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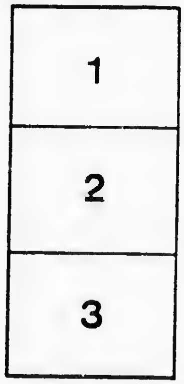
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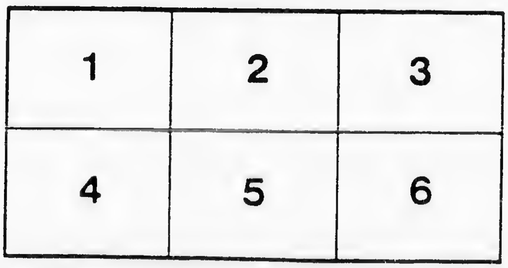
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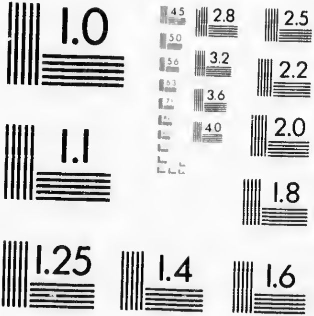

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QUESTIONS

FOR

EXERCISE IN NAVIGATION,

Embracing all of that Science required by the Marine Boards of Examination in England.

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QUESTIONS FOR EXERCISE

IN

NAVIGATION,

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EXPEDITION AND ACCURACY

IN

NAUTICAL CALCULATIONS.

In Two Parts.

PART 1ST.—Logarithms—Log-line—Trigonometry—the various sailings—Latitude by observation of any of the heavenly bodies—Variation of the Compass—Tides, &c.

PART 2ND.—Chronometer—its error and rate--Equation of time—Apparent time from the altitude of the sun, moon, star, or planet—Greenwich mean time by Lunars—Great circle sailing.

BY JAMES CAMPBELL.

"Old sages say, Dame Truth is known to dwell
(Strange place enough) at the bottom of a well
And QUESTIONS are the windlass and the rope
To pull the grave old gentlewoman up."—P. PINDAR.

St. John's Newfoundland:

PRINTED AT THE "TELEGRAPH" OFFICE, BY JOHN T. BURTON.

ERRATA.

Question 113—For 3h. 92m. 20s., read 3h. 42m. 20s.

" 141—For eye 24 feet, read 20 feet

" 151—Equation of time — 0m. 11.42s.

QUESTIONS FOR EXERCISE

IN

NAVIGATION,

RESPECTFULLY INSCRIBED

AND

(BY PERMISSION)

DEDICATED

TO HIS EXCELLENCY

Sir ALEXANDER BANNERMAN, *Knight,*
Governor, &c.

His Excellency's prompt and courteous proffer to give all the patronage in his power to "A work of so great utility and of so great necessity to our Mariners" deserves the gratitude of every one desirous to promote Nautical Science; and as no one can be more desirous to promote this science, so no one can be more grateful to his Excellency than the

AUTHOR.

PREFATORY ADDRESS

To Sir A. Bannerman, *Knight, Governor, &c.*

Sir,—Some few observations seem due to your Excellency, regarding the "Questions for Exercise in Navigation" of which your Excellency so graciously accepted the Dedication, with a frank and earnest proffer to give all the patronage in your power to "a work of so great utility and of so great necessity to our Mariners." These observations seem due also to the public, as it is hoped, through your Excellency's patronage that the expense of publication will be afforded from the public funds.*

Your Excellency has declared yourself but too well aware of the deficiency of our seamen in Nautical Science, how to best remedy this deficiency has been to me a subject of much consideration. I know that to understand the Science of Navigation thoroughly, it would be necessary to learn systematically both branches of Trigonometry, Plane and Spherical--the first to understand the Sailings, the second to understand Nautical Astronomy; but to become masters of a science so abstruse to them, cannot be expected from the class of men generally, who are destined to navigate the ships of the merchant service. To learn Navigation by lectures or written treatises is quite impossible, so that no other means seems left to acquire a practical knowledge of

* The business of the Assembly having been closed before the arrival of this work in St. John's, His Excellency regretting the circumstance, and anxious to promote the Science of Navigation by all the means in his power, suggested the publication by subscription from Merchants, Ship-owners, &c., he himself subscribing for that end ten pounds—(vide list of Subscribers.)

Navigation than by practice in working out, and solving questions for exercise in Navigation, to acquire an accurate knowledge of the application of the rules deduced from the above science. These rules are concise and easy to those who understand fully the terms in which they are expressed, but experience enables me to say that our seamen are very deficient in this respect, and consequently have the more need of questions for exercise,certainly for more than is given in Norie's Epitome of Navigation, the only work on that science used in our Schools. To find the altitude of the heavenly bodies, for example, at a given time and place, is a problem of the greatest importance to the navigator, and yet, though Norie gives the rules, he does not give even one question for exercise on them.

In these questions for exercise which I have the honour to present to your Excellency, there are but four or five questions for each particular rule, the answers are given to three or four, so that one or two are left to the skill of the learner to find the answer. As the Nautical Boards of Examination in England require some particulars to find which there is no rule given in Norie's Epitome, I have given the requisite rules in the Appendix, so that all of navigation required by the Marine Boards of Examination established by law in Great Britain, is embraced in these exercises, and he who learns to solve these questions thoroughly, will be qualified to undergo an examination in navigation for a first-class Master at any of those Boards.

But questions for exercise in navigation, as your Excellency must know, are not sufficient for the nautical student; a school in which to learn to solve these questions, is necessary for him. In this school he should be taught to use the Nautical Almanac, a thorough knowledge of which is indispensable to the navigator. In this school he should be taught to adjust the nautical instruments and find the amount of the error arising from the want of due adjustment, with the proofs of such adjustment or error being correctly found. In this school, in short, the young student in navigation should be taught and made to practice taking altitudes and distances of the heavenly bodies, and from these altitudes and distances find the apparent and mean time, and thence the error and rate of a chronometer, the greatest desideratum in the modern practice of navigation. Finally, an efficient nautical school is requisite not only for the practitioner, but also for the teacher of Navigation; the means of duly qualifying themselves for their profession should be afforded to both.

Your Excellency is aware that since September 1st, 1851, no ship or vessel is allowed to clear out from any Custom-House in Great Britain, unless the Master and Mate produce Certificates of competency granted them, after a rigid examination by the Marine Board of Examination established by law for that purpose. Should not the example set by England be sufficient to induce the Colonists to endeavour to raise the qualifications of the Masters and Mates of their merchant vessels? England understands well the interests of trade, commerce and navigation, and to promote these interests, she has determined to raise the qualifications of those destined to navigate, her merchant vessels. Would not the interests of the trade, commerce and navigation of the Colonies be promoted by a similar procedure? As it is the peculiar province of persons in your Excellency's position, to inaugurate and give effect to measures calculated to advance the public weal, these suggestions are here respectfully submitted by

Your Excellency's
Most obedient,
Most humble Servant,
JAMES CAMPBELL.

N.B.—" In all our sea-port towns, Night Schools are now established, and well attended by our merchant seamen, especially the apprentices and junior officers and there receiving instructions and qualifying themselves for the respective grades of their profession; whereas, formerly these people generally spent their nights in tippling-houses and other resorts of immorality. Such are some of the benefits resulting from the late amendment in our Marine Laws."—*Shipping Gazette.*

Part the First.

Logarithms—Log-line—Trigonometry—The various Sailings—Latitude by Observation of any of the Heavenly bodies—Variation of the Compass—Tides, &c.

1. Find the log for the natural number 87683.
   Answer—4.942915.
2. Find the log for the decimal number .0764.
   Answer—8.883093.
3. Find the decimal number for the log 6.987645.
   Answer—.0009719.
4. Find the whole number for the log 5.989665.
   Answer—976484.
5. Find the log for the whole number 36.558.
   Answer—1.562982.
6. Find the log for the number $3\frac{7}{9}$.
   Answer—0.577230.
7. By logarithms multiply 76.4 by 5.4.
   Answer—412.56.
8. By logarithms divide 479.5 by 25.2.
   Answer—19.03.
9. If a Chronometer loses 3.7 seconds daily, required the loss in 7 weeks, 4 ds. 8h. by logarithms.
   Answer—3′.17″.3.
10. Find the log. co. secant for 81° 17′ 41″.
    Answer—10.005032.
11. Find the log. sec. and co. sec for 105° 19′ 25″.
    Answer— { sec. 10.577951. co. sec. 10.015727.
12. Find the log. sine for 0° 21′ 35″.
    Answer—7.797839.
13. Find the log. co.tang. for 89° 48′ 43″.
    Answer—7.516153.
14. Find the logs. co. sine. co.tang. and co. sec. for 47° 34′.35″.
    Answer— { co. sir. 9.829051. co.tang. 9.960890. co.sec. 10.131840.

The length of the knot of the log-line depends on the number of seconds the glass runs. The most common method is to see how many seconds a glass runs and to the seconds annex a cipher, then divide by 6, the quotient will be the length of the knot in feet and fraction of a foot.

15. Required the length of the knot when a glass runs 31 seconds, 310 divided by 6 gives for answer, 51 feet 8 in.

16. If a glass runs out in 27 seconds, what should be the length of the knot.

Answer—45 feet.

17. If a ship is running $7\frac{1}{2}$ knots an hour by a log-line of 45 feet, used with a glass that runs 29 seconds, what will be her true rate of sailing per hour.

Answer—7 knots.

18. A ship sails 300 miles by a log-line of 50 feet to a knot used with a glass that runs out in 29 seconds. Required the true distance run.

Answer—310 miles.

In whatever direction a vessel sails off the meridian, the distance she runs forms the side of a triangle, and the compass indicates the angle: thus all sailings are triangles, the solution of which (called plane trigonometry) should be thoroughly understood by the navigator.

19. A ship from lat. 20°.35′ N. sailed in a direct course between south and west 280 miles and then her departure is 77 miles more than her difference of latitude. Required the course steered and latitude in.

Answer—course steered S. 56°.13′W. lat. in 17°.59′N.

20. The base of a triangle is 20. the angle opposite 48°30′ the sum of the other sides 36. Required the other angles and the sides separately.

Answer—Angles 23°.26′.
108°. 4′.
Sides 10.62
25.39

21. One side of a triangle is 20. the adjacent angles are 28° and 45°. Required the other two sides and

angle. Or, a light bears from a ship E. 28° N. then having run eastwardly 20 miles, the same light bears W. 45° N. Required the ship's distance from the light at the time of taking each bearing.

Answer—At 1st bearing dist. 14.79′.
2nd do do 9. 8′.

22. Given the two sides and the contained angle, to find the other angles and third side. Or, a ship is bound to a port which bears S.b.W$\frac{1}{2}$W. distant 150 miles. sails S.S.E.$\frac{1}{2}$E. 130 miles. Required her course and distance to her port.

Answer—course S. 74°.35$\frac{1}{2}$′W. dist. 108.7 miles.

23. A ship sails from a port, (suppose St. John's N. F.) 250 miles, in the south east quarter: then has to heave to in a gale in which she drifts 235.5 miles in the north west quarter: when she bears up and after a run of 141 miles, anchors at St. John's. Required the courses steered and her drift.

Answer—1st course S.E.b.S.
Drift W.N.W.
2nd course N.E.b.N.

24. Required the course and distance from Baccalieu island N. F. to the isle of Valencia, Ireland, by Mercators sailing.

Answer—Course N. 82°.8′E.
Distance 1650 miles.

25. How many miles to a degree of longitude on the parallel of St. John's latitude, viz. 47°34′35″.

Answer—44.29 miles.

26. Find by Mercator's sailing, the courses and the whole distance from St. John's N. F. to Hobart Town, Van Diemen's land by the Cape of Good Hope.

Answer—Course to the Cape S. 38°.1′.20″E. dist. 6241
Do from Cape to Hobart T., S. 85°.9′E. dist 6050

Distance from St. John's to Hobart Town 12291

27. A ship sails due east 100 miles and then had made 170 miles dif. of longitude. Required on what parallel of latitude she sailed.

Answer—54°.N. or S.

28. A ship runs a direct course 111.7 miles and then finds her difference of latitude double her departure. Required the course, and difference of latitude and departure made good.

Answer—Course 26° 23′
Dif. of lat. 100 miles
Dep. 50 do.

29. A ship sails N. 13° 38′ E. till she had made 291 miles dif. of longitude, then dropt anchor in the narrows of St. John's N. F. Required the port sailed from.

Answer—Bermudas.

30. The wind at S.W. a ship beating to windward runs 225 miles on her port tacks, and 225 miles also on her starboard tacks, and then finds she has made 150 miles directly to windward. Required the courses steered and how near the wind did the ship lie.

Answer—Course on port tack N. 64° 28′ W.
Do on starboard tack S. 25° 32′ E.
The ship lay 6¼ points from the wind.

