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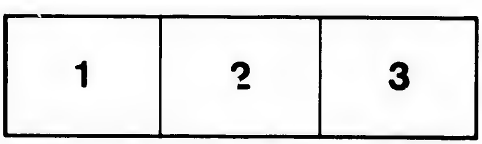
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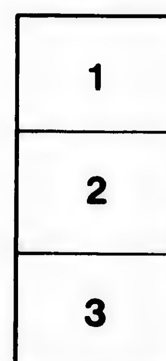
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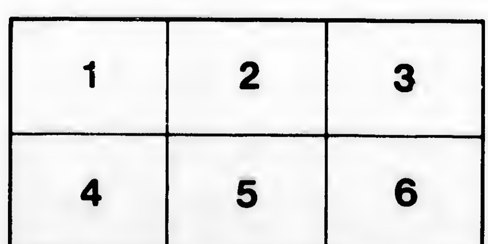
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AN

# INTRODUCTION

TO THE

# PRACTICE

OF

# NAUTICAL SURVEYING,

AND THE

## Construction of Sea-Charts:

ILLUSTRATED BY THIRTY-FOUR PLATES.

*TRANSLATED FROM THE FRENCH OF*

C. F. BEAUTEMPS-BEAUPRÉ,

HYDROGRAPHER OF THE FRENCH MARINE, MEMBER OF THE LEGION OF HONOUR, &c.

---

BY CAPTAIN RICHARD COPELAND,

OF THE ROYAL NAVY.

---

WITH

## AN APPENDIX,

CONTAINING

MR. DALRYMPLE'S ESSAY ON THE MOST COMMODIOUS METHODS OF MARINE SURVEYING;

AND THE

DESCRIPTION OF OBSERVATIONS

BY WHICH THE LONGITUDES OF PLACES, ON THE COASTS OF AUSTRALIA, &c. HAVE BEEN SETTLED; BY CAPTAIN MATTHEW FLINDERS, R.N. &c.

*LONDON:*

PUBLISHED BY R. H. LAURIE,

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1823.

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# Dedication.

TO THE RIGHT HONOURABLE THE LORDS COMMISSIONERS OF THE ADMIRALTY.

*My Lords,*

*WITH sentiments of the utmost respect, I beg leave to express my gratitude for the flattering distinction your Lordships have been pleased to confer on the following Work, in permitting me to announce to the Public, that my humble endeavours to facilitate the progress of Nautical Science have received the sanction and approbation of the acknowledged patrons of every improvement calculated to advance the prosperity of the British Navy.*

*I have the honour to be,*

*My Lords,*

*Your most obedient and faithful servant,*

RICHARD COPELAND.

*Eton, 4th June, 1823.*

## PREFACE BY THE TRANSLATOR.

At no period of our history has the attention of naval men been so generally directed to the study of hydrography as the present: yet this branch of nautical science has been, hitherto, so little cultivated, that it is difficult to find officers qualified to undertake the duties of surveyors.

The principal cause of this defect, in our system of nautical education, has arisen from the want of a good practical treatise on the subject. The English authors, who have written on Nautical Surveying, have confined themselves entirely to the elementary principles; hence the difficulty always experienced, by naval men, on entering into the practice of surveying; and this difficulty, being generally known, has deterred many from entering into the study; but it might, in a great measure, be obviated by an illustration of the subject in the form of an *Analysis of an actual Survey.*

With this view, I have ventured to offer to the public a translation of the Treatise of the celebrated French hydrographer, M. Beautemps-Beaupré, which was published at Paris, in 1808, under the title of '*Appendix to the Narrative of Rear-Admiral Bruny Dentrecasteaux's Voyage.*' The author, without entering into a long detail of different modes of surveying, and examining their respective merits, *comes to the point at once,* by giving an interesting statement of the methods he himself has adopted in the construction of his Charts.

*The nature of his work is such as leads directly to the practice of surveying.* In his illustrations of the defects to which many of the Elements are liable, he invariably refers to occurrences which have fallen immediately under his own observation: the errors to which he was exposed, from circumstances arising out of various causes, inseparable from the operations of surveying, are very fully detailed.

He enters very minutely into the operations of laying down soundings, and gives a most elaborate example for the illustration of this important branch of the surveyor's duty.

The mode of conducting a survey on a coast without landing, the most difficult and delicate of all hydrographic operations, he has elucidated in a complete and masterly style, by giving the analysis of a survey conducted under his own direction, of the Archipelago of Santa Cruz, a group of islands, situated between 10° and 11° south of the equator, and about 166 degrees to the eastward of the meridian of Greenwich, commonly known by the name of *Queen Charlotte's Islands*; a name given to them by Captain Carteret, when he visited them in the year 1767. In short, the whole treatise, with the exception of the mathematical demonstrations of the formation of a statimetric scheme of points, is an interesting narrative of facts; and I am convinced that the student in hydrography, who peruses Treatise with attention, will save himself, in practice, many mortifying proofs of the impropriety of placing too much confidence in many of the practical rules laid down in elementary works on this subject.

Care has been taken, in this Edition, to render the views of the land more in accordance with the general knowledge of the art of drawing, which now exists, by attention to aerial perspective; the French plates being, many of them, compounds of ground-plans and profiles, which gives them a very uncouth and incorrect appearance.

The trigonometric Chart is reduced to the English scale of measurement; and the Chart accompanying the French work, comparing the position of the islands of Santa-Cruz, as laid down by M. Beautemps-Beaupré, with that given by Captain Carteret, is omitted in this edition, as it may be considered to belong more properly to Dentrecasteaux's Narrative, than to this Treatise when published separately.

But, lest I may be supposed to have omitted this Chart from a reluctance to give the French hydrographer the full benefit of his comparison, I think it right to state that, a perusal of his analysis is quite sufficient to satisfy the mind of any impartial person of the superiority of his operations.

In the Table of the astronomical observations, for the variation of the compass, an expression occurs which I have had some difficulty in translating; and, as I cannot positively assure myself that I have properly understood the author's meaning, I here give the sentence as it is in the French edition:

"A midi, par une distance prise au soleil,"

which I have translated,—

"At noon, by a magnetic bearing of the sun."

If I have not given the true meaning of this term, I must confess that the sentence is, to me, perfectly unintelligible.

It is from a consideration of the nature of such observation, that I remain in doubt.

The Appendix has been added, on the suggestion of a friend, who has observed, that the document by Mr. Dalrymple would be acceptable, as originally composed, not only as being recommended by so eminent a name, but by the simplicity of its principles, exemplified in the use of Hadley's quadrant or the sextant. The extract from Captain Flinders is added, as an important one, which must be equally interesting and desirable to all who do not possess his most valuable, but expensive, work, the Voyage to, and Surveys of, Australia, published in 1814.

Richard Copeland.

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[Page 2, line 8, for *Cartaret* read *Carteret*.]

# AN INTRODUCTION

TO

# The Practice

OF

# NAUTICAL SURVEYING, &c.

## INTRODUCTORY REMARKS.

During the interval which had elapsed between the time of the first attempts at bringing the Art of Navigation to perfection, by means of reflecting instruments and chronometers, and the year 1791, at which period Rear-Admiral Dentrecasteaux was sent in search of La Pérouse, many celebrated navigators had materially increased our knowledge of hydrography, and it had already become difficult to exceed the point at which they had arrived.

Every sea had been explored, and there remained no great discoveries to be made. The latitudes and longitudes of a great number of important positions had been determined, and these positions had become the bases on which the corrections of marine charts were to be founded.

Rear-Admiral Dentrecasteaux was aware that he was entering a career in which navigators, both French and English, had acquired so much fame, at so late a period, that he could not hope to add to the interest of the voyage by making new discoveries; nevertheless he entertained the hope of being able, in the course of his long navigation, to contribute to the advancement of science in general, and more particularly hydrography, by giving a very minute description of the coasts and islands which he had received orders to visit; this being in accordance with the principal object of his mission.

I was charged with the office of principal Marine Surveyor of the expedition entrusted to M. Dentrecasteaux, and I used my utmost endeavours to second the views of this seaman, so justly regretted by all who have known him, and who have appreciated those rare qualities he was known to possess.

