442\,A_1 + 8.310\,B_1 + 0.462\,C_1 - 1.205\,D_1 - 4.543\,E_1 \\
0 &= -0.2024 - 5.641\,A_1 + 0.462\,B_1 + 8.691\,C_1 + 3.900\,D_1 - 4.438\,E_1 \\
0 &= -0.1116 + D_1 + \tfrac{1}{2}(B_1^2 - C_1^2) \\
0 &= +0.0002 + E_1 + B_1\,C_1
\end{aligned}$$

Hence

$$\begin{aligned}
A_1 &= -0.0434 = -2^\circ\ 29'.3 \\
B_1 &= -0.0199 = -1\ \ 8.5 \\
C_1 &= -0.0552 = -3\ \ 9.7 \\
D_1 &= +0.1129 = +6\ \ 28.2 \\
E_1 &= -0.0013 = -0\ \ 4.5
\end{aligned}$$

FORWARD ALIDADE COMPASS.

$$\begin{aligned}
0 &= -1.0908 + 17.000\,A_1 + 8.442\,B_1 - 5.641\,C_1 + 0.924\,D_1 + 0.383\,E_1 \\
0 &= -0.4111 + 8.442\,A_1 + 8.310\,B_1 + 0.462\,C_1 - 1.205\,D_1 - 4.543\,E_1 \\
0 &= +0.4058 - 5.641\,A_1 + 0.462\,B_1 + 8.691\,C_1 + 3.900\,D_1 - 4.438\,E_1 \\
0 &= -0.0235 + D_1 + \tfrac{1}{2}(B_1^2 - C_1^2) \\
0 &= -0.0007 + E_1 + B_1\,C_1 + 0.0125\,(B_1^2 - C_1^2)
\end{aligned}$$

Hence

$$\begin{aligned}
A_1 &= +0.0615 = +3^\circ\ 31'.5 \\
B_1 &= -0.0084 = -0\ \ 28.8 \\
C_1 &= -0.0166 = -0\ \ 57.2 \\
D_1 &= +0.0236 = +1\ \ 21.1 \\
E_1 &= +0.0006 = +0\ \ 1.9
\end{aligned}$$

FORWARD BINNACLE COMPASS.

$$
\begin{aligned}
0 &= -\,0.5643 + 17.000\,A_1 + 8.442\,B_1 - 5.641\,C_1 + 0.924\,D_1 + 0.383\,E_1\\
0 &= -\,0.3228 + 8.442\,A_1 + 8.310\,B_1 + 0.462\,C_1 - 1.205\,D_1 - 4.543\,E_1\\
0 &= +\,0.0861 - 5.641\,A_1 + 0.462\,B_1 + 8.691\,C_1 + 3.900\,D_1 - 4.438\,E_1\\
0 &= -\,0.0369 + D_1 + \tfrac{1}{2}\,(B_1^2 - C_1^2)\\
0 &= -\,0.0011 + E_1 + B_1\,C_1
\end{aligned}
$$

Hence

$$
\begin{aligned}
A_1 &= -\,0.0050 = -\,0^\circ\ 17'.1\\
B_1 &= +\,0.0523 = +\,2\ \ 59.8\\
C_1 &= -\,0.0307 = -\,1\ \ 45.5\\
D_1 &= +\,0.0360 = +\,2\ \ \ 3.7\\
E_1 &= +\,0.0027 = +\,0\ \ \ 9.3
\end{aligned}
$$

FORWARD RITCHIE COMPASS.

$$
\begin{aligned}
0 &= -\,1.7570 + 17.000\,A_1 + 8.442\,B_1 - 5.641\,C_1 + 0.924\,D_1 + 0.383\,E_1\\
0 &= -\,1.0582 + 8.442\,A_1 + 8.310\,B_1 + 0.462\,C_1 - 1.205\,D_1 - 4.543\,E_1\\
0 &= +\,0.3128 - 5.641\,A_1 + 0.462\,B_1 + 8.691\,C_1 + 3.900\,D_1 - 4.438\,E_1\\
0 &= -\,0.0407 + D_1 + \tfrac{1}{2}\,(B_1^2 - C_1^2)\\
0 &= +\,0.0013 + E_1 + B_1\,C_1
\end{aligned}
$$