31. In what latitude will one mile of departure make two miles dif. of longitude.

Answer—60°.

32. A ship sailing at the rate of 9 miles an hour and wanting to double a cape bearing from her N.W.b.W. finds she is in a current setting S.S.W. 3½ miles an hour. What course must she steer to counteract the effect of the current.

Answer—N. 33° 50′ W.

(*This question is taken from Norie's Epitome of Navigation, page* 125 *and the answer there given is N.* 36° 43′ *W. but this answer is evidently wrong.*)

33. The altitude of Rider's Hill, back of Trinity taken on the ice, was 5° 26′ 30″ then having walked 300 steps, equal to 900 feet, in a direct line towards the hill, the altitude was then found to be 7° 4′ 30″. Required the height of the hill over the level of the sea.

Answer—368 feet.

34. A steam ship bound to a port bearing N.W. 60 miles, runs 11 knots an hour in a current setting N.N.

E. 5 miles an hour. Required the course to be steered, and the distance to be run, to arrive at her port in the shortest time possible.

Answer—Course N. 69° 50′ W. dist. to run 55′.4.

35. In a current known to set N.W. b N. a ship from latitude 38° 20′N. sailed 24 hours, when by her reckoning she is in latitude 38° 42′N. having made 44 miles of easting, but by observation she finds she is in latitude 38° 58′N, Required the true course and distance made good, and the drift of the current.

Answer—Course N41° 14′ E. dist. 50′5.
Drift of current 19′24.

36. The wind at N.E. the bearing of the port N. b E.½E. distant 18 miles, the ship to make her port, ran on her port tack 48 miles, with a course made good 6 points from the wind. She now heaves about. Required what course she must steer, and what distance must she run to reach her port.

Answer—Course N. 47° 42′ W. dist. 53′.

37. Suppose the bearing and distance from Trinity to Perlican be S.S.W. 28 miles; and the wind at S. now, if the Packet make her course good 5½ points from the wind, and purposes to fetch Perlican in two boards. Required the course and distance to be run on each.

Answer—Course S.W.bW.½W. dist. 33.5 miles.
S.E.bE.½E. dist. 21.4 miles.

38. A ship from latitude 48°28′N. and longitude 5°4′W. sails between south and west in a direct course, when by observation she is found to be in longitude 10°40′W. having made 232 miles departure to the westward. Required the latitude in, the course steered, and distance run.

Answer—Course S. 43° 5′W. lat. in 44° 20′N.
Distance run 340 miles.

39. A ship from St. John's, N.F., sailed S. and W. till her departure was 568 miles, and then she was in

longitude 65°58′37″W. Required the course steered, latitude in, and distance run.

Answer—Course steered S. 59° 19′ W.
Lat. in 41° 57′ 25″ N.
Distance run 660.4 miles.

40. A ship taking her departure from Cape St. Roque in latitude 5°28′S. longitude 35°17′W. sailed N. 42°27′E. till she made 600 miles difference of longitude. Required the lat. and long. of the ship.

Answer—Lat. 5° 28′ N.
Long. 25° 17′ W.

41. A clipper ship making her course good $4\frac{3}{4}$ points from the wind, made her port on two boards: the first in the S.W. quarter on the port tack 50 miles, and the other on her starboard tack 70 miles, and by observation the port arrived at is 42 miles southward of the port left. Required the bearing and distance of the port and the direction of the wind.

Answer—Bearing of the port S. 57° E. dist. 77 miles
the wind S. 42° 15′ E.

42. In a current setting S.S.W. $3\frac{1}{2}$ miles an hour, a vessel steered N.W.$\frac{3}{4}$W. 9 miles an hour. Required the true course, and distance made good in 24 hours.

Answer—Course N. 76° W. dist. 211 miles.

43. A ship arrived at James' Town, St. Helena, after a course made good N. 49°41′34″ W. having made 1450 miles dif. of longitude. Required the distance run and the latitude and longitude left.

Answer—Dist. run 1710 miles
Place left Cape of Good Hope.

44. Required by Mercator's sailing the course and distance from Cape Clear, Ireland, to Sandy Hook, New York.

Answer—Course S. 76° 12′ 45″ W.
Distance 2758 miles.

45. Required by Mercator's sailing, the difference to a steamer from Liverpool to New York, (making Cape Clear her departure) by calling at St. John's N. F.

Answer—49 miles shorter by Calling at St. John's

46. A master of ship finds the true bearing of his

ship to her port to be N.b.E.$\frac{1}{2}$E. a current is known to set S. $\frac{1}{2}$E. 3 miles an hour—the variation of the compass is know to be $2\frac{1}{4}$ points W. and the ship running 8 knots. It is required to find the course by compass to run direct into port.

Answer—N. 33.56′E—N.E.b.N. nearly

47. Required the difference of latitude between two parallels on opposite sides of the equator the meridian distance in one parallel being 338 miles and in the other 196 miles, while at the equator, it is 358 miles.

Answer—76° 3′, or 19° 15′ on one side,
And 56° 48′ on the other side
of the equator.

48. Suppose a ship is bound to a port directly north and distant 25 miles, has the wind directly ahead. Now if the ship make her course good 6 points from the wind, what distance should she run on each of two tacks to fetch her port.

Answer—$32\frac{1}{2}$ miles on each.

49. Required by Mercators sailing, the course and distance from Cape East, New Zealand, in lat. 37° 44′ 30 S. long. 178° 36′ 15″ E. to Cape Horn in lat. 55° 58′ 40″ S. long. 67° 12′ 25″ W.

Answer—Course S. 76° 40′ E. dist. 47.44′

50. A ship is in latitude by observation 51° 40′ N. and longitude by chronometer 54° 50′ W. the true bearing of a Cape was observed to be N. 44° W. and having run W.N.W. 30 miles, the Cape bore N. 12° W. Required the latitude and longitude of the Cape, and find on the Chart what cape it is.

Answer—Lat. of the Cape 52° 14′ N. long. 55° 43′ W.
Cape Charles Labrador.

51. Suppose England at war with Russia, and the British Consul at New York sends a telegraph message to the Admiral or Governor at St. John's, N. F. to the effect that—a Russian agent at New York had purchased, and freighted with munitions of war and specie, a large steam ship which had sailed for St. Petersburgh and,

therefore, her course should be from Sandy Hook, to Cape Scaw, north of Denmark, and her speed supposed to be 10 miles an hour. To intercept this vessel, a man of war steamer is dispatched from St. John's whose speed may be made 12 knots an hour, and starts 72 hours after the departure of the Russian Steamer from New York. It is required to find what course should be steered, what distance must be run, and what time it will take the British steamer to fall in with the Russian, and what will be latitude and longitude of the place of interception.

Answer- British strm's. course S. 28° 5′. W.
Distance to run 185 miles
Time 15h. 26m.
Place of interception lat. 44° 51′. N.
Long. 51° 44½′ W.

52. It is required to find the latitude and longitude of the Russian steamer (in the last question) when in the nearest point to St. John's, and what time after her departure from New York, the British steamer should start from St. John's to intercept her in that point, and what course should be steered and distance should be run to do so.

Answer—In the R. Str's. course, the nearest point to St John's is latitude 45° 31′ N.
Longitude 51° 42′.W.
British steamers course S. 17° 31′. E.
Ditto's distance to run 130 miles
Time to start 89h. 52m. after the departure of the Russian from New York.

As there is no question in Norie's Epitome similar to the two last questions, they are here given and explained by projection for the learner

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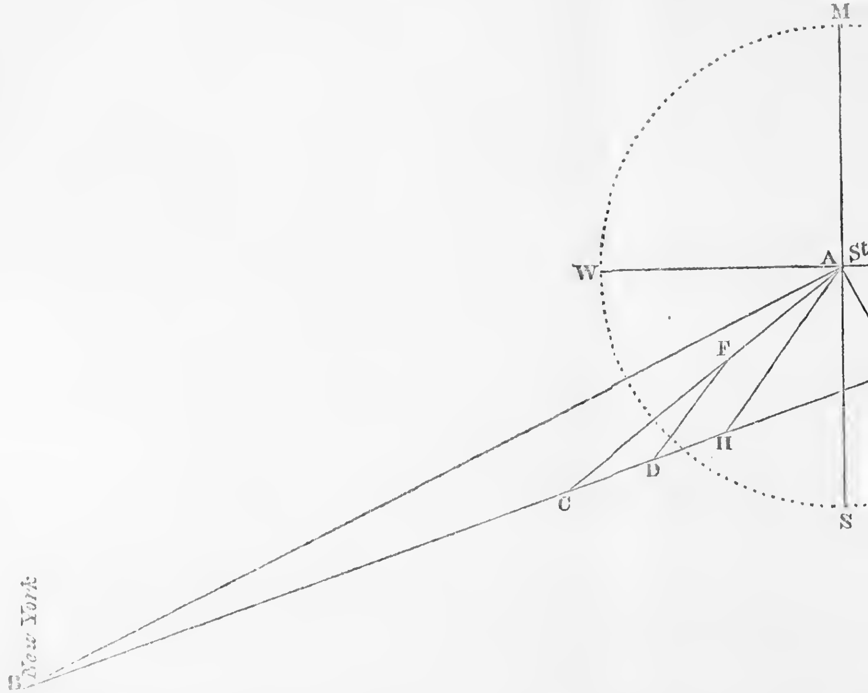
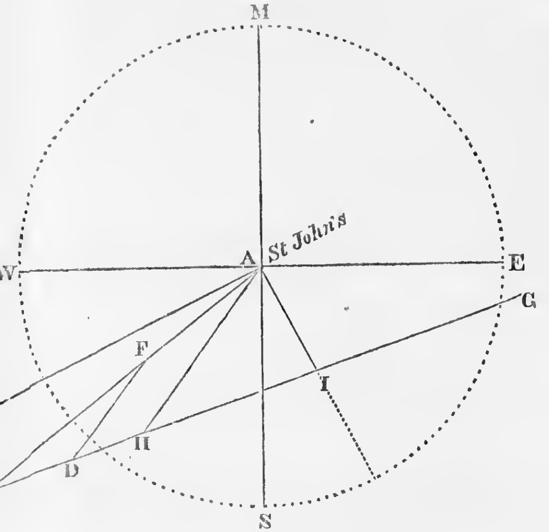


N.S.E.W. represent the compass. A. the centre, St. John's. B, New York, the line B G the course fr
The line A B the course and distance from St. John's to New York. C, 720 miles from New York, is th
when the British steamer started from St. Johns. From C to D lay off 10 miles from any scale of equa
take 12 miles in the compasses, and put one leg on D, and the other leg will reach to F in the line A
through A, draw A H which is the distance the British steamer has to run, viz., 185′ and H A S her
place of interception in latitude 44° 51′ N. longitude 54° 44½′ W.

For the second question—From A let fall a perpendicular on B G at I, then A I is the distance, 130
has to run. S. A I her course S. 17° 31′ E. I the nearest point to St. John's, is the point of intercept
tude 51° 42′ W.



York, the line B G the course from New York to Cape Scaw.
C, 720 miles from New York, is the place of the Russian steamer
10 miles from any scale of equal parts. From the samo scale
leg will reach to F in the line A C. Join D F and parallel to it
to run, viz., 185′ and H A S her course S. 28° 5′ W. and H the

t I, then A I is the distance, 130 miles which the British steamer
t. John's, is the point of interception in latitude 45° 31′ N. longi-

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Error

Latitude by Observation, Variation of the Compass, Tides.

Note.—As the Meridian altitude of the sun, or any other of the heavenly bodies, is always equal to the *sum* of the co. latitude of the place of observation and the declination of the object, when they are both north or both south, or to their *difference* when one is north and the other south: then when the latitude of a place is known the meridian altitude of the sun or other object can be easily found: and it would be advisable for a person not well skilled in the use and adjustment of the quadrant or sextant, to find when he knows his latitude, what the meridian altitude should be on his quadrant if correctly taken: when the altitude on his quadrant agrees with the altitude found by account, he may be sure of the correctness of his instrument and of his own skill, but if they do not agree, he may be certain that his instrument or his skill is in fault.

53. May 27, 1857, in lat. 48° 42′ 40″ N. long. 53° W. (Gull Islaud, Bonavista) the meridian altitude of the Sun's l.l. was taken and read off the quadrant 62° 10′ the ey 18c feet over the sea. Required the error.

		⊙ Decl. May 27, 1857, N. A.	21° 20′ 30″ N.
		Correction for long. 53° W.	1.26
		Reduced declination	21:21:56 N.
Lat. in	48° 42′ 40″ N.	Observed alt. sun's l.l.	62° 10′ 0″
	90		
Co. lat.	41. 17. 20 N.	Dip for 18 feet	4.4
			62. 5. 56
Decl.	21. 21. 56 N.	Refraction	30
⊙'s true alt.	62. 39. 16		62. 5. 26
		⊙ sem. diameter	15. 49
	62. 21. 15	⊙'s observed alt.	62: 21. 15
Error	18 miles		

54. March 21, 1858, about 15 miles east of Cape Spear, the observed meridian altitude of ☉ is 42° 43′ the eye 20 feet. Required the error of altitude.