I have unceasingly practised those lessons which I had received from M. M. Fleurieu and Buache, during six years that I was employed under their orders, constructing marine charts. The public will be enabled to judge, from what will be set forth in the following Treatise, what degree of reliance may be placed in the charts composing the Atlas of Dentrecasteaux's Voyage, which have been drawn with the same care, and constructed on the same scale, as the Chart of the Archipelago of Santa Cruz, (Queen Charlotte's Isles of Cartaret,) the analysis of which will be given.

## CHAPTER I.

### OF HYDROGRAPHIC OPERATIONS PERFORMED UNDER SAIL.

I HAD obtained, in the construction of Marine Charts, too many proofs of the inaccuracy of surveys, taken by magnetic bearings, not to have determined on using, as far as it might be possible, De Borda's reflecting-circle, as a substitute for the mariner's compass.

It is true that the use of reflecting-instruments required the co-operation of zealous and intelligent persons; but, in this respect, I had nothing wanting; for, after we had been a few months on our voyage, I was assisted by several skilful observers; among whom M. M. Raoul (brothers) and M. Gicquel are most particularly entitled to my grateful acknowledgements.

After having adopted the reflecting-circle, for measuring the angular distances of the remarkable points or headlands of coasts, and having ascertained the possibility of measuring a great number of angles at the same instant, I conjectured that the most correct and easy method of laying down the points or positions corresponding with these angles, taken from a station either afloat or on shore, was still to be sought for: the system of using the letters of the alphabet and arithmetical figures, to denote objects which were not yet named, tended, it is true, to the attainment of this point; but, in being confined to this method, the observer exposed himself to the commission of errors so much the more important, as there was not a hope of proving their existence or extent.

I have reason to believe that I discovered the method of avoiding these errors, by taking, at each station, a view of the coast, on which the most remarkable objects were indicated, not only by letters and figures, but the measures of the observed angles contained between them were also noted, the bearings of such points as were observed in one with each other, the estimate of the distances, &c. &c.

From this method of operation, which I have constantly followed, I have derived the incalculable advantage of having always before my eyes, in constructing my charts, the objects exactly as they appeared at the time of observation; and frequently, by this mean, have detected errors which have imperceptibly crept into the observations.

Whatever may be the precautions observed, in stopping the ship's way during the time the views are drawn, on which the observations are to be noted, they cannot be taken with too much rapidity: it is always sufficient to take slight sketches, or outlines, which may be filled up, more or less, after the stations are finished.

We shall now set forth the principal means, which we used, to arrive at the degree of accuracy that trigonometric operations made under sail will admit of; but, in the first place, let us pay to the officers charged with the care and direction of the chronometers, and especially to M. Rossel, the tribute of gratitude, which we owe, for the assistance they rendered us under every circumstance, by multiplying, as much as was in their power, the number of their observations; in engaging, by their example, the other officers of the expedition to assist us; and, finally, by calculating all their observations daily, so as to enable us to lay down our charts on the spot, and in repeating their calculations every time their results differed sensibly from those obtained by a chain of trigonometric operations.

We should consider it as an act of injustice towards these officers if we did not here declare, that, without such assistance, it would have been impossible to offer to the public a Work so complete as that which accompanies the NARRATIVE of REAR-ADMIRAL DENTRECASTEAUX'S VOYAGE.

The principal operations, which serve as a basis for the construction of our charts, are those which have been made at noon, and at the hours of observations for apparent time. At these times of the day I assembled near me as many observers as possible: immediately before the commencement of the operations I made a sketch of the land, commencing with those parts, which, being most remote, were the least liable to change in appearance; then, at the instant of the astronomic observations, I measured the angular distance between the object which I had pointed out to my assistants, as the point of departure, and one of the remarkable points on the coast, whilst each of them measured the angular distance from the same point of departure to some one of the other points, noted as most suitable to be used for carrying on the survey.

The results of these simultaneous observations were then noted on the sketch of the land, which had been made for that purpose.

When the sun was not too much elevated above the horizon, one of the observers measured the distance of that object, from one of the remarkable points on the coast. By means of the altitudes, observed by M. Rossel, and the distance, I obtained the bearing of this point astronomically, from which I deduced the bearings of all the objects whose angular distances from each other had been observed. The magnetic bearing of the point of departure was always taken by two azimuth compasses, during the time of the observations, and the mean of the bearings given by these instruments was noted down, whether the true bearing had been determined astronomically or not.

If circumstances (which, indeed, rarely occurred) prevented me from assembling a sufficient number of observers to take all the angles simultaneously, I arranged several instruments, so as to take, in rapid succession, two or three angles myself, without being obliged to note them instantly. M. M. Raoul (brothers) and M. Gicquel, who, as I have already stated, constantly accompanied me in my operations, made similar observations, and by these means I still obtained results sufficiently accurate; and, finally, when the frigate had too much way, she was brought-to during the short time occupied by our observations.

Such observations as were not made at the times of determining the latitudes and longitudes astronomically, were so much the more multiplied as we approached nearer to the land: our labours commenced at sun-rise, and did not terminate until night. At each of these stations, the bearings of the remarkable points of the land were determined astronomically, whenever the sun was visible, and his elevation above the horizon was not too considerable; but, when this observation was impossible, the bearings were deduced from the magnetic bearing of the point of departure of the angular distances, taken by two azimuth compasses. When the sun was visible at the hours of his rising and setting, the angular distances were taken at the time that the sun's lower limb was about 16 minutes above the horizon; and then, by measuring the distance from the sun's center to one of the principal objects on the shore, the true bearing of that object was deduced from the sun's amplitude. The point of departure of the angles was always selected from the most remarkable objects situated near the horizon, such as the point B (*fig.* 1. *pl.* I.): then, having measured the angular distance of this point from the summit A of a mountain, of a moderate elevation, the reflected image was brought to C, the point at which the vertical circle in which A is situated intersects the horizon, and the angle C S B was then given sufficiently accurate for the purpose.

When the elevated point was more than a degree above the horizon, the angular distance of the two objects and the elevation of the point A, above the horizon, was taken, and the horizontal angle B C was thence deduced by calculation.

If one of the points to be surveyed was placed between the observer and the horizon, as at E (*fig.* 2. *pl.* I.), then the point B was brought, by reflection, to the point at which the line S E, by being continued, intersects the horizon. This operation is very simple when the point D is to be found on the shore; but, in all other cases, it is necessary to measure the angular distance B E, and the angle of depression (D S E) of the point E below the horizon, to calculate the angle D S B, or to be satisfied with this angle at an approximation liable to an error of 5 or 6 minutes, which, nevertheless, may suffice; for the point E can never be very distant from the vessel.

It is unnecessary to enter into a more minute detail of the mode of conducting the survey: it will be readily admitted that every precaution was taken to guard against errors occasioned by the instability of the vessel, and such as might arise from the use of the compass. This instrument was employed only for deducing the position of one single point at each station, and whenever it was possible to set any one remarkable object on the shore by the amplitude or azimuth of the sun: the compass-bearings have been used only for the purpose of ascertaining the variation of the magnetic needle.

Particular attention was paid to the relative bearings of the remarkable points, on the coasts, when they were observed in a line with each other; because these observations form an important part of the operations performed in conducting a survey under sail.

I was soon convinced that using a multiplicity of stations, to give a minute representation of a strange coast, was not sufficient in itself; but, in order to avoid mistakes, it was necessary never to lose sight of the land during the continuance of the survey; therefore I took the precaution, under all circumstances, to remain continually on deck, in order to observe the changes which took place in the configurations of the capes, islands, mountains, &c. &c., and to take the respective bearings of the points which were brought successively in one with each other.

This attention is necessary, in order not to lose the opportunities of fixing the essential positions of a coast which the surveyor is not likely to revisit.

Besides the sketches on which the angles taken at each station were noted, I frequently made an horizontal or ground plan of the part of the coast surveyed, in order to recollect thereby such minute details as the sketches might not clearly explain.

It is from taking the bearings of objects, seen in a line with each other, that the surveyor may obtain decided and convincing proofs of the insufficiency of the compass in indicating the exact positions of stations on the shore. It will be seen in the survey of the Archipelago of Santa-Cruz, that the bearings of the same points, taken in opposite directions, frequently differed several degrees.

In taking the bearing of two objects, in a line with each other, if one of them is a very distant point, the observer can never be certain of having sight of the base of that point; and as, in this case, there is added to the errors occasioned by the use of the magnetic needle, an error, the extent of which cannot be ascertained, it is prudent not to place any reliance on the result of an observation of this kind, whatever degree of accuracy it may appear to possess; nevertheless, this inconvenience may frequently be obviated by observing from the mast-head the precise moment when the extremity of the distant point is in one with the object nearest the vessel.