Hence

$$
\begin{aligned}
A_1 &= +\,0.0564 = +\,3^\circ\ 14'.0\\
B_1 &= +\,0.0766 = +\,4\ \ 23.5\\
C_1 &= -\,0.0205 = -\,1\ \ 10.4\\
D_1 &= +\,0.0380 = +\,2\ \ 10.5\\
E_1 &= \ \ \ 0.0000 = \ \ 0\ \ \ 0.0
\end{aligned}
$$

The following are the equations of condition for the determination of the cients of the After Ritchie Compass at Monte Video.

$$
\begin{aligned}
0 &= -\,240' + 1.000\,A_1 \quad 0.000\,B_1 + 1.000\,C_1 \quad 0.000\,D_1 + 1.000\,E_1\\
0 &= -\,570 + 1.000\,A_1 + 0.195\,B_1 + 0.981\,C_1 + 0.383\,D_1 + 0.924\,E_1\\
0 &= -\,570 + 1.000\,A_1 + 0.383\,B_1 + 0.924\,C_1 + 0.707\,D_1 + 0.707\,E_1\\
0 &= -\,740 + 1.000\,A_1 + 0.556\,B_1 + 0.831\,C_1 + 0.924\,D_1 + 0.383\,E_1\\
0 &= -\,740 + 1.000\,A_1 + 0.707\,B_1 + 0.707\,C_1 + 1.000\,D_1 \quad 0.000\,E_1\\
0 &= -\,740 + 1.000\,A_1 + 0.831\,B_1 + 0.556\,C_1 + 0.924\,D_1 - 0.383\,E_1\\
0 &= -\,910 + 1.000\,A_1 + 0.924\,B_1 + 0.383\,C_1 + 0.707\,D_1 - 0.707\,E_1\\
0 &= -\,900 + 1.000\,A_1 + 0.981\,B_1 + 0.195\,C_1 + 0.383\,D_1 - 0.924\,E_1\\
0 &= -\,560 + 1.000\,A_1 + 1.000\,B_1 \quad 0.000\,C_1 \quad 0.000\,D_1 - 1.000\,E_1\\
0 &= -\,240 + 1.000\,A_1 + 0.981\,B_1 - 0.195\,C_1 - 0.383\,D_1 - 0.924\,E_1\\
0 &= -\,230 + 1.000\,A_1 + 0.924\,B_1 - 0.383\,C_1 - 0.707\,D_1 - 0.707\,E_1\\
0 &= -\,\ \ 60 + 1.000\,A_1 + 0.831\,B_1 - 0.556\,C_1 - 0.924\,D_1 - 0.383\,E_1\\
0 &= +\,270 + 1.000\,A_1 + 0.707\,B_1 - 0.707\,C_1 - 1.000\,D_1 \quad 0.000\,E_1\\
0 &= +\,100 + 1.000\,A_1 + 0.556\,B_1 - 0.831\,C_1 - 0.924\,D_1 + 0.383\,E_1\\
0 &= -\,240 + 1.000\,A_1 + 0.383\,B_1 - 0.924\,C_1 - 0.707\,D_1 + 0.707\,E_1\\
0 &= -\,240 + 1.000\,A_1 + 0.195\,B_1 - 0.981\,C_1 - 0.383\,D_1 + 0.924\,E_1\\
0 &= -\,240 + 1.000\,A_1 \quad 0.000\,B_1 - 1.000\,C_1 \quad 0.000\,D_1 + 1.000\,E_1\\
0 &= -\,410 + 1.000\,A_1 - 0.195\,B_1 - 0.981\,C_1 + 0.383\,D_1 + 0.924\,E_1\\
0 &= -\,410 + 1.000\,A_1 - 0.383\,B_1 - 0.924\,C_1 + 0.707\,D_1 + 0.707\,E_1\\
0 &= -\,240 + 1.000\,A_1 - 0.556\,B_1 - 0.831\,C_1 + 0.924\,D_1 + 0.383\,E_1\\
0 &= -\,240 + 1.000\,A_1 - 0.707\,B_1 - 0.707\,C_1 + 1.000\,D_1 \quad 0.000\,E_1\\
0 &= -\,570 + 1.000\,A_1 - 0.831\,B_1 - 0.556\,C_1 + 0.924\,D_1 - 0.383\,E_1
\end{aligned}
$$