Answer—7½ miles.

55. Nov. 20, 1858, in lat. 30° 15′ N. long. 120° E. the observed meridian altitude of the ☉ is 39° 51′ the eye 22 feet. Required the error of altitude, if any.

Answer—5 miles.

56. Sept. 19, 1858, in latitude 14° 20′ S. long. 176° W. what should the meridian altitude of the ☉ be on the quadrant, the eye 18 feet over the sea.

Answer 74° 9′ 43″.

57. Sep. 23, 1858, in lat. 48° 22′ N. long. 53° W. Required the altitude of the moon's centre when on the meridian.

Answer—46° 31′.

58. What time will the star Antares be on the meridian, June the 10th, and what will be its altitude at that time in latitude 51° 28½ N.

Answer—On the meridian 11h. 4m. P.M.
Mer. alt. 12° 24½′

59. What star will be on the meridian about half-past eleven P.M., Jan. 6th, and what will be its meridian altitude in lat. 2° 12′ S.

Answer—Sirius, its mer. alt. 75° 41′.

60. June 2nd, 1858, in longitude 129° W. the observed meridian alt. of the ☉, the observer south of the sun, was 67° 31′ 10″ index error + 1′ 10″ the eye 20 feet over the sea. Required the latitude.

Answer—On the equator.

61. Nov. 15, 1858, in long. 80° 11′ E. the observed meridian alt. of the ☉ N. of observer 67° 43′ index + 1′ 38″ the eye 18 feet over the sea. Required the latitude.

Answer—40° 37′ S.

62. May 7, 1858, in lat. 10° 40′ N. and long. 36° 10′ W. by account, the observed meridian alt. of the ☉ was 83° 44′ the observer south of the sun—Index error

2′ 20″ to subtract—the eye 20 feet over the sea. Required the error of the latitude by account.

	Lat. by observation	10° 43½′ N.
	do. by account	10. 40. N.
Answer—Error		.3½ miles.

63.—Sep. 15, 1858, in long. 60° 32′ E. the observed meridian altitude of the ☉ was 84.32′ 17″ the observer south of the sun: the index error of the sextant + 2′ 48″—the eye 22 feet over the sea. Required the latitude of the place of observation to the nearest second.

Answer—2° 6′ 44″ S.

64. June 10, 1858, in long. 172° W. the observed meridian alt. of the ☉ was 66° 31′ 42″ the observer south of the sun—index error + 1′ 20″ the eye 20 feet over the sea. Required the latitude to the nearest second.

Answer—0° 12′ 14″ S.

65. Oct. 11th, 1858, (about midnight) the observed meridian altitude of the star Spica was, 73° 38′ the observer north of the star—the index error + 45″ the eye 18 feet. Required the lat.

Answer—6° 0′ N.

66. April 12, 1858, (about 3h. A.M.) the meridian altitude of Antares, south of the observer, was found to be 78° 13′ 10″—no index error, the eye 20 feet over the sea. Required the latitude.

Answer—14° 16′ S.

67. Nov. 9, 1858, (about 0h. 30m. A.M.,) the observed meridian altitude of the star Arcturus was 71° 24′ the star north of the observer, the eye 18 feet over the sea, and no index error. Required the latitude.

Answer—1° 15′ N.

68. Nov. 25, 1858, in longitude 45° W. the altitude of the planet Jupiter on the meridian, north of the observer, was 67° 48′ 45″ the index error 2′ 10″ to subtract—the eye 16 feet over the sea. Required the latitude.

Answer—0° 0′ 0″.

69. Oct. 12, 1858, in longitude 53° 30′ W. the observed meridian altitude of the l.l. of the planet Venus, south of the observer, was 33° 35′ the index error—2′ 10″ the eye 20 feet over the sea. In what latitude was the altitude taken.

Answer—In lat. 32° 18′ 42″ N.

70. Dec. 10, 1858, in longitude 12° 20′ E. the observed meridian altitude of Mars, north of observer, was 75° 5′ 24″ the index error, 3′ 20″ to add—the eye 22 feet over the sea. Required the latitude.

Answer—30° 47′ 16″ S.

71.—Sept. 20, 1858 in longitude 36° 40′ W. the meridian alt. of the moon's l.l. was 35° 40′ the observer north of the moon: the eye 20 feet over the sea, and the index error 3′ 10″ to add. Required the latitude.

Answer—In lat. 43° 13′ N.

72. Oct. 18, 1858 in longitude 48° 45′ E. the observed meridian altitude of the moon's l.l. north of the observer, was 61° 5′ 10″ the index error 3′ 10″ to subtract—the eye 24 feet over the sea. Required the latitude to the nearest minute.

Answer 37° 35′ 52″ S.

73. Dec. 17, 1858, in longitude 52° 40′ W. the meridian altitude of the moon's l.l. south of the observer, was 64° 22′ 15″ the index error 1′ 20″ to subtract—the eye 21 feet over the sea. Required the latitude.

Answer—46° 46′ 15″ N.
Cape Bollard.

74. June 16, 1858 in longitude 161° 40′ W. the altitude of the sun's l.l. at midnight, that is on the meridian at midnight, was 7° 10′, the height of the eye above the sea 26 feet, no index error. Required the latitude.

Answer—73° 50′ N.

75. July 2, 1858 in longitude 57° 56′ W. the observed altitude of $\underline{\odot}$ on the meridian below the pole, was 5° 20′ the height of the eye 21 feet over the sea, the index error 1′ 20″ to add. Required the latitude.

Answer—72° 22′ 36″ N.

76. June 10, 1858 in longitude 109° 25′ W. the altitude of the $\overline{\odot}$ on the meridian below the pole, was 6° 22′ 20″ the index error 3′ 15″ to subtract, the eye 25 feet over the sea, Required the latitude.

Answer—72° 45′ 28″ N.

77. Oct. 8, 1858 the altitude of the star Vega (a Lyrae) when on the meridian below the pole was 12° 10′ the index error 0 the eye 16 feet over the sea. Required the latitude.

Answer—In lat. 63° 22′ N.

78, Feb. 12, 1857 the observed meridian altitude below the pole, of the star a Crux, was 12° 20′ 15″ the the index error 2′ 20″ to subtract, the eye 25 feet over the sea. Required the latitude.

Answer—In lat. 39° 50′ 14″ S.

79. March 4, 1857 the observed meridian altitude of the star Capella (a Aurigae) below the pole, was 14° 45′ the instrument exactly adjusted, the eye 20 feet over the sea. Required the latitude.

Answer—In lat. 58° 45′ 49″ N.

80. July 7, 1857 the observed altitude of Canopus (a Argo) below the pole, was 10° 20′ the index error 1′ 40″ to add—the eye 22 feet over the sea. Required the latitude

Answer—in lat. 47° 35′ S.

81. Jan. 6, 1858 in longitude 53° 16′ 50″ W. at 9h. 30m. P.M., mean time at place of observation, the observed altitude of the pole star was 49° 17′ 15″. Index error 1′ 20″ to add, the eye 18 feet over the sea. Required the latitude.

Answer—48° 21′ 33″ N.
Trinity N. F.

82. July 20, 1858 in longitude 35° W. at 10h. 20m. P.M., mean time, suppose the altitude of Polaris to be 54° 10′ the eye 20 feet over the sea, the index error + 2′ 18″. Required the latitude.

Answer—54° 28′ 49″ by N. A. method.
54° 26. 20″ by Norie's method.

83. Sep. 6, 1858 in longitude 38° 30′ W. at 11h.

51′ P.M., apparent time, the observed altitude of Polaris was 33° 30′ 25″ the eye 22 feet over the sea, index error + 2′ 10″. Required the latitude,

Answer—32° 12′ 32. N. by N. A. method.
32° 14′ 39″ N. by Norie's method.

84. March 1, 1858, in longitude 88° 30′ E. at 15h. 30m. mean time, the altitude of the pole star corrected for index error, dip. and refraction was, 70° 20′ 35″. Required the latitude.

Answer—71° 39½′ N. by one method.
71° 38′ by another.

85. May 7, 1858 by account in latitude 27° 20′ N. and longitude 18° 20′ W. the altitude of the sun corrected for index error, dip. refraction and semidiameter was 79° 25′ at 11h. 53m. apparent time at place of observation. Required the true latitude.

Answer—27° 17½′ N.

86. Aug. 4, 1858 by account in latitude 34° 13′ S. and longitude 70° 25′ E. the observed altitude of the sun's l.l. was 37° 40′ at 0h. 25m. 12s. ap. time past noon—the index error—3′ 17″—the eye 20 feet over the sea. Required the true latitude.

Answer— 34° 6′ S.

87. Dec. 16, 1858 in latitude by account 3° 40′ N. and longitude 50° 45′ W. the altitude of the ⊙ was 62° 20′ when a chronometer corrected for error and accumulated rate, showed 3h. 45. Gr. M. Time, the index error + 1′ 20″—the eye 24 feet over the sea. Required the true latitude.

Answer 3° 22′ N.

88. Oct. 18, 1858 by account in latitude 43° 10′ S. and longitude 16° 20′ W. at 0h. 36m. 20s. P.M. ap. time by a watch which was too fast 8m. 10s. by altitudes of the sun taken A.M.—the altitude of the ⊙ was 54°30′ the observer south of the sun—Index error 2′ 20′ to subtract—the eye 21 feet—and the ship having made 32 miles of east longitude since the error of the watch was determined. Required the true latitude.

Answer— 14° 22½′ S.

89. Nov. 5, 1858 in latitude 47° 30′ N. by account, and longitude 46° 56′ W. the altitude of the sun's l.l. was observed to be 24° 13′ 16″ at 10h. 40m. apparent time A.M. his centre bearing at the time S.S.E. and at 0h. 45m. P.M., the altitude of his l.l. was observed to be 25° 54′ 16″ the ship's course during the interval between the observations, was S. $\frac{3}{4}$E. running at the rate of 9$\frac{1}{2}$ knots per hour—the eye 20 feet over the sea, the index error 3′ 10″ to subtract. Required the true latitude when the last altitude was taken.

Answer—47° 19′ N.

90. Jan. 16, 1858 in latitude 12° 18′ S. and longitude 150° 0′ W. the altitude of the $\overline{\odot}$ was observed to be 58° 36′ 38″ when a watch shewed 9h. 52m. 15s. apparent time A.M. the sun bearing at the time E.S.E.$\frac{1}{4}$E. and at 11h. 42m. A.M. by the same watch, the altitude of the $\underline{\odot}$ was observed to be 80° 12″ the ships course between the observations N.b.E.$\frac{1}{2}$E. on her larboard tack, making 1$\frac{1}{2}$ points lee-way, and running 7$\frac{1}{2}$ knots per hour. The index error 2′ 20′ to add: the eye 22 feet over the sea. Required the true latitude of the ship when the greater altitude was taken.

Answer—12° 16$\frac{1}{2}$′ S.

91. July 12, 1858, in latitude 40° 20′ S. and longitude 110° 15′ E. by account, the observed altitude of the $\overline{\odot}$ was 25° 0′ 0″ at 10h. 36m. apparent time A.M. and at 2h. 6m. P.M., by the same watch, the altitude of the $\underline{\odot}$ was 20° 56′ 8″ bearing at the time N.N.W. $\frac{3}{4}$W. the ship's course during the interval S. S. E. on her starboard tack and making $\frac{1}{2}$ a point lee-way, and running 10 knots per hour. No index error, the eye 22 feet over the sea. Required the latitude of the ship when the greater altitude was taken.

Answer—40° 4′ S.

92. April 1, 1858 in latitude 30° 2′ N. by account and longitude 67° 59′ W. the observed altitude of the $\underline{\odot}$ was 31° 24′ 13″ bearing east, at 8h. 16m. 48s. A.M., appa-

rent time, and at 11h. 1m 54″ A.M., ap. time, the observed altitude of his l.l. was 61° 0′ 20″. The course and distance in the interval S.b.E.½E, 28 miles, no lee-way—the instrument perfectly adjusted—the eye 22 feet over the sea. Required the true latitude when the greater altitude was taken.

Answer—30° 4′ N. by Norie's method.
29° 58½′ by Turnbull's method.

93. Aug. 1st, 1858 in lat. 5° 18′ N. by account, and longitude 42° 24′ W. the altitude of the sun's l.l. was observed to be 68° 9′ at 10h. 48m. 15s. A.M., ap. time the sun's centre bearing at the time N.E.b.N. and at 0h. 55m. 10s. P.M., the altitude of his l.l. was 71° 17′ the course and distance in the interval S.b.E.½E. 18 miles, no lee-way—the eye 22 feet, the index error 0. Required the latitude when the greater altitude was taken.