We have ascertained, by a great number of observations, and principally by the differences found in the bearings of points seen in one with each other, which had been taken in opposite directions, that the compass-bearings taken on the deck of a vessel, even under the most favorable circumstances, are liable to an error of three degrees at the least.

For example, it frequently occurred to us that we have taken bearings from a point, such as C, (*fig.* 3,) the cape A in one with the cape B; then, from the point D, the cape B in one with the cape A; and have found considerable differences in the results of the two observations.

We have observed, also, in determining the variation at sea, that, in an interval of a few minutes between the observations, which were taken with the greatest care, the results have differed some degrees.* We have noted on the views taken at each station, or on ground plans, the bearings of objects taken in one with each other, and particularly when these objects were not already marked by letters, or when seen for the first time.

The survey of the Archipelago of Santa-Cruz, which I give complete, together with the analysis of the Chart, drawn from the results of these operations, will explain all that has been stated here and in the preceding pages.

* These remarks on the compass have been noted and verified by Captain Flinders. See his Appendix, vol. II. p. 512 to 532, or Purdy's Memoir on the Atlantic Ocean, 4th Edit. p. 247 to 254.—Edit.

## OF DEAD RECKONINGS.

The distance run by the ship has been measured with the greatest care, and the strictest attention has been paid to the steerage of the vessel, at all times, when the dead reckoning has been resorted to as an element in the construction of the charts.

However, we were satisfied that, in general, it was advisable not to make use of the dead reckoning unless the hourly rate of the vessel's sailing exceeded three knots, and that she had run on the same course at least half an hour. In every other case, as the vessel makes but little way, the same objects are set from several stations, and it is almost always possible to fix very accurately the positions of some remarkable points which might afterwards serve to rectify those of the ship, and to give the detail of a coast better than it might have been done by mean of the dead reckoning. Be that as it may, I was unwilling to neglect any means which could contribute to give accuracy to my work; I have always been careful in noting down the times at which the most remarkable objects were on the same parallel, or on the same meridian, as the ship.

It will be needless to insist on the necessity of great circumspection in using the dead reckoning, in the construction of charts; no seaman is ignorant of the liability of this element to error. By means of chronometers, the surveyor may multiply his astronomic observations sufficiently to determine his bases with an accuracy far superior to those which could be deduced from the dead reckoning, even under the most favourable circumstances. We could, if necessary, support our opinion by a great number of examples; but we shall be satisfied with citing one only, which, at the same time, will show to what errors the surveyor is exposed in making hydrographic observations without the assistance of that invaluable instrument, by means of which the errors of the ship's run may be corrected daily.

Late in the evening of May 26th, 1793, finding ourselves near Cape Philip, (Island of San-Christoval,) and having set the bearings of a mountain, having, at its summit, a notch, or cut, resembling a battlement, M. Dentrecasteaux ordered us to close nearer the land, and to hold our own by making short boards, so as not to make more than two leagues westing during the night, that we might be enabled to commence the operations of the morrow at the point where the survey last terminated. On the 27th, at sun-rise, I sought the points which had been set the preceding evening at sun-set; I could discern none of them, and immediately commenced my operations, trusting to the astronomic observations for correcting the error in the reckoning: but, towards ten o'clock in the morning, I was not a little surprised to discover Cape Philip again, and the mountain which, by its notch, could not be confounded with any other object; I then examined my draught, and perceived that I had repeated the description of an extent of six leagues of the coast we had run down the day before. It was proved, by the astronomic observations, that we had been driven four and twenty miles to the eastward, in twelve hours, by the *effect of the current only*, on a coast and at a season at which we were led to expect currents setting to the westward. Without the assistance of the chronometers we should probably have repeated, on our charts, the same part of the coast, notwithstanding the similarity of the results obtained by the two operations. Such a repetition, it would be supposed, could occur only on an unknown or newly-examined coast: but I am not the less convinced that more than one example of this kind of error would be found in the Charts of coasts very much frequented.

We have never neglected to note, either on the sketches of the land or the horizontal draughts, the estimated distances, from the ship, of the most remarkable objects on the shore, at the times of the observations: but these estimated distances have assisted us only in retaining in our memory the appearances under which these objects presented themselves, and to convince us of the danger there would have been in using these elements in the construction of our Charts. We could cite a thousand examples to prove that, even on the most frequented or best-known coasts, the *dead reckoning, or estimated distances, should never be trusted.*

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## OF HYDROGRAPHIC OPERATIONS PERFORMED BY BOAT.

We shall not here speak of all the operations which it is necessary to perform, in order to lay down marine Charts with the most rigorous accuracy; because the surveys of the coast, roadsteads, and ports, in the immediate neighbourhood of the different anchorages of our ship *La Recherche*, have always been made in haste, and only with that degree of accuracy that could be expected from our having been under the necessity of going over as much ground as possible in a short space of time; and these are the only operations which we are about to describe.

The instruments which we have employed, when making surveys in boats, are, the *reflecting circle*, for measuring the angular distances between the points, the positions of which it was necessary to determine, whether by stations afloat or on the shore; an *azimuth circle* with telescopes, the upper telescope of which had a movement perpendicular to the plane of the instrument, for the stations of points too much elevated above the level of the sea; a *telescope*, with a micrometer, for measuring bases; an *artificial horizon*, for obtaining the altitude of the sun, at times when the sea-horizon was not to be seen or defined, and it was nevertheless desirable to get the true bearing of some terrestrial object; a *good azimuth compass;* and, finally, under some circumstances, the *astronomical circle*.

All the operations that have been carried on in boats are preserved on views and sketches, in the same manner as those which have been made on board the ship. We have succeeded so well with this method, in drawing plans and charts, which required very minute details, that we cannot too strongly recommend it to those who are likely to be engaged in similar pursuits: it spares the description of coasts, always long, and, when in an unknown country, tedious and unintelligible: it has (we cannot help repeating it) the incalculable advantage of recalling the remembrance of all the objects seen at one station, and of never leaving a shadow of uncertainty upon their relative positions: of an angle that has been falsely read off the instrument, or falsely noted on the draught, the error is recognized in constructing the chart; and, if the angle cannot be used, at least the error is not communicated to any other positions: it brings likewise the advantage of not being obliged to distinguish the angles which are on the right hand of the point of departure from those which are on the left. I have constantly adopted it, even latterly, when surveying on the coasts of France, Istria, and Dalmatia, and I am the more and more convinced of its utility.

I have in vain endeavoured to avail myself of the use of the compass in boats, to take the bearings of remarkable points in one with each other, as also to determine the courses of the same boats: the movements of these light vessels are so quick, that it is seldom possible to take a bearing nearer than to 10 degrees. The compass I carried with me I could use on shore only: it was intended to take, at each station, the bearing of one single object, from which was deduced the variation of the compass; and to give, on the spot, a rough estimate of the direction of the coast: I was seldom able to make use of the compass-bearings taken on shore, in the construction of our charts; nevertheless, we never neglected taking them.

I could make it appear, by a great number of examples, with what inaccuracy the compass gives the bearings when used on shore, whatever precautions may be taken to guard against the errors occasioned by the instability of the magnetic needle: but shall be content with stating one example only.

In December, 1793, when I was (with M. Willaumez) taking the hydrographic survey of the Archipelago of La Recherche, (Nuyts's Land,) we landed the compass on one of the capes on the main-land, to take the bearings of a point, the true bearings of which had just been determined astronomically. When the compass-bearing had been taken, we moved the compass from the station, and it was placed about six feet on the other side of a very large stone: while it was in this new position, the index was directed, by chance, to the same point which had been set from the station, and a difference of four degrees was found in the bearings, although the object was at so great a distance, that the change of position in the compass ought not to have occasioned one minute of difference; consequently we verified the first observation, being persuaded that some error had arisen, either in leading off the bearing, or in noting it down: but we found, to a few minutes, the same result as that which was noted on the draught; and we were satisfied that the stone, near which we had made the observation, had alone occasioned so great an error.*

* *Note from Capt. Flinders, &c.*—" Besides the errors which the attraction of the iron produced in the compasses at the binnacle, differences are frequently mentioned as having been found in the magnetic needle on shore, and on board the ship in the vicinity of land. That there are few masses of stone totally devoid of iron, and that all iron, which has long remained in the same position, will acquire magnetism, or a power of attracting one end of the magnetic needle towards one part of it, and the opposite end towards another, is, I believe, generally admitted. The kinds of stone, which I have observed to exert the greatest influence on the needle, are iron-ore, porphyry, granite, and basaltes; and the least are, sand or free-stone, and calcareous rock, and the argillaceous earth very little.