The resulting normal equations are

$$
\begin{aligned}
0 &= -\ 2.5365 + 22.000\ A_1 + 7.482\ B_1 - \ 3.999\ C_1 + 3.938\ D_1 + 2.631\ E_1 \\
0 &= -\ 1.0294 + \ 7.482\ A_1 + 9.685\ B_1 + \ 1.969\ C_1 - 2.334\ D_1 - 3.774\ E_1 \\
0 &= -\ 0.3901 - \ 3.999\ A_1 + 1.969\ B_1 + 12.316\ C_1 + 3.708\ D_1 - 1.665\ E_1 \\
0 &= -\ 0.0340 + D_1 + \tfrac{1}{2}\,(B_1^2 - C_1^2) \\
0 &= +\ 0.0008 + E_1 + B_1\ C_1
\end{aligned}
$$

Hence

$$
\begin{aligned}
A_1 &= +\ 0.1143 = +\ 6^\circ\ 32'.8 \\
B_1 &= +\ 0.0146 = +\ 0\ \ 50.3 \\
C_1 &= +\ 0.0555 = +\ 3\ \ 10.9 \\
D_1 &= +\ 0.0354 = +\ 2\ \ 1.8 \\
E_1 &= -\ 0.0016 = -\ 0\ \ 5.5
\end{aligned}
$$

The following are the equations of condition, together with the resulting normal equations, and the values of the coefficients A_1, B_1, C_1, D_1, E_1, as determined for each compass from the observations made in Magdalena Bay.

EQUATIONS OF CONDITION AT MAGDALENA BAY.

Absolute Terms.						Coefficients of the Unknown Quantities.				
Admiralty Standard.	After Binnacle.	After Ritchie.	Forward Alidade.	Forward Binnacle.	Forward Ritchie.	A_1	B_1	C_1	D_1	E_1
+ 20′	— 10′	— 100′	— 300′	— 300′	— 540′	+ 1.000	— 0.707	— 0.707	+ 1.000	0.000
+ 60	— 10	— 180	— 370	— 290	— 460	+ 1.000	— 0.831	— 0.556	+ 0.924	— 0.383
+ 110	+ 80	— 180	— 210	— 210	— 380	+ 1.000	— 0.924	— 0.383	+ 0.707	— 0.707
+ 140	+ 160	— 180	— 130	— 210	— 290	+ 1.000	— 0.981	— 0.195	+ 0.383	— 0.924
+ 180	+ 170	— 80	— 130	— 120	— 200	+ 1.000	— 1.000	0.000	0.000	— 1.000
+ 230	+ 320	+ 170	— 210	+ 50	+ 50	+ 1.000	— 0.981	+ 0.195	— 0.383	— 0.924
+ 230	+ 320	+ 330	— 130	+ 130	+ 210	+ 1.000	— 0.924	+ 0.383	— 0.707	— 0.707
+ 250	+ 320	+ 320	— 120	+ 210	+ 210	+ 1.000	— 0.831	+ 0.556	— 0.924	— 0.383
+ 220	+ 320	+ 160	— 40	+ 300	+ 210	+ 1.000	— 0.707	+ 0.707	— 1.000	0.000
+ 220	+ 320	+ 160	— 40	+ 380	+ 300	+ 1.000	— 0.556	+ 0.831	— 0.924	+ 0.383
+ 160	+ 320	+ 150	+ 40	+ 380	+ 370	+ 1.000	— 0.383	+ 0.924	— 0.707	+ 0.707
+ 100	+ 230	+ 60	+ 40	+ 380	+ 210	+ 1.000	— 0.195	+ 0.981	— 0.383	+ 0.924
+ 40	+ 150	— 100	+ 40	+ 370	+ 210	+ 1.000	0.000	+ 1.000	0.000	+ 1.000
+ 30	+ 70	— 190	— 50	+ 290	+ 120	+ 1.000	+ 0.195	+ 0.981	+ 0.383	+ 0.924

Normal Equations.