Answer—5° 9′ N.

The latitude found by double altitudes as well as that by a single altitude of the sun taken near the meridian is, by the usual methods of calculation, but an approximation to the true latitude. This approximation, however, is sufficiently near the truth, for the practice of Navigation. The calculations are rather long and intricate in all, but Ivory's method is most recommended for practice. Students in Navigation should be well practised in double altitudes as the Nautical Boards in England require a thorough knowledge of them from all candidates for certificates of qualification as competent navigators. Several other methods for finding the latitude are given in books and treatises on Navigation—such as Sumner's method of double altitudes,* and Towson's method by ex-meridian altitudes, &c.

Variation of the Compass, Tides.

94. Jan. 21, 1858 at 6h. 15m. 20s. A.M., ap. time in 10° 20′ S. longitude 72° 15′ W. the sun's rising ampti-

*The rules for this method are given in the Appendix.

tude by compass was S.E.½E. Required the variation.

Answer—19° 7′ 26″ W.

95. Dec. 4, 1858, at 2h. 57m. P.M., ap. time, in lat. 47° 20′ N. and longitude 51° 18′ W. the observed altitude of the sun's l.l. was 10° 36′ bearing at the time S. 66° W. by compass. The index error 2′ 41″ to add, the eye 19 feet. Required the variation.

Answer—26° 54′ W.

96. April 5, 1858, at 6h. 2m. A.M., ap. time, in lat. 5° 30′ S. longitude 140° E. the sun's rising amplitude by compass was observed to be N. 73° E. Required the variation.

Answer—10° 57′ 11″ E.

97. May 20, 1858, at 9h. 10m. 20s. A.M., ap. time, at ship in lat. 38° 40′ S. long. 108° W. the altitude of ☉ was 18° 54′ 45″ bearing by compass N. 42° 14′ E. no index error, the eye 20 feet. Required the variation.

Answer—No variation.

98. April 10, 1858, required the A.M. and P.M. tides at New York.

Answer—A.M., Tide.	P.M., Tide	
5h 49m.	6h. 13m.	Norie's 1st. method
6h. 14m.	6h. 38m.	do's 2nd. method
6h. 3m.	6h. 27m.	Turnbull's method.

99. Aug. 15, 1858, required the P.M., tide at Rio Janeiro (Brazil) and at Hamburgh (Germany.)

Answer—P.M., T. at Rio.	6h. 50m.	Norie's
do. do. do. do.	6h. 29m.	Turnbull's
do. do. do. Hamburg	9h. 59m.	Norie's
do. do. do. do.	9h. 44m.	Turnbull's.

100. Dec. 15, 1858, required the time of high water P.M., at St. John's N. F., and at St. John, N. B.

Answer—H. W. at St. John's N. F. 2h. 58m. ap. time P.M.
Norie's 2nd method
do. do. do. 2h. 55m. Turnbulls 2nd
do. St. John N. B. 6h. 40m. ap. time, P.M.

The times of high water cannot be found and determined with precision, owing to the influence of the winds. Turnbull observes "From the influence of the winds &c. on the ocean, the time found by the most accurate computations will be seldom found to agree with the actual time of high water found by observation in any port." The time of high water found by computation will, however, be sufficiently accurate for nautical purposes.

Part the Second.

Chronometer—Its error and rate—Equation of time—Apparent time from an altitude of the sun, moon, star or planet—Greenwich mean time by Lunars—Great Circle Sailing.

Time is the great, the paramount object to be found—to be accurately determined in all the calculations and problems of Nautical Astronomy. If the time be accurately known the skilful navigator, with good nautical instruments, will have no difficulty in finding what he wishes to know by his observation.

As the learner will find sufficient for his instruction in the article "Time" of his Epitome, and in the Nautical Almanac it is enough to say here, that Time and Longitude may be considered as convertible terms, if one be known the other can be found. For, as the Earth or Globe always turns fully round on its axis in equal spaces of time, which space is divided into twenty-four equal parts, or hours, and as the circumference of the globe is divided into 360°, then we have the following:

24h.	0m.	0s.	equal to	360°	0′	0″
12	0	0	....	180	0	0
1	0	0	....	15	0	0
0	4	0	....	1	0	0
0	1	0	....	0	15	0
0	0	4	....	0	1	0
0	0	1	....	0	0	15

From these figures any other interval of time or longitude can easily be found, when either of them is known by the simple rule of proportion; for example, what will be the time at St. John's, N.F. longitude 52° 38′ 37″ W. when it is noon or 12 o'clock at Greenwich.

Answer—15° : 1h. : 52° 38′ 37″ : 3h. 30m. 34½s.

which is the difference of time between St. John's and Greenwich, and as St. John's is to the west of Greenwich, 3h. 30m. 34½s. subtracted from 12h. leave 8h. 29m. 25½s. A.M., the time at St. John's. But the most convenient way of turning time into longitude, and longitude into time, are these two

RULES.

1st.—To turn time into longitude reduce the time to minutes and divide by 4, the quotient will be the degrees, minutes and seconds of longitude. Example, required the longitude for 9h. 25m. 41s.

h.	m.	s.
9	25	41
60		

4	565	41		
	141°	25′	15″	= the longitude.

2nd.—To turn longitude into time, multiply the longitude by 4 and divide the degrees by 60, the quotient will be the hours, the remainder the minutes and seconds of time. Example. Required the time corresponding to 74° 3′ 31″.

			4
6|0	29|6	14	4

4h. 56m. 14s. 4-tenths = the time.

It can now be easily comprehended that when the navigator finds by the altitude of the sun, moon, star or planet, the precise time at place of observation, and having a chronometer shewing Greenwich time at the same moment, he can, by the difference of time, find his longitude exactly. It may here be remarked, that chronometers are set and rated to Greenwich *mean* time, while it is only *apparent* time at place of observation that can be found by the altitude of any of the heavenly bodies. The Greenwich *mean* time, is found by the observed distance between the moon and the sun or any other of the heavenly bodies, marked in the Nautical Almanack for that purpose.

The nautical student may now observe the importance of finding the *precise* time at ship, and to do this he should be well practised in all the questions that here follow in this second part.

101. April 10, 1858, at noon a chronometer is fast 9m. 25s. on G. m. t. and gaining daily 1.4s. On May 19, the same chronometer shewed 7h. 35m. 44s. P.M., civil time. Required the corresponding ap. time at St. John's, N.F., that is, longitude 52° 38′ 37″ W.

Answer—May 19d. 3h. 58 m. 37s. P.M.

102. Sep. 29, 1858, at noon a chronometer is 4m. 18s. slow on G. m. t. and gaining daily 2.7s. When this chronometer shewed Nov. 10d. 17h. 18m. 10s. in longitude 27° 19′ 42″ E. Required the corresponding ap. time on that meridian.

Answer—Nov. 11d. 7h. 25m. 43s. A.M.

103. April 14, 1858, (civil time) in longitude 76° 12′ W. it is 7h. 17m. 10s. A.M., ap. time. Required the corresponding astronomical G. m. t.

Answer—14ds. 0h. 22m. 15s. ast. G. m.t.

104. Dec. 4, 1858, at noon on the meridian of 16° 20′ 30″ E. a chronometer shewed 10h. 47m. 38s. and on the 22nd at noon on the meridian of 76° 16′ W. it shewed 5h. 5m. 4s. P.M. Required the daily rate of the chronometer.

Answer—Losing 5.1s. daily.

105. March 17, 1858, in longitude 170° 16′ E. at 8h. 50m. 20s. A.M., ap. time, a chronometer shewed March 16ds. 9h. 40m. 10s. and on the 25th in longitude 120° 10′ E. at 3h. 5m. 10s. P.M. ap. time, it shewed March 24ds. 19h. 13m. 48s. Required the daily rate of the chronometer.

Answer—Gaining 6.6s. daily.

106. Aug. 1, 1858, at 7h. 21m. 12s. A.M., ap. time at

Trinity, longitude 53° 16′ 50″ W. a chronometer shewed July 31ds. 22h. 57m, 13s. Required the error of the chronometer on G. m. t.

Answer—Chron. shewed G. m. t.—no error.

107. Feb. 1, 1858, at 18h. 40m, 15s. G, m. t. Required the sun's right ascension and declination.

Answer—R. A. 21h. 2m. 39s.
Decl. 16° 52′ 21″ S.

108. April 12, 1858, at 6h, 30m. 10s. P.M., ap. time in longitude 20° 30′ 15″ W. Required the sun's R. A. and declination.

Answer—R. A. 1h. 23m. 35s.
Decl. 8° 47′ 58″ N.

109. July 25, 1858, at 6h. 15m. P.M., ap. time, in longitude 86° 18′ 0″ E. Required the R. A. and decl. of the planet Venus.

Answer—R. A. 10h. 44m. 27s.
Decl. 9° 22′ 58″ N.

110. June 1, 1858, at 14h. 16m. 10s. G. m. t. Required the moon's right ascension and declination.

Answer—R. A. 20h. 51m. 51s.
Decl. 20° 29′ 41s. S.

111. July 25, 1858, required the G. m. t. when the moon will be on the meridian of St. John's, N. F., (lat. 47° 34′ 35″ N. longitude 52° 38½ W.) and what will be its altitude at that place and time, and also its R. A. decl. sem. diameter and hor. parallax at that time.

Answer—On Mer. of St. John's at	12h. 16m. 12s.
Alt. at that time, and place,	19° 53′ 14″
R.A..................	20h.23m. 17s.
Decl..................	22° 32′ 11″ S.
Sem. diam.	14′ 54″
Hor. Par.	54′ 34″

112. Feb. 12, 1858, required the ap. time when the sun bears due east, and due west in lat. 34° 30′ 5″.

Answer—Due East at 7h. 25m. A.M.
do. West at 4h. 35m. P.M.

The Apparent Time from the altitude of the Sun, Moon, &c.

THE ARTIFICIAL HORIZON.

As already observed, time is the all-important object in Nautical Astronomy. The artificial horizon seems to afford the most convenient means to attain this object. Turnbull observes, (and other authors of Navigation use language to the same effect) that "Of all the methods for ascertaining the rate and error of a chronometer, that by equal altitudes of the sun, or an artificial horizon is to be preferred in practice, both on account of the simplicity of the computation and the great degree of accuracy attainable by it. This method is also free from the instrumental error" and Norie says,—"The rate of a chronometer may be found nearly as correct as with an astronomical clock, by equal or single altitudes taken on shore with a sextant and an artificial horizon; indeed these two instruments may be considered a portable observatory, and a person with their assistance will be enabled to regulate chronometers wherever he may chance to stop a few days."

113. Sep. 1, 1858, at Trinity, in lat. 48° 22′ N. and long. 53° 17′ W. the following double altitudes were taken on an artificial horizon, with the corresponding times by a watch which was at the time of observation, 3h. 92m. 20s. slow of a chronometer whose error on G. m. time, was required to be determined. The instrument was truly adjusted. Required the error.

Ap. times by watch.				Obserd. doubl. alt. ⊙'s centre.		
8h.	35m.	10s.	A.M.	62°	41′	44″
"	35	52	....	62	42	4
"	36	32	....	62	42	24

Answer—M. T. at Trinity by observation	8h.	35m.	5s.
Long. 53° 17′ in time........	3	33	8
G. m. time	12	8	13
Time by Chron.............	12	18	11
Chrn. fast on G. m. time,	0	9	58

114. Sep. 13, 1858, to determine the rate of the chronometer in the last question, the following double altitude of the ☉ were taken on an artificial horizon in the same place, with the corresponding times by the chronometer. The sextant, as before, truly adjusted. Required the rate.

Times by chron.....	Double alt. ☉
11h. 43m. 18s.A.M....	45° 42′ 8″
11 43 48........	45 47 30
11 44 28........	45 52 15

Answer—Chron. gaining 1.25s. daily.

115. June 2, 1858, equal altitudes of the sun were taken in lat. 48° 22′ N. and long. 53° 17′ W. (Trinity) on an artificial horizon, to determine the sea rate of a chronometer, purchased in London April 25th, on which day at noon, it was set to G. m. t. its rate, gaining 4.8s. daily. The means of the times corresponding to equal altitudes were, by Chron. June 1d. 22h. 53m. 22s. and June 2d. 8h. 12m. 56s. Required the true sea rate of the chronometer.

Answer—Gaining 5.3s. daily.

116. June 8, 1858, at Calcutta in lat. 22° 35′ N. and long. 88° 21′ E. equal altitudes of the sun were taken in artificial horizon, when the corresponding times by chronometer were 8d. 13h. 46m. 36s. and 8d. 22h. 26m. 38s. Required the error of the chronometer on m. t. at Calcutta and also on m. t. at Greenwich.