" The iron in the ship attracted the south end of the needle in the southern hemisphere; and in the same part of the world it was the same end of the needle upon which the land had an attraction. The following are some instances:—

" In King George's Sound, (New Holland,) the *west* variation was 6° greater on the western head of Michaelmas Island than it was on the east side of a flat rock in the sound. The stone here is granite.

" On approaching the granite islands of the Archipelago of the Recherche, from the *west*, the corrected variation on board the ship was increased from 5° 25′ to 6° 22′ west, contrary to the regular order; but, when Termination Island bore nearly west, and the principal cluster N. N. W., the corrected variation was no more than 0° 51′; and, after clearing the Archipelago some distance, it again increased to 4½° west.

" Near the *west* side of Yorke's Peninsula, the corrected *east* variation was 3° *less* than on the east side, although the places of observation were not more than forty-eight miles asunder: the uncorrected observations differed 6°.

" Upon the *east* side of the high hills behind Memory Cove, the *east* variation was 1° 40′ greater than at the granitic summit of the same hills.

The method I adopted, of taking only one compass-bearing at each station on shore, has always gained me the advantage of giving the needle time to settle, and fix in the plane of the magnetic meridian, while I was employed in drawing the views of the land, and taking the angles: thus I was enabled to secure the greatest degree of accuracy that can be expected from the best instruments of this kind.

From a tolerably frequent use of the compass, I have learned that, independent of the considerable differences which are occasioned in the variations by ferruginous substances, there was still an error to guard against, the cause of which appears to be friction, and which may be estimated as far as a degree.

For example: it has often happened that, after having left the needle nearly half an hour, to allow it to become stationary in the plane of the magnetic meridian, I have made it vibrate 15′, 30′, 45′, or even a degree, by tapping the glass of the compass-box; sometimes it has remained immoveable, at the new division to which it pointed; sometimes it has returned nearly to its former position; but never have I obtained the same result twice. I have tried this same experiment, since my return, on the coasts of Belgium, at low water, with compasses constructed by Le Noir, and I have always found differences between the first

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"In Shoal-water Bay, at anchor near the eastern shore, the corrected east variation was 1° 25′ less than near the west shore: at Broad Sound, also, it was 1° less on the east than on the west side. These effects were correspondent to the former, though the expression of the situations be unavoidably different.

"In the Investigator's Road, Gulf of Carpentaria, the *east* variation was full 1° more on the east side of Bentinck's than on the west side of Sweers' Island. The rock here is partly iron-ore.

"Near the east side of Pellew's Group the east variation appeared, from the bearings, to be increased 2° from what it had been at a farther distance, though, in regular course, it should have diminished; and, at stations on the east sides of different islands, I found it necessary to allow 1° more than on the west sides.

"There were several other examples where the south end of the magnetic needle was drawn towards the nearest land; but only two where the contrary attraction seemed to have been exerted. These were both on shore, and probably might not be exceptions to the rule, if all the circumstances were known; for, although the body of an island may lie to the west, a single block of stone near the theodolite on the other side might do more than counteract the opposite attraction."—*Flinders' Appendix*, vol. ii. pp. 526, 7.

In his '*Essay on Magnetic Attractions*,' 1820, Mr. Barlow has developed another source of unsuspected error, which he found in a land-compass excellently constructed. The needle was six inches in length, of the bar-form, and very powerful. It had remained, for a time, in a certain position; and, on trial, it was found that a part of the brass-box itself had become sufficiently magnetic to produce a vibration of the needle, when applied outside the glass, of 14 or 15 degrees, and to retain the same 1½ degree out of its natural direction. Every screw and detached piece in the instrument had acquired the same quality in some, though a less, degree; so that no dependence could be placed upon the needle, until they were all removed.—*Essay*, pp. 16, 17.

position of the needle, and those it had taken after having been disturbed by the above means. I have, also, sometimes, seen needles, which had been exposed to a powerful sun, lose much of their magnetic virtue.

We have, on several occasions, availed ourselves of the use of the micrometer, with great advantage, for determining extensive bases, by means of marks or beacons attached to a staff, placed at one extremity of the distances required to be measured: the accuracy of an observation of this kind depends on the excellence of the instrument; on the care taken in measuring the minute interval contained between the two marks; on the attention paid in placing the spar in the plane perpendicular to the direction of the base; finally, on the practical skill of the observer in micrometic measurements, which are always of a very delicate nature.

We have taken every opportunity that presented itself to compare distances measured by the micrometer with the same distances deduced from bases measured with a chain, and we have almost always found the results agree so nearly as to use either one or the other, indifferently, in the construction of charts: one of these verifications, which took place in Adventure Bay, did not give one fathom difference, in a distance of 1731 fathoms; but I am far from believing that we can always reckon on so near an approximation.

It has not always been in my power to use the micrometer in measuring distances that I expected would be necessary for the construction of charts of coasts, roadsteads, and ports, the surveys of which were carried on in boats, and at a distance from the ships; because it was then necessary to use despatch, and to renounce the hope of determining bases with great precision: in such case, the astronomical circle, and more frequently the reflecting circle, have been substituted for the micrometer.

When I found a station where the ground permitted me to measure a base of 30 fathoms and more, on the beach, and perpendicular to a remarkable point, from which I proposed measuring angles, as at the station B, (*fig.* 4, *pl.* I,) I took two stakes, and mounted them with white paper, and placed them, one at the station B, the other at the extremity C, of the short base, in such a position that both were visible from the station A; the short base B C was measured two or three times with the greatest care, because, from that base was to be deduced the principal distance A B.

Every thing being thus arranged, I continued my operations; and, when I arrived at the point A, I measured, with extreme attention, the angle subtended by the distance between the two stakes B, C; and, with this angle, and the short base B C, I calculated the side A B of the right-angled triangle A B C.

When I was able to measure the angle B A C, with the astronomical circle, I was certain, by means of ten observations, of having its value with a degree of accuracy almost equal to that which could be obtained by the micrometer: but the result was not the same when I was obliged to use the reflecting circle; for then it became necessary to make a great number of observations, to get the value of the angle within ten seconds.

I am far from thinking that bases should be measured by the methods just pointed out, when the localities will admit of using better means; and, when the time will admit of a strict and minute survey of a roadstead, port, or any part of a coast, in that case those means should be employed only to verify the measures taken by the chain.

An example, which I take from my survey-notes, will suffice to show what degree of accuracy may be expected in employing the reflecting circle to determine great distances by means of short bases; and what errors are to be feared from trusting to chain-measures, although taken with care, and by skilful persons, if the precaution is not taken to verify those measures by the instruments above mentioned.

While conducting a survey on the coasts of France, I had occasion for a base, which I caused to be measured by an officer, with a copper-chain of fifty feet: this officer found,

| | |
|---|---|
| At the first measurement .......... | 68 chains, 1 foot, 7 inches: |
| At the second.................... | 68 chains, 1 foot, 3 inches: |
| At the third .................... | 68 chains, 1 foot, 2 inches: |

from which he concluded that the mean distance was 3401 feet 4 inches; but, as this measure did not agree with the results obtained by previous operations, I judged that there had been a great mistake made in the three measurements, which, in other respects, agreed well enough with each other; and, to satisfy myself, I measured, at one of the extremities of the base, a short base of 139 feet 10 inches; then at the other extremity of the principal base, and, with a reflecting circle, I observed the angle subtended by the base of verification, and found that the length of the principal base was 3346 feet 2 inches; from which I readily concluded that a mistake of at least a chain had been made in the measurement, which seemed incredible to the officer who had been entrusted with this operation: but he was convinced of the truth, when the result of a fourth measurement, which we made together, showed him effectually that he had reckoned one chain too much.

In many cases it would be sufficient to have a distance of 500 fathoms, with the degree of approximation that we have obtained from this verification, which had been used solely for the purpose of detecting a considerable error: but we are confident that a nearer approximation may be acquired, if the precaution is taken to measure the short base on a perfectly horizontal plane, and to multiply the observations with the reflecting circle, so as to obtain, within a few seconds, the angle subtended by this base, at the extremity of the principal base, which is to be deduced from it.