ADMIRALTY STANDARD COMPASS.

$$
\begin{aligned}
0 &= +\ 0.5789 + 14.000\ A_1 - 8.825\ B_1 + 4.717\ C_1 - 1.631\ D_1 - 1.090\ E_1 \\
0 &= -\ 0.4310 - \ 8.825\ A_1 + 7.545\ B_1 - 0.816\ C_1 + 0.934\ D_1 + 4.272\ E_1 \\
0 &= +\ 0.2352 + \ 4.717\ A_1 - 0.816\ B_1 + 6.456\ C_1 - 4.554\ D_1 + 3.784\ E_1 \\
0 &= -\ 0.0169 + D_1 + \tfrac{1}{2}\,(B_1^2 - C_1^2) \\
0 &= +\ 0.0009 + E_1 + B_1\ C_1
\end{aligned}
$$

Hence

$$
\begin{aligned}
A_1 &= +\ 0.0026 = +\ 0^\circ\ \ 9'.1 \\
B_1 &= +\ 0.0559 = +\ 3\ \ 12.1 \\
C_1 &= -\ 0.0204 = -\ 1\ \ 10.3 \\
D_1 &= +\ 0.0156 = +\ 0\ \ 53.5 \\
E_1 &= +\ 0.0002 = +\ 0\ \ 0.8
\end{aligned}
$$

AFTER BINNACLE COMPASS.

$$\begin{aligned}
0 &= +0.8029 + 14.000\,A_1 - 8.825\,B_1 + 4.717\,C_1 - 1.631\,D_1 - 1.090\,E_1\\
0 &= -0.5291 - 8.825\,A_1 + 7.545\,B_1 - 0.816\,C_1 + 0.934\,D_1 + 4.272\,E_1\\
0 &= +0.4497 + 4.717\,A_1 - 0.816\,B_1 + 6.456\,C_1 - 4.554\,D_1 + 3.784\,E_1\\
0 &= -0.0385 + D_1 + \tfrac{1}{2}(B_1^2 - C_1^2)\\
0 &= +0.0018 + E_1 + B_1\,C_1 + 0.0047\,(B_1^2 - C_1^2)
\end{aligned}$$

Hence

$$\begin{aligned}
A_1 &= -0.0208 = -1^\circ\ 11'.4\\
B_1 &= +0.0393 = +2\ \ 15.0\\
C_1 &= -0.0222 = -1\ \ 16.2\\
D_1 &= +0.0380 = +2\ \ 10.5\\
E_1 &= -0.0010 = -0\ \ 3.3
\end{aligned}$$

AFTER RITCHIE COMPASS.

$$\begin{aligned}
0 &= +0.0989 + 14.000\,A_1 - 8.825\,B_1 + 4.717\,C_1 - 1.631\,D_1 - 1.090\,E_1\\
0 &= -0.1171 - 8.825\,A_1 + 7.545\,B_1 - 0.816\,C_1 + 0.934\,D_1 + 4.272\,E_1\\
0 &= +0.2238 + 4.717\,A_1 - 0.816\,B_1 + 6.456\,C_1 - 4.554\,D_1 + 3.784\,E_1\\
0 &= -0.0340 + D_1 + \tfrac{1}{2}(B_1^2 - C_1^2)\\
0 &= +0.0008 + E_1 + B_1\,C_1
\end{aligned}$$

Hence

$$\begin{aligned}
A_1 &= +0.0627 = +3^\circ\ 35'.5\\
B_1 &= +0.0778 = +4\ \ 27.3\\
C_1 &= -0.0497 = -2\ \ 51.0\\
D_1 &= +0.0322 = +1\ \ 50.7\\
E_1 &= +0.0031 = +0\ \ 10.6
\end{aligned}$$

FORWARD ALIDADE COMPASS.

$$\begin{aligned}
0 &= -0.4683 + 14.000\,A_1 - 8.825\,B_1 + 4.717\,C_1 - 1.631\,D_1 - 1.090\,E_1\\
0 &= +0.4115 - 8.825\,A_1 + 7.545\,B_1 - 0.816\,C_1 + 0.934\,D_1 + 4.272\,E_1\\
0 &= +0.1082 + 4.717\,A_1 - 0.816\,B_1 + 6.456\,C_1 - 4.554\,D_1 + 3.784\,E_1\\
0 &= -0.0235 + D_1 + \tfrac{1}{2}(B_1^2 - C_1^2)\\
0 &= -0.0007 + E_1 + B_1\,C_1 + 0.0125\,(B_1^2 - C_1^2)
\end{aligned}$$