Answer—Chron. slow on m. t. at Calcutta 5h. 52m. 11s.
do. fast on m. t. at Green. 0h. 1m. 13s.

117. Aug. 8, 1858, at Valparaiso lat. 33° 2′ S. long. 71° 41′ W. equal altitudes of the sun were taken, when the corresponding times were 8d. 2h. 23m. 22s. and 8d. 6h. 48m. 38s. by a chronometer which was slow on G. m. t. 8m. 25s. June the 30th at G. mean noon. Required the error of the Chronometer on m. time at

Valparaiso, also on m. time at Greenwich, and its daily rate.

Answer—Chron. fast on m. t. at Valparaiso 4h. 30m. 28s.
do. slow on G. m. t......... 0h. 16m. 16s.
Its rate losing................ 12s daily.

Time from altitudes taken on the Sea Horizon.

118. March 17, 1858, A.M., at ship, in lat. 47° 30′ N. the following altitudes were taken, with the corresponding times by a chronometer, which was fast 12m. 10s. on G. m. t., Feb. 25th at G. m. noon, and gaining daily 2.4s. The eye 16 feet over the sea. Index error 2′ 8″ to subtract, Required the ap. time, and m. time at ship when the observation was made, the G. m. t. by chronometer, and the longitude.

Times				Alt. ⊙
16d.	23h.	3m.	10s.	16° 4′.
	23.	3.	58.	16. 17.
	23.	4.	24.	16. 26.

Answer—Ap. time of observation 7h. 45m. 10s. A.M.
M. time............ 7h. 53m. 43s.
G. m. t. by chron. 16d. 22h. 50m. 53s.
Long. .... 44° 17′ 30″ W.

119. Sep. 30, 1858, P.M., at ship in latitude 34° 10′ S. the mean of several altitudes of ⊙ was, 23° 16′ the eye 21 feet, index error + 3′ 17″ the corresponding time by chronometer 30d. 0h. 20m. 15s. which was slow 14m. 28s. on G. m. t., July 10th, and losing daily 2.7s. Required the longitude.

Answer—In long. 51° 13′ 30″ E.

120. March 25, 1858, P.M., at ship in lat. 4° 56′ N. the mean of a set of altitudes of the ⊙ was 23° 24′. Index error 0. eye 22 feet. The mean of the times was 25d. 7h. 0m. 14s. by chronometer which had been rated Jan. 19, at G. m. noon when it was fast 18m. 10s. on G. m. t. and gaining daily 1.9s. Required the longitude.

Answer—In long. 31° 58¼′ W.

121. Oct. 12, 1858, A.M., at ship in lat. 29° 2′ S. the observed alt. of the ☉ was 16° 29′ when 11d. 8h. 7m. 15s. were shewn by a chronometer which was slow 6m. 42s. on G. m. t. at noon, June 20, and losing daily 3.2s. Index error + 1′.48″—the eye 24 feet. Required the longitude.

Answer—In long. 156° 50′ E.

122.—April 12, 1858, A.M., at ship in lat. 30° 24′ N. the observed alt. ☉ was 16° 20′ at 12d. 6h. 44m. 48s. by chronometer which was fast 10m. 40s. on G. m. t. Jan. 20, at G. m. noon, and gaining daily 0.7s. Index error 2′ 20″ to subtract—the eye 24 feet. Required the longitude.

Answer—In long. 174° 8′ 45″ W.

123. Jan. 6, 1858, in lat. 48° 22′ N. long. 52° 17′ W. the alt. of the star Aldebaran was observed to be 41° 14′ 42″ (east of meridian) when a watch shewed 6h. 16m. 22s. ap. time, P.M., the eye 20 feet. Index error 1′ 4″ to add. Required the error of the watch on ap. time, and the G. m. t. when the altitude was taken.

Answer—Watch fast on ap. time 17s.
G. m. t..... 9h. 51m. 32s.

124. July 15, 1858, P.M., at ship in lat. 9° 10′ S. the observed alt. of the star Arcturus west of meridian, was 29° 6′ when 15d. 13h. 48m. 21s. were shewn by a chronometer which was fast on G. m. t. 12m. 20s. June 1 at G. m. noon, and gaining daily 1.2s.—the eye 20 feet —Index error 2′ 10″ to subtract. Required the longitude.

Answer—In long. 50° 33′ 15″ W.

125. April 9, 1858, in lat. 30° 42′ S. about midnight the alt. of the star Antares, east of meridian was observed to be 49° 45′—the eye 22 feet. Index error 1′ 10″ to add. The time 9d. 16h. 33m. 6s. by chronometer, which was slow 45m. 25s. on G. m. t. January 20, at noon, and losing daily 3.7s. Required the longitude.

Answer—79° 40′ 45″ W.

126. Feb. 1, 1858, in lat. 6° 4′ N. and long. 160° W.

at 9h. 37m. P.M., ap. time by watch, the observed altitude of the centre of the planet Jupiter west of meridian, was 26° 31′ 51″ a chronometer at the time shewing 1d. 20h. 31m. Sextant truly adjusted. The eye 20 feet. Required the error of the watch on ap. time at ship, and the error of chronometer on G. m. t.

Answer—Watch showed ap. time correctly.
Chron. showed G. m. t. no error.

127. Oct. 13, 1858, in lat. 15° 50′ S. the observed altitude of the centre of the planet Venus, west of meridian, was 42° 0′ 44″ when a chronometer corrected for error and rate, shewed Oct. 13d. 1h. 3m. 53s. Index error 3′ 35″ to add—the eye 24 feet. Required the longitude.

Answer—Long. 76° 20′ E.

128. May, 10, 1858, lat. 4[illegible]° 10′ S. the observed altitude of the planet Mars, east of meridian, was 27° 5′ when 10d. 13h. 55m. 34s. were shewn by a chronometer, which was fast, 15m. 10s. on G. m. t. March 12th at G. m. noon, and gaining daily 3.8s. Index error + 3′ 30″—the eye 24 feet. Required the ap. time at ship, and the longitude.

Answer—Ap. time at Ship 7h. 42m. 6s. P.M.
Longitude 89° 36′ W.

129. Oct. 31, 1858, lat. 4° 10′ S. the observed alt. of the centre of the planet Venus, west of meridian, was 9° 28′ 43″—the eye 20 feet. Index error 2′ 40″ to add—the time 31d. 7h. 49m. 52s. by chronometer which was slow 16m. 24s. on G. m. t. when the altitude was taken. Required the longitude.

Answer—Long. 0° 0′ 0″.

130. Aug. 27, 1858, in lat. 26° 36′ N. the alt. of the moon's l.l. was observed to be 24° 24′ 0″ east of meridian. Index error 3′ to add,—the eye 18 feet. The G. m. t. by chronometer when the alt. was taken 27d. 12h. 54m. 34s. Required the ap. time at ship, and the longitude.

Answer—Ap. time at Ship 10h. 4m. P.M.
Long......... 42° 20′ W.

131. Nov. 15, 1858, in lat. 5° 10′ S. the observed alt. of the moon's l.l. west of meridian, was 41° 50′ 41″—the sextant adjusted, the eye 19 feet, the G. m. t. 15d. 12h. 46m. 27s. by chronometer corrected for error and rate. Required the ap. time at ship, and the longitude.

Answer—Ap. time at ship 11h. 0m. 0s. P.M.
Long......... 30° 24′ W.

132. Dec. 21, 1858, in lat. 15° 27 N. the observed alt. of the moon's l.l. east of meridian, was 39° 20′ 15″, index error 2′ 18′ to subtract, eye 22 feet. Time by chronometer 21d. 21h. 50m. 27s. which was rated Oct. 18th at noon, when it was 16m. 10s. fast on G. m. t. and gaining daily 4.2s. Required the longitude.

Answer—166° W.

At a given time to find the Altitude of the Sun, Moon, Star or Planet.

133. June 18, 1858, at St. John's *i.e.* lat. 47° 34′ 35″ N. long. 52° 38′ 37″ W. at 5h. 20m. 15s. P.M., ap. time. Required the true alt. of the sun's centre, and also the ap. alt. of his l.l. above the horizon.

Answer—True alt. ☉'s centre 23° 35′ 58″
Ap. alt. ☉ .. ... 23 18 9.

134. Dec. 20, 1858, in lat. 34° 30′ S. and long. 150° E. Required the true altitude of the sun's centre at 7h. 15m. 20s. A.M., ap. time at ship.

Answer—True alt. ☉'s centre 27° 59′ 40″

135. Oct. 2, 1858, in lat. 4° 45′ N. and long. 34° 20′ W. Required the true and ap. altitudes of the centres of the sun and moon, at 8h. 45m. ap. time A.M. at ship.

Answer—True alt. sun's centre 40° 35′ 50″
Ap. alt. do. do. 40° 36′ 49″
True alt. moon's do. 73° 32′ 15″
Ap. alt. do. do. 73° 15′ 34″

136. March 24, 1858, in lat. 46° 40′ N. long. 52° 59′ W. (Cape Race, N. F.) at 7h. 30m. P.M. ap. time at place. Required the true altitude of the plane

Jupiter, and of the moon's centre, and also the true distance between them at that moment.

Answer—Jupiter's true alt. 21° 51′ 27″
Moon's true alt. 61° 50′ 9″
True distance 82° 21′ 4″

137. Nov. 12, 1858, in lat. 10° 14′ N. long. 78° 45′ E. when a chronometer shewed 12d 0h. 35. 10s. G. m. t. Required the true al . of Venus and of the moon, and the true distance between them at that moment.

Answer—Venus' true alt. 26° 56′ 3″
Moon's do. do. 56° 39′ 2″
True dist. [illegible]° 53′ 28″

138. Aug. 29, 1858, in lat. 5° 30′ S. long. 163° 30′ W. when a chronometer shewed Aug. 30d. 3h. 28m. 42s. G. m. t. Required the altitudes of the stars Fomalhaut and Pollux, and their distance each from the moon at that time.

Answer—Fomalhaut's alt. 24° 31′ 4″
Pollux's alt. 17° 17′ 42″
Fomalhaut's dist. 81° 58′ 19″ W.
Pollux's do. 59° 41′ 6″ E.

To find the Greenwich Mean Time and thence the Longitude by Lunars.

139. Sep. 10, 1858, in lat. 48° 20′ N. at 5h. 42m. P.M., ap. time by watch at ship—a set of observations of the sun and moon were taken, of which the means were,—the observed alt. $\underline{\odot}$ 6° 31′ 23″ the observed alt. $\underline{☽}$ 12° 14′ 24″ the observed distance of nearest limbs 40° 22′ 6″—the mean of the times by chronometer 10d. 8h. 50m. 8s.—the instrument adjusted—the eye 20 feet. Required the error of the watch on ap. time at ship, the error of chronometer on G. m. t. and the longitude.

Answer—The watch showed ap. time
Chron. slow 7m. 28s. on G. m. t.
Long. 49° 41′ 45″ W

140. Aug. 2, 1858, A.M., at ship in lat. 3° 45′ N. the observed alt $\underline{\odot}$ 34° 14′ 56″ the observed alt. $\overline{☾}$ 47° 21′ 54″ the observed distance between their nearest limbs

88° 52′ 11″ the time by chronometer 2d. 4h. 27m. 0s. the eye 24 feet, instruments adjusted. Required the error of the chronometer on G. m. t. and the longitude by lunars.

Answer—Chron. fast 1m. 44s on G. m. t.
Long. 119° 49′ W

141. Nov. 11, 1858, at 5h. 38m. 50s. P.M., ap. time, by watch at ship, in lat. 10° 15′ S. the observed alt. moon's l.l. 68° 7′ the observed alt. of Venus's centre (west of meridian) 44° 42′ the observed distance between the centre of Venus and the moon's nearest limb 24° 19′ 24″—the eye 24 feet. The instruments adjusted—the time by chronometer 10d. 21h. 17m. 40s. Required the error of the watch on ap. time at ship—the error of the chronometer on G. m. t. and the longitude.

Answer—Watch slow 25s. on ap. time.
Chron. fast 1m. 0s. on G. m. t.
Longitude 121° 41′ 15″ E.

142. March 21, 1858, suppose a ship bound for St. John's, N. F., in lat. 47° 31″ N. and longitude by account 51° 30′ W. took a set of altitudes and distances of the moon and Jupiter, with the corresponding times by watch, the means of which were—alt. moon's up. l. 58° 44′, Jupiter's centre 21° 42′ (west of meridian) distance between Jupiter's centre and moon's farther limb 41° 16′ 25″. Time by watch 7h. 48m ap. time, P.M. No index error—eye 16 feet. Required the error of the watch on ap. time and the true longitude by lunars.

Answer—Watch slow 36s.
True longitude 50° 42′ 30″ W.