We have also measured, both at sea and in port, the angle subtended by a vessel's mast to determine distances; but this method should never be employed where any other can be made use of.

Although I have stated that distances measured by chain ought to be employed, when the time will allow of this operation, yet it may happen that the ground will not admit of measuring bases long enough; for we have carried on operations when, in a space of 20 leagues, we have found it impossible to measure an horizontal distance of 500 fathoms; then the use of the micrometer and the reflecting circle became indispensable.

It is necessary also to resort to the same means in surveying an archipelago composed of small islands, a roadstead bounded by abrupt steep rocks, or surrounded by a mountainous and woody shore.

I do not think it necessary to speak here of all the precautions that we have taken on shore, to measure, with the reflecting circle, the horizontal angles between the object taken as a departure of the angles, and points which are elevated above, or depressed below, the horizon. It will be sufficient to repeat that, the point of departure for the angles has always been chosen from among the objects situated on the horizon; and that, when it has been necessary to measure the arch of the horizon contained between this point of departure and the vertical plane of an object elevated above or depressed below it, the operation was performed in the manner already explained in speaking of the operations conducted under sail; that is to say, the reflected image was brought to the point at which the vertical plane passing through the elevated or depressed object intersected the horizon.

In the preceding pages sufficient has been said to show the methods we have employed to construct the Charts and Plans which compose the Atlas of Rear-Admiral Bruny-Dentrecasteaux's Voyage, either by the ship's run along the coast, or by means of the boats in the immediate vicinity of the anchorage; and thus some estimate may be made of the degree of accuracy which is attainable in employing reflecting instruments in opérations less precipitate and hurried than those above mentioned; nevertheless, we shall demonstrate, in the following chapter, for the edification of young seamen and students in hydrography, the advantage we have derived from the use of these instruments, in hydrographic observations which required accuracy and celerity: we have used them, at all times, when it was possible to place marks on the shore to determine the positions of the soundings, rocks under water, banks, shoals, &c.; likewise for the topographical detail of the coasts.

# CHAPTER II.

## OF THE PROPER METHOD OF CONSTRUCTING MARINE CHARTS.

Suppose it to be required to construct the Chart of the portion of a coast, represented by figure 23, (*pl.* IX.); the respective positions of the marks A, B, C, D, E, and F, placed along the beach, on the rocks, &c., are already determined, as also the positions of the remarkable points inland, represented by the letters G, H, and I; further, it is supposed that a base has been measured; that the bearings of one of the directions AB, BC, AD, &c., have been determined astronomically; that a scale, divided into feet and inches, is placed on some point on the beach, for the purpose of observing, daily, the rise of the tide, at ten minutes interval: finally, it is required to complete the nautic and topographic details.

### OF SOUNDINGS.

Nothing is, apparently, more easy than to sound any part of a coast; but, in reality, nothing demands greater attention: it is by sounding that the positions of rocks under water, the edges of banks, shoals, &c. &c. are determined. The following example is given to illustrate the methods I have adopted since my return to Europe, whenever I have had occasion to perform this most important part of the duty of a marine-surveyor.

The observations necessary for fixing the positions of the soundings may be made either on shore or in boats. The *first method* consists in placing observers on the beach, at two points, whose positions are determined, to take with an azimuth-circle, graphometer, or some other instrument, the bearings of the boat employed in sounding every time she anchors and makes a signal.

This method is good; but it has the disadvantage of not being serviceable, except in confined spaces, and it is also extremely tedious; moreover, it exposes the surveyor to innumerable errors; it is necessary to anchor every moment, the signals may be confounded with each other, the watches may stop, the instruments may be put out of order, and the least evil to be dreaded is the loss of the fruits of a very laborious operation.

The *second method* consists in observing in the boat, employed in sounding, the angles contained between some of the points whose positions have been determined, viz. A, B, C, D, E, F, G, H, I; such of them as are most conspicuous at the time required to fix the position of a sounding, a rock, &c. This method is preferable, because it possesses great advantages: it is particularly to be recommended on account of the celerity of the operations, when one or two observers are in the boat.

The principle on which this method is founded is one of the first elements of geometry; nevertheless I shall take notice of it here, previous to speaking of the practical operations to which I have applied it. I think it necessary to state, also, that it was from the perusal of a work, entitled, "*Essay on the most commodious Methods of Marine Surveying*," published by the celebrated hydrographer Dalrymple, in 1771, that I first conceived the possibility of substituting the method which I have followed, for that which was ordinarily used in constructing marine Charts.*

"An angle, at the centre of a circle, is measured by the whole arc on which it stands." (*fig.* 3, *pl.* XXXIII.)

"An angle, at the circumference of a circle, is measured by half the arc on which it stands." (*fig.* 4, *pl.* XXXIII.)

"If the circumference of a circle be described, touching the extremities of a straight line, that line becomes a chord of the circle, the centre of which is to be found on the perpendicular raised at the centre of the line." (*fig.* 7, *pl.* II.)

An infinite number of circles may be described, whose circumferences will touch the extremities of the given line A B, (*fig.* 5, *pl.* II,) and, as this line A B becomes a chord, common to all the circles which pass at the extremities A and B, it follows that the centres of all those circles will be found on the perpendicular D L, raised at the centre of A B: the measure, in degrees, of each of the arcs subtended by the chord A B, depends on the radius of the circle to which it belongs: thus, when it is required to describe a circle, of which A B is the chord, of a given number of degrees, the radius must first be found, which is determined in the following manner:

* This notice of Mr. Dalrymple's Essay has caused its insertion, for the satisfaction of the reader, in the Appendix.——EDIT.

An angle at the centre ACB (*fig.* 6. *pl.* II,) being measured by the whole arc ADB, subtended by the chord AB, is equal to double the angle AGB at the circumference, subtended by the same chord AB; it is also double the angle BAF, formed by the chord AB, and the tangent AF; but the perpendicular DL, raised at the middle of the chord AB, passes through the centre C, of the circle AGBD, and bisects the arc ADB; the angle at the centre then is divided into two angles, equal to each other, and also equal to the angles AGB and BAF, which are at the circumference of the circle, and which are measured by half the arc ADB, subtended by the chord AB: hence the angle ACH, of the right-angled triangle AHC, being measured by half the arc subtended by the chord AB, it follows that the angle HAC, which is its complement, is measured by the complement of half the arc ADB, subtended by this same chord. This angle HAC is then the complement of the angle AGB, which is formed by the chords GA, GB, and is measured by half the arc ADB; it is also the complement of the angle BAF, which, being formed by the chord AB and the tangent AF, is measured in the same manner by half the arc ADB. Then, since the angle CAF, which is formed by the radius AC, and the tangent AF, is a right-angle, it will be easily perceived that the angle HAC is the complement of the angle BAF; and, consequently, it is also the complement of the angle AGB.

From the foregoing propositions are deduced the means employed to find, either by projection or by computation, the radius of a circle, of which the definite line AB (*fig.* 7. *pl.* II,) subtends an arc of a given number of degrees.

Problem.—To describe a circle, touching the extremities of the line AB, whose radius is such that the line AB shall subtend an arc of 80°.

First, raise an indefinite perpendicular line DL, on the centre of the line AB; then, at the point A, and with the side AB, make the angle BAC equal to 50°, the complement of half the value of the arc subtended by AB; and the point C, where the line AC intersects the perpendicular DL, will be the centre of the circle required:

For in the right-angled triangle AHC, $AH = \frac{1}{2} AB$; and the angle $ACH = \frac{80^\circ}{2} = 40^\circ$; then its complement $CAH = 50^\circ$. The value of the radius AC is found by the following proportion:

$$\text{Sine} \angle ACH = 40^\circ : \text{radius} :: AH : AC.$$

$$AC = \frac{\text{radius} \times AH}{\text{sine} \angle ACH}$$

The side HC is found thus:

$$\text{Radius} : \text{cotang.} \angle ACH :: AH : HC.$$

All the angles, AKB, AEB, AFB, &c. (*fig.* 8, *pl.* II,) which stand at the circumference of the circle, and whose sides meet the extremities of the chord AB, are equal; for they are measured by half the arc ADB, contained between their sides, and subtended by this chord: hence it follows that, having a given distance, such as the distance AB, under any angle whatever, it may be taken as the chord of double the observed angle; and the radius of the circle, in the circumference of which the observation is made, may be found by computation.