Hence

$$\begin{aligned}
A_1 &= +0.0200 = +1^\circ\ 8'.8\\
B_1 &= -0.0361 = -2\ \ 4.1\\
C_1 &= -0.0197 = -1\ \ 7.6\\
D_1 &= +0.0230 = +1\ \ 19.2\\
E_1 &= \ \ 0.0000 = \ \ 0\ \ 0.0
\end{aligned}$$

FORWARD BINNACLE COMPASS.

$$\begin{aligned}
0 &= +0.3956 + 14.000\,A_1 - 8.825\,B_1 + 4.717\,C_1 - 1.631\,D_1 - 1.090\,E_1\\
0 &= +0.0125 - 8.825\,A_1 + 7.545\,B_1 - 0.816\,C_1 + 0.934\,D_1 + 4.272\,E_1\\
0 &= +0.7497 + 4.717\,A_1 - 0.816\,B_1 + 6.456\,C_1 - 4.554\,D_1 + 3.784\,E_1\\
0 &= -0.0369 + D_1 + \tfrac{1}{2}(B_1^2 - C_1^2)\\
0 &= -0.0011 + E_1 + B_1\,C_1
\end{aligned}$$

Hence

$$\begin{aligned}
A_1 &= -0.0298 = -1^\circ\ 42'.6\\
B_1 &= -0.0478 = -2\ \ 44.3\\
C_1 &= -0.0719 = -4\ \ 7.3\\
D_1 &= +0.0384 = +2\ \ 11.8\\
E_1 &= -0.0023 = -0\ \ 7.9
\end{aligned}$$

FORWARD RITCHIE COMPASS.

$$\begin{aligned}
0 &= +0.0058 + 14.000\,A_1 - 8.825\,B_1 + 4.717\,C_1 - 1.631\,D_1 - 1.090\,E_1\\
0 &= +0.2058 - 8.825\,A_1 + 7.545\,B_1 - 0.816\,C_1 + 0.934\,D_1 + 4.272\,E_1\\
0 &= +0.6749 + 4.717\,A_1 - 0.816\,B_1 + 6.456\,C_1 - 4.554\,D_1 + 3.784\,E_1\\
0 &= -0.0407 + D_1 + \tfrac{1}{2}(B_1^2 - C_1^2)\\
0 &= +0.0013 + E_1 + B_1\,C_1
\end{aligned}$$

Hence

$$\begin{aligned}
A_1 &= +0.0477 = +2^\circ\ 43'.8\\
B_1 &= +0.0116 = +0\ \ 39.9\\
C_1 &= -0.1051 = -6\ \ \ 1.3\\
D_1 &= +0.0462 = +2\ \ 38.7\\
E_1 &= -0.0004 = -0\ \ \ 1.3
\end{aligned}$$

For convenience of reference the values of the coefficients A_1, B_1, C_1, D_1, E_1, obtained at stations where the compasses were not read on all the thirty-two points, have been collected in the following table. No use has been made of them.