143. April 28, 1858, in lat. 46° 40′ S. and by account in longitude 88° 45′ W. at 10h. 40m. P.M., ap. time by watch at ship, the observed altitude of the moon's l.l. was 55° 21′, the observed alt. of Antares, (a Scorpii) 46° 24′ 30″, east of meridian. The observed distance of moon's nearest limb 16° 46′ 30″. Instruments adjusted—eye 15 feet. Required the error of the watch

on ap. time at ship, the G. m. t. and the longitude by lunars.

Answer—Watch fast 27s. on ap. time.
G. m. t. 23d. 16h. 33m. 7s.
Long. 89° 4′ 30″ W.

144. Nov. 29, 1858, in lat. 12° 16′ N. suppose the observed alt. of the moon's l.l. was 9° 40′ the alt. of the star Regulus, east of meridian, was 48° 57′ the observed distance of moon's nearest limb 39° 23′ 45″ when 29d. 14h. 0m. 55s. were shewn by a chronometer, which was slow on G. m. t. 10m. 8s. on the 5th at noon, and losing daily 3.8s.—eye 21 feet. Instruments adjusted. Required the longitude by lunars and by chronometer.

Answer—Long. by lunars 6° 15′ 30″ E.
do. by chron. 6° 13′ 30″ E.

Miscellaneous questions such as are put by the Nautical Boards in England, to Candidates for Certificates of Qualification as competent Navigators.

151. Dec. 24, 1858, at noon, the equation of time is 0m. 11s.42 and on the 25th it is + 0m. 18s.46 what will be the time when the apparent and mean time coincide, and what will be the equation at midnight.

152. The true course is N.bE.½E. the distance 250 miles, the variation of the compass 1¼ points E. a current setting N.W.bW. 2½ miles an hour. Required the course by compass which a steamer, running 9½ knots an hour, should steer and what distance she must run to reach her port in the shortest possible time.

153. If the sun's alt. be 10° 20′ at 7h. 15m. 48s. and 11° 49′ 25″ at 7h. 31m. 16s. what will be its alt. at 7h. 21m. 33s.

154. A ship at noon is in lat. 4° 10′ S. and long. 178° 40′ E. and next day at noon found by observation that she was in lat. 2° 47′ S. and long 178° W. having run by log 156 miles, steering E.N.E. Required the course and force of the current, supposing it the only cause of error.

155. Dec. [illegible], 1858, at [illegible]h. 4[illegible]m. P.M., ap. time at place, the observed alt. of Polaris was 48° 40′ the eye 22 feet, index error 5′ 10″ to add, longitude by account [illegible] 40″ W. Required the latitude.

156. Dec. 8, 1858, about 5h. 15m. ap. time at ship [illegible] compass [illegible] Required the [illegible].

157. July 2, 1858, in longitude 85° 30′ W. the observed alt. of the sun's L.L. was 7° 10′ at midnight, the eye 17 feet, index error 1′ 10″ to add. Required the latitude.

158. Required the natural whole number corresponding to the log. 5.805437.

159. Required the length of a degree of longitude on the parallel of Cape Farewell in lat. 59° 49′ 12″ N.

160. Oct. 7, 1858, in longitude 66° 40′ E. the observed meridian alt. of Procyon (a con. min) was 55° 35′ observer south of star—eye 21 feet, index error + 2′ 15″ Required the latitude.

161. A ship from lat. 34° 20′ S. running in the south east quarter for 24 hours found her difference of lat. and difference of long. were equal. Required the course steered.

162. Nov. 18, 1858, (astronomical time) in lat. 48° 22′ N. and long. 52° 20′ W. what will be the ap. time at place when the moon bears due west.

163. April 2, 1858, in lat. by account 30° 2′ N. long. 67° 59′ W. the observed alt. $\underline{\odot}$ was 31° 24′ 13″ (bearing east by compass) at 8h. 16m. 48s. A.M., ap. time and at 11h. 1m. 54s. A.M., the observed alt. was 61° 0′ 20″ —course and distance in the interval S.bE½E. 28 miles—the eye 22 feet. No index error. Required the lat. when the latter alt. was taken.

164. March 24, 1858, P.M., at ship lat. 9° 4′ S. the observed alt. $\underline{\odot}$ is 29° 50′ 30″. Index error 1′ 10″ to add, eye 17 feet, the time by chronometer 24d. 1h. 3m. 10s. which had been rated Jan. 2, when it was fast 3m 13s. on G. m. t. at noon, and losing daily 3s. Required the longitude.

165. Nov. 18, 1858. Required the times of high water P.M., and A.M., at Croque Harbour, N. F.

166. Dec. 15, 1858, required the ap. time when the moon will be on the meridian of St. John's, N. F. and what will be her true and apparent alt. at that time, and also her semi-diameter horizontal parallax, R. A. and declination.

167. March 25, 1858, lat. 18° 20′ N. long. 140° 20′ W.

equal altitudes of the sun were taken on an artificial horizon when the corresponding times by chronometer were 25d. 6h. 31m. 20s. and 25d. 12h. 30m. 35s. Required the error of the chronometer on ap. and mean time at place, and also its error on G. m. t.

168. Supposing the wind at S.W. and a ship beating to windward, runs on her port tacks 220 miles and then on her starboard tacks 225 miles, and now finds she has made 160 miles directly to windward. Required the courses steered on each tack, and how near the wind did the ship lie.

169. May 1st, 1858, the meridian altitude of the star Deneb (a cignus) below the pole is 12° 40′ the eye 18 feet—index error + 3′ 12″. Required the latitude.

170. Nov. 4, 1858, lat. 0° long. 177° 30′ W. the observed alt. ☉ 14° 18′ at 5h. ap. time at ship—the magnetic azimuth of the sun's centre was S. 74° 7′ W. Index error—1′ 20″, eye 19 feet. Required the variation of the compass.

171 Required the arithmetical compliment of the log, corresponding to the decimal number. 87694.

172. April 3, 1858, in lat. 5° 36′ S. about half past four A.M., at ship. Several sets of altitudes and distances of the moon and Spica were taken, of which the means were—observed alt. moon's l.l. 63° 45′, observed alt. of spica, (west of meridian) 30° 19′ 41″, observed distance between star and moon's nearest limb 32° 32′ 0″, mean of times by chronometer, corrected for error and rate—2d. 18h. 15m. 49s. the eye 22 feet, index error + 1′ 20″. Required the error of the chronometer on G. m. t. and the longitude.

173. July 21, 1858, in lat. by account, 12° 28′ S. and long. 20° 10′ W. the observed alt. ☉ near the meridian was 56° 30′ 40″ when 21d. 1h. 48m. 54. were shewn by a chronometer corrected for error and rate, the eye 16 feet. Index error—3′ 2″. Required the true latitude.

174. A ship from lat. 10° 10′ S. sailed in a direct course between north and west, for several days, when it was found by observation, that her difference of lat, her difference of long. and her departure were equal, and the degrees and minutes of her latitude, were also equal to those of her longitude. Required the course steered, the distance run, the lat. and long. in, and the longitude left.

175. Sep. 21, 1858, in lat 46° 20′ N. long. 160° W. at 9h. 20m. 30s. P.M., ap. time at place. Required the apparent and true altitude of the moon, and a Arietis, and also the true distance between them at that time.

176. Required the ap. time at Port Jackson, New Zealand long. 174° 23′ 30″ E. and at San Francisco, California, long. 122° 27′ 23″ W. when it is noon May 1st, at St. John's, N. F.

177. A man of war, bound to the Western Isles,
Whose distance then S.E. was ninety miles,
With flying topsails bent her watry way
In a swift current through the briny spray:
Fifty miles on her larboard tack she bore;
Sixty on her starboard,and then reached the shore
From hence, ye sons of the raging main,
The course made good upon each tack explain.

178. Oct. 13, 1858; the sun, Venus, Antares, Fomalhaut, and a Pegasi are given in the Nautical Almanac for lunar observation; required to which of these preference should be given in order to obtain the greatest degree of confidence in the accuracy of the time found by observation.

179. Nov. 22, 1858, (civil time) about 2h. 50m. A.M. at ship, supposing a vessel bound for St. John's, N. F. after a long continuance of fog, got a clear sky and horizon, and took the altitude of the star Sirius on the meridian, and found it 26° 41′ 15″, at the same time the altitude of Dubhe (a Ursae Majois) east of meridian,

was observed to be 51° 40′ 16″, when a chronometer corrected for error and rate, shewed 21d. 18h. 0m. 28s. the error of the sextant + 3′ 10″, the eye 16 feet. Required the lat. and long. of the vessel when the altitudes were taken, and her course to, and distance from Cape Spear.

180. Suppose the vessel in the last question sees Cape Spear bearing N.W. distant 25 miles the wind W.N.W. blowing fresh, and the vessel making one point lee-way, lying within $5\frac{1}{2}$ points of the wind, and running at the rate of 6 knots an hour. Suppose a current setting N.bE. 2 knots an hour, and a swell from N.E.bE. 1 knot an hour, and it is purposed to fetch the Cape in two tacks, the first on the starboard. Required the course made good, the distance to be run on each tack add in what time she will fetch the Cape.

Great Circle Sailing.

It is a great defect in Norie's Epitome of Navigation, that there is nothing of Great Circle Sailing in it. In the present advanced state of Nautical practice, when ships are rendered almost independent of wind and tide by the use of steam as a propelling power, it becomes indispensable for masters of vessels on long voyages, to make themselves familiar with the mode of conducting their ship the nearest way to her intended port; and this can be accomplished only on the principles of Great Circle Sailing. The shortest track should be matter of importance, now that the time occupied in the voyage is reckonèd not alone to days but even to the hours and minutes. To masters of sailing vessels a knowledge of Great Circle Sailing is useful when adverse winds render it impossible to run the ship on her direct course, then Great Circle Sailing teaches on which side of the plane track to lay the ship with most advantage in order to make the shortest course; under any circumstances it is impossible to run a ship directly on the Great Circle course; but by changing the course at every 5 or 6 degrees of longitude, a very close approximation to it, can be effected. There are but six cases in Great Circle Sailing, and two of these require no calculation whatever, for the first case is sailing due east or west on the equator so that the difference of longitude is the shortest distance; in like manner when a ship sails due north or south, her difference of latitude is the shortest distance which is the second case; so that four cases only require calculation—and these are as follow:—

1st. Case—When the place of departure and that of destination are on the same parallel of latitude N. or S. but differing in longitude.

2nd Case—When one of the places is on the equator in a given longitude, the other N. or S. of it, in a different longitude.

3rd Case—When the places are on different sides of the equator and on different meridians.

4th Case—When both places are on the same side of the equator, having different latitudes and longitudes. This last case is the most important, an example is here given.

Required the Great Circle Course and distance, (the ship changing her course at every five degrees of longitude) from St. John's, lat. 47° 34′ N. long. 52° 38′ W. to Galway, lat. 53° 17′ N. long. 8° 51′ W. the calculations are tabulated as follows:—

ST. JOHN'S.	NO.	COURSES	DIST.	LAT.	LONG.	
	1	N. 61° 45′ E.	48	47° 57′	51° 35′ W.	
	2	" 62. 32 "	220	49. 31	46. 35	
	3	" 66. 17 "	207	50. 48	41. 35	
	4	" 70. 8 "	197	51. 49	36. 35	
	5	" 74. 2 "	189	52. 35	31. 35	
	6	" 77. 59 "	187	53. 7	26. 35	
	7	" 81. 58 "	180	53. 25	21. 35	
	8	" 85. 59 "	178	53. 32	16. 35	
	9	S. 85. 59 "	178	53. 25	11. 35	
	10	" 83. 47 "	98	53. 17	8. 51	GALWAY.

A diagram is here given, shewing the Great Circle Track which is pricked off from the foregoing table of latitude and longitude; the Vertex or highest latitude is 53° 32′ N. and 16° 35′ W. longitude; the point of maximum seperation is 52° 38′ N. lat. and 31° 5′ W. long. In this case of Great Circle Sailing it is worthy of particular remark, that the Great Circle Course is alway in a higher latitude, be that latitude N. or S. than the plane or Mercator's course.

As this work is intended for exercise in applying the various rules by which all the problems of Navigation are solved, it is necessary the learner should have these rules before him to work the questions, and as these rules are not in Norie's Epitome, the only work of Navigation used in our schools, exercise in Great Circle Sailing would be useless here. The learner is referred to Towson's, Turnbull's or Mrs. Janet Taylor's works on Great Circle Sailing.