If the distance AB is drawn, the radius of the circle required, and the centre of this circle, which it is known must fall on the perpendicular raised at the centre of the chord AB, may be found by projection.

When the observed angle is acute, the angle BAC is its complement; and, the station of the observer is a point on the greater segment of the circle.

When the observed angle is obtuse, the observer is placed at a point on the lesser segment, subtended by the chord AB, (*fig.* 9, *pl.* II,) and the angle BAC is the excess of the observed angle above 90°; for then the angle ACH is but the supplement of the observed angle AOB = ACL.

Finally, when the observed angle is 90°, the chord AB becomes the diameter of a circle, on the circumference of which the observation is made; and the observer may be placed on either of the segments.

It is by the property of angles, at the circumference and on the same arc of a circle, being equal to one another when their sides are intercepted by the extremities of the same chord, that the most simple method of acquiring (without the assistance of astronomic observations, the compass, and bearings taken from the shore, of the boats employed in sounding) all the nautical details of a coast, on which it may have been possible to determine positions, such as are marked on *plate* IX, *fig.* 23.

It is generally sufficient to measure the angles under which two known distances, AB, AD, (*fig.* 10, *pl.* III,) are seen, to be able to note on the chart the place where the observation is made: thus, if at any point afloat, the distance AB is observed under an angle of 49°, and the distance AD under an angle of 40°, the value of the sides AB, AD, and the excess of the angle BAD above 180°, contained between these two sides, being given, the point of station may be determined in the following manner:

Describe the circle AFBO, touching the extremities A and B of the side AB, which then becomes the chord of an arc equal to double the angle under which the side AB was observed, $= 49° \times 2$, the arc AOB is then given, from every point of which the side AB will be seen under an angle of 49°.

Then describe the circle AHDL, touching A and D, of which the arc AHD is equal to 80°, that is to say, double the second observed angle; the point of observation must fall on the portion ALD of this circumference, but this same point being situated on the arc AOB, of the circumference described on AB, it is then at the point of intersection K of the two circles.

Whenever the objects B, A, D, (*fig.* 11, *pl.* III,) are not in the same direction with each other, it may happen that the station falls on the circumference of a circle passing the three objects B, A, D: in this case, as the circles described on the sides AB, AD, would have their centres at the same point, their circumferences would be in one, and the point of observation could not be ascertained. The same thing would occur, whatever was the number of angles taken, if the observed objects B, F, E, A, D, and the point of station were on the same circumference.

When the sum of the angles under which the objects AB, AD, were seen, is equal to the supplement of the angle BAD, the observer is on the arch BHD of the circumference which passes the extremities of the given objects BA and D.

The circles described on the sides AB, AD, (*fig.* 10,) sometimes intersect each other, at such acute angles, that it is impossible to get the point of intersection K with accuracy: then, to avoid the inconveniences arising from this circumstance, it is necessary to resort to another mode of construction, to place the points of station.

Suppose, as above, the side AB to be observed under an angle of 49°, and the side AD under an angle of 40°, the point K being determined by projection, according to the method above stated; that, having then drawn the line AK, which is a chord common to both circles, and the line C C*, which joins the centres of the circles; the line CC* (continued if it be necessary) bisects the chord AK, and is perpendicular to it; from which the following construction is derived:

Let fall on the line CC* (*fig.* 12, *pl.* III,) which joins the centres of the circles (at the intersection of which the point K must stand) the perpendicular AT, and measure on this line, below the line CC*, a line GK = GA, and the point K will be the point of station.

If the radius AC*, (*fig.* 10,) is continued to the point L, where it meets the circumference of the circle described on the side AD, and the radius AC, to the point O, where it meets the circumference described on the side AB, then, from the extremities L and O, of the diameters AL and AO, draw the line OL: this line will necessarily pass the point of intersection K; from which is derived a second mode of finding the point K, without describing the circles.

At the point A, (*fig.* 12,) make, with the side AD, an angle DAL, equal to the complement of the observed angle AKD; and, at the point D, a right-angle, by which the point L is given: at the point A make, with the side AB, an angle BAO, equal to the complement of the observed angle AKB; and at the point B, a right-angle; the point O is then given. Draw the line OL; then, from the point A, let fall a perpendicular on this line, and the point K, where the perpendicular intersects it, will be the point of station required.

The point K being marked on the plan, (*fig.* 10,) by means of the circles described about the sides AB, AD; if the lines KA, KB, KD, are drawn, they will form two triangles, KAD, KAB, in each of which one angle and one side only are given; but, as the angle ADK, of the first triangle, is equal to the angle AC*C, of the triangle CAC*, and as the angle ABK, of the second triangle, is equal to the other angle ACC*, the value of these two angles are easily found by calculation, and thence all the required parts of the triangles KAD, KAB.

In the triangle CAC* the angle CAC* is equal, in this example, to the angle BAD + 180°, minus the sum of the complements of the two observed angles: compute the values of the radii, AC*, AC, of the circles described; these radii are the sides containing the angle CAC*, and with these given, the value of the two other angles, of the triangle CAC*, may be determined.

There are two other methods to be explained, which we employed advantageously, to mark the stations, with a scale and protractor: for, I have experienced that, the projector of a chart has not always at his command compasses of sufficient extent to describe the circles, by means of which the different points are generally determined by projection; and I have also observed that this operation, too often repeated, ends in spoiling the draughts.

Let us suppose that, being afloat, the side AB (*fig.* 13, *pl.* IV.) was observed under an angle of 80°, and AD under an angle of 44°, the point K is determined by the usual method. Draw the lines BK, AK, DK, and continue the line BK to E, where it again meets the circumference of the circle described about the side AD; and, finally, from this point E draw the lines AE, DE, which, with the side AD, form the triangle ADE; in this triangle is given the side AD, the angle DAE = DKE, the supplement of the sum of the two observed angles; the angle AED equal to the observed angle AKD, and, consequently, the angle ADE is equal to the supplement of the sum of the two other angles of the triangle; that is to say, equal to the observed angle AKB; by this method the point E is projected on the draught, and the position of the line EB is determined, on which line (continued if necessary) the point of observation K must fall.

If the line DK, is continued to the point E*, where it intersects the circumference described about AB, the means of determining the position of the point E, will be found by analogy; for, in the triangle AE*B, is given the angle BAE*, = BKE*; the angle AE*B, equal to the observed angle AKB; and, consequently, the angle ABE* is equal to the supplement of the sum of the other two angles of the triangle, viz. the observed angle AKD.

Then, in the first place, the point E (*fig.* 14, *pl.* IV.) will be marked by making at the point A, with the side AD, an angle DAE, equal to the supplement of the sum of the two observed angles = 56°; and, at the point D, an angle equal to the angle under which the side AB was observed = 80°.

Secondly, the point E* will be marked by making, at the point A, with the side AB, an angle BAE*, equal to the supplement of the sum of the two observed angles; and, at the point B, an angle equal to the angle under which the side AD was observed: the point E determines, with the point B, the position of the line BS, on which the point K must fall: the point E* determines, with the point D, the position of a second line DT, upon which, also, the point K must fall: this point then is the point of intersection of the lines BS and DT.

When the point K falls on the extension or continuation of the lines BE, DE*, the construction of the figure, for marking the points E and E*, is always the same; as will be demonstrated by an example.

Suppose the side AB, (*fig.* 15, *pl.* V.) observed under an angle of 40°, and the side under an angle of 33° 30′, and that the position of the point K is determined by the ordinary method: draw from the point E the lines EA, ED, and from the point E* the lines E*A, E*B; and thence it will be found, 1st, that in the triangle AED, the angle AED is equal to the observed angle AKD, and that the angle ADE is equal to the other observed angle AKB, and that the third angle of the triangle is, consequently, the supplement of the sum of the two observed angles.

2dly, That, in the triangle AE*B, the angle AE*B is equal to the observed angle AKB; and that the angle ABE* is equal to the other observed angle AKD; and, that the third angle of this triangle is, consequently, the supplement of the sum of the two observed angles; then, also, the point K is at the intersection of the lines BE and DE* continued: the figures 14 and 16 will demonstrate the details of this third method, by which the points of stations are determined without the assistance of the circumferences of the circles.

It is now to be shown how, according to the foregoing construction, the position of the point K (*fig.* 13, *pl.* IV.) is to be found by computation, when the numerical value of the sides AB, AD, is known, together with the angle contained between these sides; which angle, in our example, has an excess above 180°.