Stations and Compasses.	A_1	B_1	C_1	D_1	E_1
Ceara, December 19, 1865.					
Admiralty Standard Compass	− 0° 35′.1	+ 4° 46′.3	+ 2° 19′.2	+ 0° 48′.8	− 0° 14′.8
After Binnacle Compass	+ 0 21.3	+ 4 35.2	+ 2 4.6	+ 2 3.6	− 0 16.3
After Ritchie Compass	+ 5 54.2	+ 7 56.0	+ 4 55.4	+ 1 36.6	− 0 43.7
Forward Alidade Compass	+ 2 3.5	+ 0 0.2	+ 1 4.8	+ 1 21.4	+ 0 2.4
Forward Binnacle Compass	− 0 54.7	+ 0 24.6	+ 1 26.9	+ 2 7.8	+ 0 3 2
Forward Ritchie Compass	+ 3 31.0	− 0 26.1	+ 3 36.9	+ 2 26.6	− 0 3.9
Rio Janeiro, January 10, 1866.					
Admiralty Standard Compass	+ 2 35.7	+ 2 58.5	+ 0 0.2	+ 0 53.5	− 0 3.1
After Binnacle Compass	+ 0 50.8	+ 5 25.4	− 0 25.2	+ 1 57.1	− 0 4.1
After Ritchie Compass	+ 9 39.0	+ 3 46.6	+ 1 9.8	+ 1 50.1	− 0 7.4
After Azimuth Compass	− 2 29.3	− 1 8.5	− 3 9.7	+ 6 28.2	− 0 4.5
Forward Alidade Compass	+ 3 31.5	− 0 28.8	− 0 57.2	+ 1 21.1	+ 0 1.9
Forward Binnacle Compass	− 0 17.1	+ 2 59.8	− 1 45.5	+ 2 3.7	+ 0 9.3
Forward Ritchie Compass	+ 3 14.0	+ 4 23.5	− 1 10.4	+ 2 10.5	0 0.0
Monte Video, January 24, 1866.					
After Ritchie Compass	+ 6 32.8	+ 0 50.3	+ 3 10.9	+ 2 1.8	− 0 5.5
Magdalena Bay, June 9, 1866.					
Admiralty Standard Compass	+ 0 9.1	+ 3 12.1	− 1 10.3	+ 0 53.5	+ 0 0.8
After Binnacle Compass	− 1 11.4	+ 2 15.0	− 1 16.2	+ 2 10.5	− 0 3.3
After Ritchie Compass	+ 3 35.5	+ 4 27.3	− 2 51.0	+ 1 50.7	+ 0 10.6
Forward Alidade Compass	+ 1 8.8	− 2 4.1	− 1 7.6	+ 1 19.2	0 0.0
Forward Binnacle Compass	− 1 42.6	− 2 44.3	− 4 7.3	+ 2 11.8	− 0 7.9
Forward Ritchie Compass	+ 2 43.8	+ 0 39.9	− 6 1.3	+ 2 38.7	− 0 1.3

At a number of the ports visited during the cruise, the line dividing the north from the south polarity, on the exterior of the turrets, was traced out; but as the boundary between the two kinds of magnetism was frequently very badly defined, and the observations were otherwise unsatisfactory; and further, as they throw no light whatever on the theory of the deviations of the compasses, and can only be shown by means of drawings on a rather large scale, it has not been deemed worth while to insert them here.

In conclusion, the results of the observations made during the cruise may be briefly recapitulated as follows:

1°. The latitudes of seven points have been determined.

2°. The magnetic declination, inclination, and horizontal force, have been determined at eighteen places.

3°. The deviations of seven compasses have been observed, and compared with the theory, at ten places so situated as to afford very great changes in the terrestrial magnetic elements. For all these compasses the coefficients depending upon the hard and soft iron have been so far separated from each other as to render it possible to predict the deviations in any part of the world; and for the Admiralty Standard and After Azimuth Compasses every one of the coefficients in Poisson's general equations has been determined separately with a considerable degree of accuracy.

The conclusions drawn from the discussion of the observations are that, in the case of the Monadnock,

a. The agreement between the theoretical and observed deviations is sufficiently exact for the purposes of navigation, but is not entirely satisfactory in a scientific point of view.

b. It is questionable whether the theory really represents the semicircular as well as it does the quadrantal deviation; and to settle this point there is great need of more observations.

c. The so-called permanent and subpermanent magnetism of the ship were undergoing a constant and rapid change such as would correspond to a transfer of magnetism from aft forward; and to a rotation from right to left in the direction of the force.

d. The ratio of the hard to the soft iron force was slowly varying at each compass; and, for the different compasses it ranged between 4.3 and 67.4.

e. There was not a compass on board at which the direction of the hard and soft iron forces coincided; from which it follows that in no case was the ratio of the hard to the soft iron force the same in the coefficient $\mathfrak{B}$ as it was in the coefficient $\mathfrak{C}$.

f. So far as can be judged from the observations discussed in this report, in the case of a vessel swung for the first time, it is impossible to make any reliable estimate of the ratio of the hard to the soft iron force in the coefficients $\mathfrak{B}$ and $\mathfrak{C}$; and therefore, it is also impossible to make any reliable estimate of the changes the deviations of the compasses will undergo upon a change of magnetic latitude.