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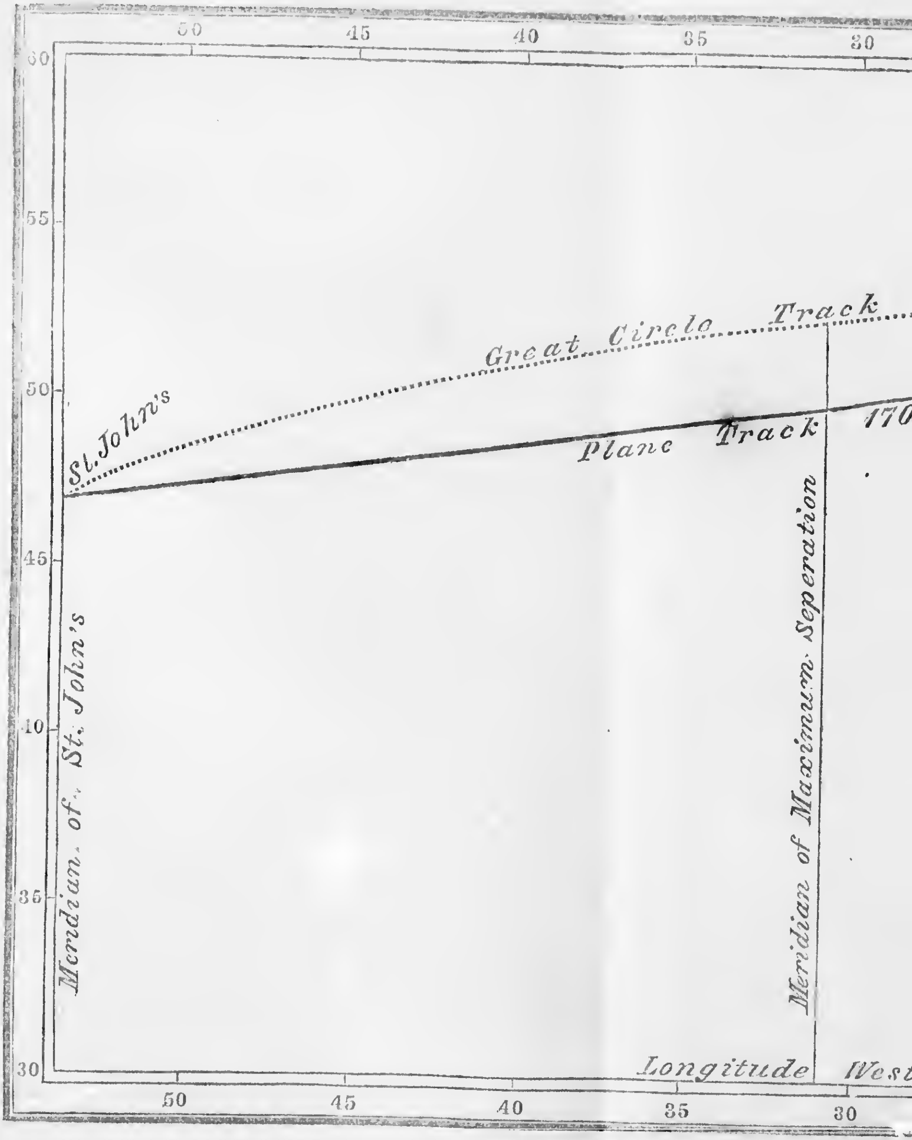

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Great Circle Track
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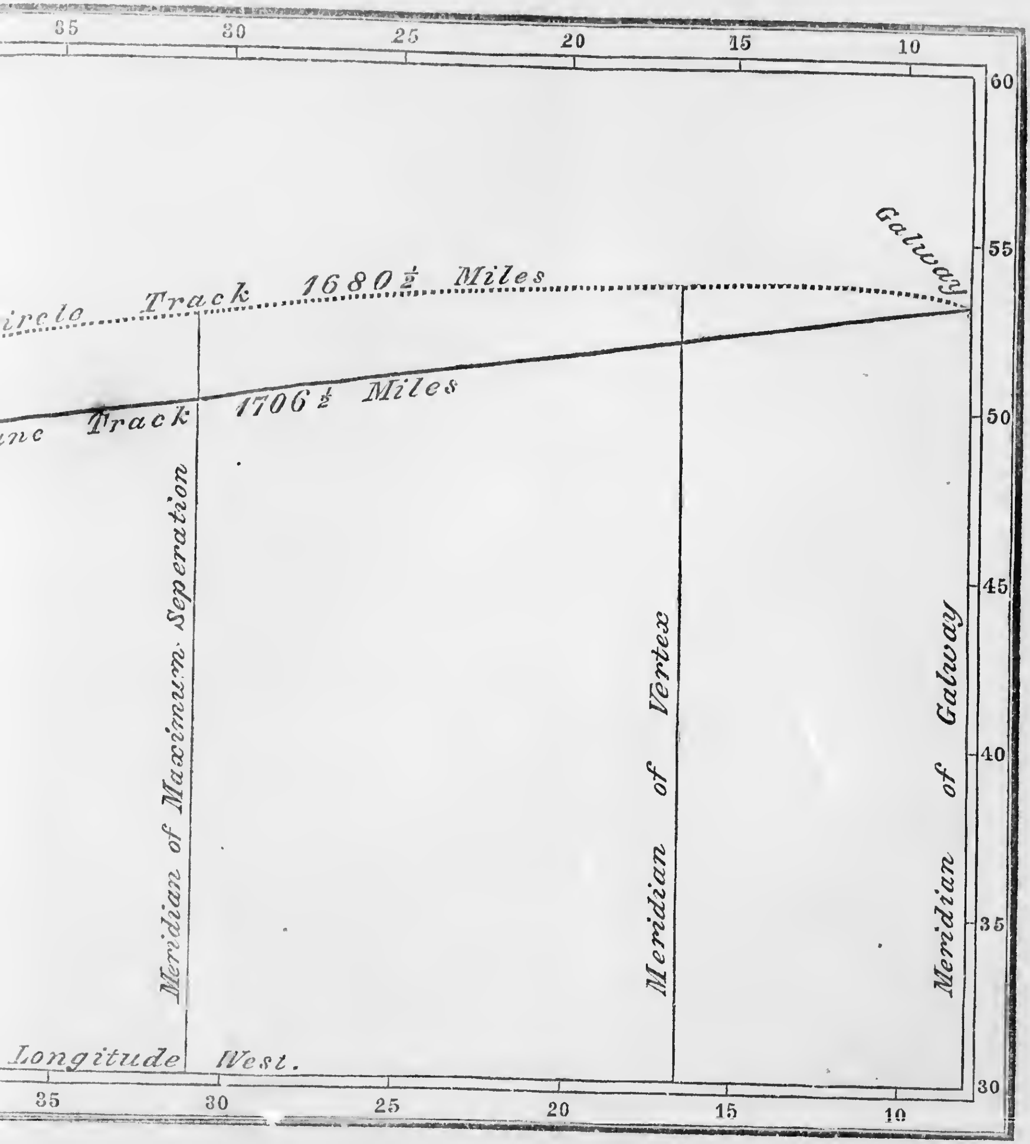

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Meridian of Galway
Longitude West.

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APPENDIX.

To find the time of high water in all the ports of Great Britain and Ireland, and in ports contiguous marked in the Nautical Almanack, is made matter of paramount importance, and insisted on by the Nautical Boards of Examination in England, and as the rules by which the time of high water is found by the Nautical Almanac method, are not given in Norie's Epitome—they are here given.

RULES.

1.—Find the time of high water at place, on the full and change of the moon, and also at London Bridge in the Nautical Almanac page 524, and 525, and take the less from the greater, the difference to be marked + or addative when the time at place is *more* than the time at London, but when the time at place is *less*, the difference to be marked — or subtractive.

2.—Take the time of high water at London Bridge for the given day from Nautical Almanack, pages 522 and 523, and to this time add or subtract the difference found above according as it is marked + or — the result, if *less* than 12 hours will be the time of high water, afternoon of the given day at the given place; but if the result is *more* than 12 hours, it will be the morning tide of the following day, in which case subtract 12h. 24m. from it, and the remainder will be the time of the afternoon tide on the given day, and it is this tide that is generally required, and from the time of the afternoon tide, subtract 24m. and the remainder will be the time of the morning tide of the same day nearly, but when precision is required, use the following.

3.—Take the London tide for the preceding day and apply to it the difference found by rule the 1st.

NOTE.—When the London tide is marked —, take the preceding tide, if the difference found above is marked + but the following tide when the difference is marked —. In the margin of pages 522 and 523 of the Nautical Almanac, the learner will find directions to use these tables.

EXAMPLE.

April 2, 1858, required the time of high water P.M., at Cork.

Time of H. W. at full and change at Cork	4h.	30m.
do........................ London	2	7
	+ 2.	23
Time of high water at London bridge	4.	29
Time of high water at Cork, Ap. 2 P.M.	6.	52

Sumner's Method of Verification of the Latitude by Double Altitudes of the Sun.

The Nautical Boards of examination in England require this method of finding the latitude, and as the rules by which it is thus found are not given in Norie's Epitome, they are here given.

Rule 1st.—Find the true altitudes of the sun by the usual method of double altitudes.

Rule 2nd.—Find the Greenwich time of each observation

Rule 3rd.—Find the suns declination at each time.

Rule 4th.—Assume two latitudes, one *greater* and the other *less* than the latitude by account, and such that there may be a difference of one degree exactly between the two latitudes chosen.

Rule 5th.—Find the apparent time from noon in each of the following cases.

(*a*) With the first altitude, the corresponding declination and *less* latitude.

(*b*) With the second alt. the corresponding declination and *less* lat.

(*c*) With the first alt. the corresponding declination and *greater* lat.

(*d*) With the second alt. the corresponding declination and *greater* lat.

Rule 6th.—Obtain the elapsed time corresponding to each assumed lat. thus—If one observation be A. M. and the other P. M. take the sum of the apparent times found by (*a*) and (*b*), if both be A. M. or P. M. take the difference of the results of (*a*) and (*b*), call this sum or difference the elapsed time (*e*) for the *less* lat. Proceed in the same manner, using the results of (*c*) and (*d*) to find the elapsed time (*f*) for the greater lat.

Rule 7th.—Take the difference of elapsed time (*e*) for the less lat. and the *true* apparent elapsed time, calling the remainder *too little* ,if the former is less than the latter but *too much* if the reverse is thec ase. Find also the difference of the elapsed time (*f*), for the greater lat. and the true apparent time, naming the remainder on the same principle as before.

Rule 8th.—When one elapsed time is *too much* and the other *too little*, take their sum, but if both are too much or both *too little*, take their *difference* for the error of elapsed time, caused by an error of one degree of lat.

Rule 9th.—Make this proportion which can be computed by proportional logarithms : thus

As the error of elapsed time on 1° of lat.
Is to 1°
So is the error of elapsed for the less or greater assumed lat.
To a correction to be applied to that assumed lat.

It will be seen that when the elapsed time of one assumed lat. is *too little* and that of the other *too much*, the *true* lat. is between the two assumed ones, consequently the correction must be added to the *less* or subtracted from the greater lat. according to which is used for the determining of the correction. But both the elapsed times of the two assumed latitudes, may be too much or both too little, each case is possible, then the correction must be applied to satisfy the following conditions—if the elapsed of the less assumed lat. differs from the true elapsed time by a given quantity, and that of the greater assumed lat. by a less quantity, then the true lat. must be greater than the greater assumed one; also if the elapsed time of the greater assumed lat. differs from the true elapsed time by a given quantity, and that of the less assumed lat. by a less quantity, then the true lat. must be less than the less assumed one.

Questions 89, 90, 91, 92, and 93, will serve for exercise by this method.

Steamers Lights and the Law of passing Vessels or the Rules of the Road.

1.—All steamers, when under way, must show the following Lights between sun set and sun rise.

A Bright light at the fore-mast head.
A Green light on the starboard bow.
A Red light on the port bow.

Remark.—The bright light should be seen at least 5 miles in a dark night, with a clear atmosphere, and the lantern so constructed that the light may be seen round an arc of the horizon of 20 points, that is, 10 points on each side, being from right-a-head to 2 points abaft-the-beam on each side. The colored lights should be seen at least 2 miles, and round an arc of the horizon of 10 points, being from right-a-head, to 2 points abaft the beam. The colored lights are seen only on their own side; as to prevent them being seen across the bow, an inboard screen, of at last 3 feet in length is fitted to each light; they being placed in a fore-and-aft line with the inner edge of the side light.

2.—All steamers when at anchor, must show a bright light at the foremast head, visible all round the horizon. Sailing vessels must do the same.

3.—Sailing vessels at night, approaching any other vessel, must show a light so as to be best seen by that other vessel.

4.—In meeting vessels, steamers and sailing vessels with the wind free, have to comply with the same rule, that is, they must give way to those on a wind on either tack.

5.—Sailing vessels close hauled on the starboard tack always keep their wind.

6.—Sailing vessels close hauled on the port tack must give way to those on the starboard tack.

7.—In passing vessels, whether they are proceeding in the same or in an opposite direction, pass them on your port hand.

8.—In passing a vessel which is proceeding across your bow, go astern.

Examinations of Masters and Mates established in consequence of the Mercantile Marine Act of 1850.