Suppose, in the first place, the angle BAD, = 188°, that the side AB has been observed under an angle of 80°, the side AD under an angle of 44°, and it is required to compute the position of the point K.

The value of the side AE, of the triangle AED, is found by proportion.

$$\text{Sine AED} = 44° : \text{Sine ADE} = 80° :: \text{AD} : \text{AE}.$$

$$\text{Hence AE} = \frac{\text{Sine ADE} \times \text{AD.}}{\text{Sine AED.}}$$

Then in the triangle BAE, where the sides AB, AE, are given, together with the angle BAE, contained between them, which is equal to 188°—the supplement of the sum of the observed angles, the two other angles, ABE, AEB, will be given by computation; the angle ABE is evidently equal to the angle under which the side AK would have been seen from the point B, at the moment of observation, and the other AEB, to the angle under which the side AK would have been seen from the point D, at the same moment, the angles ABK, and ADK, being given, all the required parts of the triangles AKB, AKD, may be computed.

If we suppose, in the second place, that the side AB (*fig.* 15, *pl.* V.) was observed under an angle of 40°, and the side AD under an angle of 33° 30′, and it is required to find, by calculation, the position of the point K, which is on the prolonged lines BE and DE*, the side AE, of the triangle AED, must first be computed: in the triangle BAE, the sides AB and AE are given, and the angle contained between them, which is = 188°.—106° 30′ = 81° 30′; thence will be deduced the angles ABE and AEB.

The first of these angles, ABE, is evidently the angle under which an observer placed at B would have seen the side AK, at the moment of observation: the second angle, AEB, which is found by the chord AE, and the secant BEK, measuring half the arcs AE, EK; equal to the angle ADK, under which an observer, placed at D, would also have seen the distance AK, at the moment of observation: these angles being given, the sides AK, BK, and DK, of the triangles AKB, AKD, may be computed.

Now let us suppose that, instead of describing the circles about the sides AB, AD, (*fig.* 17, *pl.* VI,) to find by their intersection the point K, the side AD is taken as a common chord, double the value of the chord of the sum of the two observed angles; about which a circle being described, the point of observation must stand in its circumference; then, having divided the arc

BED into two parts, so that BE shall be double the angle under which the side AB has been observed, and the other, DE, double the angle under which the side AD has been observed; it is evident that the line EAM, carried through the points E and A, will meet the circumference in a point, K, which will be the point of station. But the line EAM forms, with the lines BE, DE, two angles; the one, DEM, is equal to DBK, or $x$, the other, BEM, equal to BDK, or $y$: which angles, being known, will give the means of finding the position of the point K.

Whatever may be the position of the point A, relative with the points B, D, between which it has been observed from the point K, it will be easy, by the following figure, to find the place of observation on the draught, without describing the circles; provided, always, that the point A is not on the circumference of the circle touching B and D.

To find the point E, the angle DBE must be made equal to the angle under which the side AD was observed, and the angle BDE equal to the angle under which the side AB was observed; then the line EAM must be drawn to an indefinite length: at B make an angle DBK, = DEM or $x$, or at the point D an angle BDK, = BEM or $y$, and the point K, where the extended line EA is intercepted by either of the lines DK, BK, will be the point of station required.

It is particularly necessary to make use of this method (which is a very good one) when the point seen between B and D is at some distance from the point E. It must be substituted for the constructions before mentioned, whenever one of the distances AB, BD, has been observed under a very small angle, and that the point A is at a very considerable distance: in this last case the radii of the circles are so great that it is impossible to describe these circles.

The point A (*fig.* 18, *pl.* VI.) being seen between the points B and D, let us suppose that the side AB has been observed under an angle of 10°, and the side AD under an angle of 46°; that it is required, by the construction above mentioned, to find the point of station K; the point E will be first determined by making the angle BDE = 10°, and the angle DBE = 46°: then, having drawn the indefinite line AEM, at the point D, with the side BD, make an angle BDL = BEM or $y$; and the point K, where the line DL intersects the line AEM, will be the point of station required.

Although it is easy to understand how the position of the point K (*fig.* 17, *pl.* VI.) is to be found by computation, it may, nevertheless, be necessary to say a word on this subject.

Be the given points in a line, as BAD, or be they in a triangle, as the points BA*D, BA″D, BA‴D, &c. it is always necessary to compute the angle DEM = DBK, or the angle BEM = BDK, to determine the value of the sides BK, DK, of the triangle BDK. To compute one of these angles, DEM, BEM, the first step is to find the value of the side DE by this proportion:

Sine BED = supplement BKD : sine DBE = AKD :: BD : DE.

$$DE = \frac{\text{Sine } A^*KD \times BD}{\text{Sine } BKD.}$$

Then, the three points being supposed in a line with each other; in the triangle ADE, the sides AD, DE, and the angle contained between these two sides = BKA; one of the other two angles will be computed: for instance, the angle DEA, or DEM = DBK, or $x$.

When the angle DEA is known, BEA is also known; as the whole angle BED, which is equal to the supplement of the observed angles, is always given; the remainder of the operation is too simple to require further illustration.

If the point A is at A* the angle BDE, = AKB, must be added to the given angle BDA*: then there is given in the triangle A*DE, the sides AD, DE, and the angle contained between them; with these the angle DEA may be computed.

If the point A is at A″, subtract from the angle BDE = A″KB, the angle BDA″; the remainder will be the angle A″DE, contained between the given sides A″D, DE; thence the angle DEA″ is given by computation.

Finally, when the point A is beyond the point E, as at A‴, subtract the angle BDE, = AKB, from the angle BDA‴; the remainder is the angle EDA‴, contained between the sides DE and DA‴; with these compute the angle DEA, the supplement of which is the required angle DEM.

When the point A is beyond the line BD, and the angle BAD is equal to the supplement of the observed angles, the point of station is on the circumference of the circle which passes through the points B, A, D; the point A will be confounded with the point E; then the problem is indeterminate.

When the point of station is in the direction of either of the points A, B, D, (*fig.* 19, *pl.* VI,) and of a fourth point E, it is then sufficient to observe the angle under which one of the sides AB, AD, of the triangle ABD, are seen, to be able to find, by construction or computation, the position of the point K. Thus, for example, suppose at the point K, in the direction of the given points AE, the angular distance, under which the side AD presented itself, was observed; there will be given, in the triangle AKD, the side AD, the angle DAK, the supplement of the angle DAE, the observed angle AKD, and, consequently, the angle ADK: hence the sides AK and DK may be computed; or the point K may be determined by construction, describing the circumference of a circle about the extremities of the side AD, considered as a chord subtending an arc double the value of the observed angle AKD; the operation would be the same if the angle AKB had been observed.

If the angle BKD was observed, the circumference of a circle should be described about the points B and D, of which the side BD would subtend an arc double the value of the observed angle: and, where this circumference cut the line, EAK, would be the station.

When it happens that a position is to be fixed, from which only two given points on the coast can be seen, as A and B, (*fig.* 20, *pl.* VI,) it is necessary to anchor and observe the azimuth of one of these two points; also the angle under which the distance AB is seen; then, having deduced from these observations the bearings of the two sides CA, CB, of the triangle ABC, and, consequently, the angles CAB and CBA, the means are furnished of determining the position of the anchorage C, either by computation or by construction. The compass must not be used to take the bearing of either of the points A, B, except when the true bearing cannot be determined astronomically; for the impossibility of using these instruments without risk of considerable errors cannot be too strongly insisted on.

This particular description of the method of finding, by projection, the points at which angles have been observed, has been entered into, because it frequently happens that it is impossible to find them by computation:* thus, such objects as A, B, D, (*fig.* 17,) can be accurately placed on a draught without knowing the numerical value of the sides AB and AD, and the value of the angle BAD contained between them.

* *Note, by the Translator.*—Mr. Beautemps Beaupré could not have meant the word *impossible* to have the same positive meaning generally attached to it; for he must have been aware that, if the data of a trigonometrical problem are sufficient for the projection of the figure, they must also be sufficient for the solution by computation. To prove this, let us take the example given by himself. In the figure 17, the objects A, B, D, can be accurately placed on a draught, without knowing the value of the sides AB and AD, and the value of the angle, BAD, contained between them; this position is granted; but, in order to find the place of the point A by projection, it is necessary that the angles ABD and ADB should be given, together with the numerical value of the side BD: this being the case, the angle BAD is also known. These data are certainly sufficient for ascertaining the numerical value of the sides AB and AD by computation; therefore, although the figure may be projected without the numerical value of the sides AB and AD, the data will always be sufficient for the solution of the problem by computation, if it be requisite.