After the first day of September, 1852, no foreign-going vessel will be permitted to clear out from any Custom-house in the United Kingdom without the Masters and Mates respectively being in possession of Certificates either of service or of competency.

The Certificate of service entitles an officer, who has already served as either Master or Mate, in the British Merchant Service before the first day of January 1851, to go in those capacities again, and may be had by application to the Registrar-General of seamen, Custom House, London, on the transmission of the necessary Certificates and testimonials.

Certificates of competency will be granted by the

Board of Trade to all Mates and Masters who have passed examination, whether under the old or the present regulations, and also to all officers who have passed Lieutenants' Masters' and second Masters' examination in the Royal Navy and East India Company's Service, unless special reasons to the contrary exist: and any person desirous of exchanging a passing Certificate—obtained under the former Boards of Examiners—for a competency Certificate, should send it to the Registar-General, as before mentioned, with a request to that effect, and state the port to which he wishes it to be sent, where it will be delivered to him by the Collector of Customs or the Shipping Master.

All other officers, entering for the first time upon their duties, whether as mate or master, will be required to undergo an examination before one of the Local Marine Boards before they can act in either of those capacities.

The qualifications required for the several ranks undermentioned, are as follows:—

A Second Mate must be seventeen years of age, and must have been four years at sea.

In Navigation.—He must write a legible hand and understand the first four rules of arithmetic, and the use of logarithms. He must be able to correct the courses steered for variation and lee-way, and find the difference of latitude and longitude therefrom, be able to correct the sun's declination for longitude, and find the latitude by the meridian altitude of the sun; and work such other easy problems of a like nature, as may be put to him. He must understand the use of the sextant, and be able to observe with it, and read off the arc.

In Seamanship.—He must give satisfactory answers as to the rigging and unrigging of ships, stowing of holds &c., &c.,—must understand the measurement of the log-line, glass, and lead-line, be conversant with the rule of the road, as regards both steamers and sailing-vessels, and the lights carried by them.

An Only Mate must be eighteen years of age, and have been four years at sea.

In Navigation.—In addition to the qualification required for a Second Mate, an Only Mate must be able to work a day's work complete, including the bearings and distance of the port he is bound to, by Mercator's method. He must know how to lay off the place of the ship on the chart, both by bearings of known objects, and by latitude and longitude; must be able to observe and calculate the sun's amplitude, and deduce the variation of the compass therefrom. He must be able to use a sextant and determine its error, and adjust it, and find the time of high water from the known time at full and change.

In Seamanship.—In addition to what is required of a Second Mate, he must know how to moor and unmoor, and to keep a clear anchor; to carry out an anchor; to stow a hold, and make the requisite entries in the ship's log.

A First Mate must be nineteen years of age, and have served five years at sea, of which one year must have been as either Second or Only Mate, or as both. (Service in a superior capacity is in all cases to be equivalent to service in an inferior capacity.)

In Navigation.—In addition to the qualification required for an Only Mate, he must be able to observe azimuths and compute the variation; to compare chronometers and keep their rates, and find the longitude by them from an observation of the sun; to find the latitude by a single altitude of the sun off the meridian; and be able to use and adjust the sextant by the sun.

In Seamanship.—In addition to the qualification required of an Only Mate, a more extensive knowledge of seamanship will be required, as to shifting large spars and sails, managing a ship in stormy weather, taking in and making sail, shifting yards and masts, &c., and getting cargo in and out; especially heavy spars and weights, &c.; casting ship on lee-shore, and securing the masts in the event of accident to the bowsprit.

A Master must be twenty-one years of age, and have been six years at sea, of which one year must have been as First Mate, and one year as Second Mate; or two years as First and Only Mate.

In addition to the qualification for a First Mate, he must be able to find the latitude by a Star, &c. he will be inquired of as to the nature of the attraction of the ship's iron upon the compass, and as to the method of determining it. He must possess a sufficient knowledge of what he is required to do by law; as to entry and discharge, and the management of his crew; as to penalties and entries to be made in the official log. He will be questioned as to his knowledge of invoices, charter party, Lloyd's agent, and as to the nature of bottomry, and he must be acquainted with the leading lights of the Channel he has been accustomed to navigate, or which he is going to use. In cases where an applicant for a Certificate as Master ordinary, has only served in fore-and-aft rigged vessels, and is ignorant of the management of a square-rigged vessel, he may obtain a Certificate on which the words "*Fore and aft rigged vessel*" will be written. This however is not to apply to Mates, who being younger men, are expected for the future to learn their business completely.

An Extra Master's Examination is intended for such persons as wish to prove their superior qualifications. Before being examined for an Extra Master's Certificate, an applicant must have served one year either as a Master with an *ordinary certificate of competency*, or as a Master having a *first class certificate*, granted by one of the former Boards of Examination.

In Navigation.—As the vessels which such Masters will command, frequently make long voyages, to the East Indies, Pacific, &c., the candidate will be required to work a lunar observation by both sun and star to determine the latitude by the moon and star, by Polar Star off the meridian, and also by double altitudes of the sun, and to verify the result by Sumner's Method. He must be able to calculate the altitudes of the sun or star when they cannot be observed, for the purpose of lunars —to find the error of a watch by the method of equal altitudes—and to correct the altitudes observed with an artificial horizon.

He must understand how to observe and apply the deviation of the compass, and to deduce the set and rate of the current from D. R. and from observation. He will be required to explain the nature of Great Circle Sailing, and know how to apply practically that knowledge; but he will not be required to go into the calculations. He must be acquainted with the law of storms so far as to know how he may probably best escape those tempests common to the East and West Indies, and known as hurricanes.

In Seamanship.—The extra examination will consist of an inquiry into the competency of the party to heave a ship down, in case of accident befalling her abroad; to get lower masts and other heavy weights in and out; how to construct rafts, and as to his resources for the preservation of the ship's crew in the event of wreck, and in such operations of a like nature as the examiner may consider necessary.

The candidates will be allowed to work out the various problems according to the method and tables they have been accustomed to use, and will be allowed five hours to perform the work; at the expiration of which, if they have not finished, they will be declared to have failed, unless the Local Marine Board see fit to extend the time.

Applicants for examination are required to give their names to the Shipping Master, or to the Local Marine Board at the place when they intend to be examined, on or before the day of examination, and to conform to the regulations in this respect which may be laid down by the Local Marine Board, and if this be not done, a delay will be occasioned.

The examinations will commence early in the forenoon on the days appointed, and be continued from day to day until all the candidates whose names appeared upon the Shipping Master's list on the day of examination, are examined.

Testimonials of character on which *sobriety* and *trustworthiness* must be written, will be required of all applicants, and without which no person will be examined: and as testimonials may have to be forwarded to the office of the Register-General of seamen in London for verification, before any Certificates can be granted, it is desirable that candidates should lodge them as early as possible. Upon application to the Shipping Master, candidates will be supplied with a form, which they will be required to fill up and lodge with their testimonials in the hands of the examiners.

The fee for examination must be paid to the Shipping Master. If a candidate fail in his examination, half the fee he has paid will be returned to him by the Shipping Master on his producing a document which will be given him by the examiner.

The following are the fees to be paid by applicants for examination.

	£	s.	d.
Second Mate	1	0	0
First and Only Mates, if previously possessing an inferior certificate	0	10	0
If not	1	0	0
Master whether Extra or Ordinary	2	0	0

Any one who has been one year in possession of a Master's first-class Certificate granted by one of the former Boards of examiners, or an Ordinary Master's certificate of competency granted under the present examiners, may pass an extra examination, and receive an extra Certificate in exchange for his former one, without payment of any fee. But if he fails in his first examination, he must pay half a Masters fee on his coming a second time; and the same sum for every subsequent attempt.

If the applicant passes, he will receive a document from the examiner which will entitle him to receive his certificete of competency from the Shipping Master at the port to which he has directed it to be forwarded. If his testimonials have been sent to the Registrar to be verified, they will be returned with his certificate.

If an applicant is examined for a higher rank and fails, but passes an examination of a lower grade, he may receive a certificate accordingly, but no part of the fee will be returned.

As the examinations of Masters and Mates are made compulsory, the qualifications have been kept as low as possible; but it must be distinctly understood that it is the intention of the Board of Trade to raise the standard from time to time, whenever, as will no doubt be the case, the general attainments of officers in the Merchant Service shall render it possible to do so without inconvenience; and officers are strongly urged to employ their leisure hours, when in port, in the acquirement of the knowledge necessary to enable them to pass their examinations: and Masters will do well to permit apprentices and junior officers to attend schools of instruction and to afford them as much time for this purpose as possible.

Lights of Newfoundland.

Name of Light	Feet over the sea	Miles seen in clear weather	Lat. North	Long. West	Description of Light	Variation of Compass
Fort Amherst	110	12			Fixed White	
Cape Spear	275	36	47° 31′	52° 33′	White revolving one minute	29° W.
Cape Bonavista	150	30	48° 42′	52° 59′	Red and white alternate revolving 2 minutes	30° W.
H. Grace Island	151	30	47° 42′	53° 5′	White fixed	
H. Grace Beacon	40	10			White fixed double one over the other	
Green Island	92	12	48° 30′	53° 3′	Fixed white	30° W.
Offer Wadham	96	12	49° 36′	53° 46′	Fixed white	32° W.
Cape Pine	314	36	46° 37′	53 30′	White revolving 30 seconds	27° W.
Cape Race	180	17	46° 39′ 11″	53° 2′ 58″	Fixed white	27½° W
Dodding Head	410	36	47° 0′	55° 0′	White revolving 20 seconds	26° W.
Baccalieu Island	380	36	48° 0′ 9′	52° 30′	White revolving 20 seconds	30° W.
Cape St. Mary's	230	28	46° 53′	54° 11′	Revolving alternate red & white one minute	27° W.

Remarks.

At entrance of St. John's Harbour. Stone building.

Wood building. White with bands of red on the roof.

Wood building. White with red stripes.

Wood building. White with red bands on the roof.

House painted white—Red roof.

House white. Tower brick, detached.

Tower iron—painted with alternate bands of red & white—House separate painted white—roof red.

Tower iron painted in stripes red and white—Dwelling detached, white, roof red.

Tower striped red and white vertically.

House and Tower as at Green Island, painted white—Roof red.

Tower detached from dwelling—painted white roof red.

(Not yet finished.)

Lights in Gulf of St. Lawrence and Straits of Belle Isle.

Name of Light	Position	Lat. N.	Long. W.	Description of Light.	In clear weather seen Naut. miles	Height over the sea, feet	Variation of the Compass
Belle Isle	S.W. Point of Island	51° 53′	55° 26′	A single fixed white light	20	470	35° W.
Point Amour	S.E. Point of Forteau Bay	51°27′30″	56°43′40″	Single fixed white	18	155	34° W.
Anticosti	West end of Island	49°52′30″	64° 35′	Single fixed white	15	112	27½°W
Cape Rozier (East coast of Gaspe)	Point of Cape	48° 51′	64° 15′	Single fixed white	17	136	26° W.

NOTE.—Signals are given at or near each of the above Houses, by means of an air or fog-whistle, sounded at short intervals during foggy weather and snow storms—or by a nine-pounder gun fired every hour, in case of the whistle being out of order.

REMARKS.

Whole Horizon lighted from sun rise to sun set.

Circular stone tower, faced with fire brick of light colour $\frac{2}{3}$ of horizon illuminated.

Tower &c., same as Point Amour.

Tower and light same as Anticoste.

SUBSCRIPTION LIST.

GOVERNMENT HOUSE, APRIL 14, 1859.

I consider that such a work as Mr. Campbell proposes to publish would be very useful in this colony for those young men who may wish to acquire a knowledge of Navigation. I have not read the work, but as Mr. C. intends to publish by Subscription I shall readily contribute towards that end £10.

A. BANNERMAN,
Governor.

	£	s.	d.
Walter Grieve	5	0	0
J. McGregor	3	0	0
McBride & Kerr	3	0	0
C. F. Bennett & Co.	3	0	0
Brooking Son & Co.	2	0	0
Harvey, Fox & Co.	2	0	0
W. & H. Thomas & Co.	2	10	0
Job Brothers & Co.	3	0	0
Clift, Wood & Co.	1	0	0
P. Tasker	1	0	0
F. B. Carter	1	0	0
Dr. Winter	1	0	0
S. March	1	0	0
R. O'Dwyer	1	0	0
Bowring Brothers	2	0	0
Newfoundland Marine Assurance Company	5	0	0
St. John's Marine Insurance Company	5	0	0
William Hounsell & Co.	1	10	0
W. W. LeMessurier	1	0	0
John Kavanagh	1	0	0
John Hogsett	1	0	0
R. Alsop & Co.	1	0	0
W. F. Wilson	1	0	0
James Cormack	1	0	0
John Munn	3	3	0
Ridley & Sons	2	0	0
W. Donnelly	1	0	0
John Rorke	1	0	0

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