In many cases the soundings to be marked on the draught are so numerous, that it would be almost impossible to calculate all the positions: moreover, it would assuredly be useless to attain a greater degree of accuracy than that obtained by projection, especially when the charts are constructed on a scale of 6 lines for 100 fathoms, which is the scale I have generally used.

Two angles taken with three objects, which are in a direct line, are always sufficient to fix, on the draught, the point from which the observation is taken; but, as it seldom occurs that remarkable objects are to be found in a line with each other, and as it is difficult to dispose of signals in this manner, it may happen that the point of station falls on the circumference of the circle which passes the three observed objects: thence it follows, that it is always prudent to measure, at each station, the angular distance of one of these three with a fourth. When the third angle is not indispensable to determine the point of station, it is employed in verifying the position obtained, by means of the first two angles; and, on this account, it may be considered extremely useful.

From the foregoing observations it may be concluded, that, when the angles under which three known and contiguous distances present themselves, are taken, the given quantity is not only sufficient to fix the points of station, but also to verify the results obtained by means of two angles. It has been particularly on coasts where there are strong currents, that I have proved the advantage of this method above all others; for then I never was obliged to contend against winds or currents to place myself at any particular point, as would have been necessary had the position of the boats been determined by observers on shore; and I could continue my operations wherever the boat drifted. Moreover, I was never obliged to anchor to fix the position of rocks, soundings, &c., and, consequently, I was enabled to go over an extensive surface in the course of the day.

It frequently occurred that I had but one assistant, and still, in this case, I seldom anchored. We took two angular distances by three points, advantageously situated; and, by means of a circle, which I had at hand for the purpose, I measured a third angle the instant after the observation of the two others, and before I had read off the former one measured by myself: this third angle was noted on the journal, with a sign signifying that it was only to be used in verifying the point of station, fixed by means of the angles taken simultaneously.

When I had no assistant, I previously prepared beacons, disposed in such a manner as to enable me to fix, with a single angle, the position of my boat, whenever I found myself in a line with any two of the beacons: by this method

I avoided the loss of time occasioned by anchoring so frequently as would otherwise have been necessary: but, if I had to fix important positions, which did not fall in one of these lines, I was then obliged to anchor, in order to be enabled to take several angles.

Finally, when the depth of water varied but little, and it was necessary to prove the course of the boat, instead of anchoring, I stopped the boat's way, and, with two circles, I took quickly two angles with three of the points most advantageously situated for determining my position; then I repeated the measure of the first angle, and with the mean I placed the point of station.

Thus, for example; if I had observed from any point, the distance AB (*fig.* 19,) under an angle of 49° 50′, and the distance AD under an angle of 69° 20′, and that some seconds afterwards I found between A and B 49° 40′, I placed my point of station by using 49° 45′ for the angle under which the distance AB would have been observed at the moment I observed the distance AD. This method of operation, which requires great skill in the use of the reflecting circle, gives an accuracy sufficient under many circumstances.

After having shown with what facility the positions of boats, carrying on the operations of sounding, may be fixed by observations made afloat, it may be proper to give some idea of the method I adopted for distinguishing banks, rocks, &c.; for keeping the journal of the nautical operations carried on in boats; for placing the stations on the draught; for reducing the soundings taken at all hours of the day to low water, at the equinoctial springs; and, finally, for marking the soundings thus reduced on the chart, which is to bear the results of all the observations taken on any part of a coast whatsoever.

Wherever the soundings are less than 25 feet, at low water, that spot is, in general, considered a bank; and the greatest attention is to be paid, in fixing its limits, by observations made on the edges of it. Then the banks of sand or mud are subdivided into three classes, according to the depth of water on them: soundings of less than nine feet water comprehend banks of the first class; banks of the second class are composed of soundings from 10 to 16 feet of water; and those of the third class, from 17 to 24 feet of water. The limits of the banks of the first class are indicated on our charts by dotted lines, and those parts which are dry at low water are dotted all over. The limits of banks of the second and third classes are indicated by a line composed of small strokes.—(See Bank Z, *fig.* 23, *pl.* IX.)

Particular attention is always paid to fixing the limits of rocks, or foul ground, whatever may be the depth of water on them, and they are indicated by a slight stroke.

Those parts U, V, X, Y, (*fig.* 23, *pl.* IX.) of the patches of foul ground, on which there is less than 25 feet of water, are separated from soundings of the same nature, where the depth of water is greater, by a dotted line, within which are marked small crosses. The patches of rocks, which cover and uncover with the tide, are marked as at R; and the small rocks in these patches, which remain above water, are marked by triangles; rocks of considerable extent, which are always above water, are marked more strongly, as at E and F.

It is necessary, previous to embarking for the purpose of sounding, to verify the lead-lines, and to set the watch of the observer of the tides with that which is carried in the boat: it is also necessary to adjust, each day, the mirrors of the reflecting circles. Previous to the commencement of the observations, place the index of the principal reflector at Zero, and then adjust the small mirror to the point of parallelism, in order to be able to take correct angles.

The verification of the perpendicularity of the mirrors with the plane of the instrument, is an operation that needs only to be performed once in the day; but it is adviseable to examine the adjustment of the parallelism of the mirrors frequently, because it is subject to derangement, unless care is taken not to trust the instrument out of the hand, or to lay it down in such a manner as to prevent it's receiving any violent shock.

I think it right to add, to prove how important this latter verification is, that it has occurred to me that I have lost the fruit of several hours' work, because I neglected this examination previous to using a circle which had been some instants in the hands of one of the boat's crew.*

The method of keeping the journal of operations which are carried on in boats, is very simple; but, before giving an example, I think it proper to premise, that our notes were written with the metallic pencil, the marks of which are not liable to be effaced by the sea-water.

* It is always extremely difficult, and sometimes impossible, to measure the angular distances of terrestrial objects promptly with telescopes: we have always rejected the telescope of our circles, and substituted plain sight-vanes. We also substituted mirrors of plate for the ordinary reflectors, in operations executed in boats, as they are very much exposed to receive the spray in these vessels, and the sea-water soon injures the glass-reflectors.

# JOURNAL OF NAUTICAL OPERATIONS.

*October* 12.

The watch having been regulated by that of the observer of the tides, and the lead-lines correctly measured, the soundings commenced near the flag A. (See *fig.* 21, 22, and 23, *pl.* VII, VIII, IX.)

At 8 *h.* 10 *m.* from the flag A, standing towards the flag F, (*a*) 3, 5, rock: 7, 9, 12, rock; 14, sand.

| | | | |
|---|---|---|---|
| At 8 *h.* 19 *m.* from A to .. | I, ...... 26° 18′ | | 15, sand. |
| | B, ...... 68 54 | | |
| | C, ..... 89 42 | | |

19; 24; 29.

| | | |
|---|---|---|
| At 8 *h.* 25 *m.* from H on with C, to .......... | I, ...... 58° 28′ | 31, sand and mud. |
| | B, ...... 24 32 | |
| | A, ...... 82 4 | |

40; 45; 49; 50.

| | | |
|---|---|---|
| At 8 *h.* 35 *m.* from I to .. | A, ...... 22° 32′ | 52, mud. |
| | B, ...... 28 48 | |
| | E, ...... 28 48 + 76° 6′ | |

Veered, and stood for the flag C; 48; 39; 36, oaze; 32, *idem*.

| | | |
|---|---|---|
| Anchored, At 8 *h.* 50 *m.* from C to .. | To the left. | 29, sand. |
| | B, ...... 38° 36′ | |
| | I, ...... 63 24 | |
| | A, ......107 30 | |
| | To the right. | |
| | D, ..... 26 18 | |
| | E, ...... 67 36 | |

Weighed at 9 *h.* 0 *m.*, and continued on the same course; 25; 20, sand; 19; 24, sand and shells.

| | | |
|---|---|---|
| At 9 *h.* 10 *m.* from C to .. | D, ...... 30° 4′ | 29, shells and mud. |
| | E, ...... 84 16 | |
| | F, ...... 95 20 | |

31; 35; 40.

At 9 *h.* 15 *m.* from B, on with I, to C 75° 10′ 45, soft mud.

(*a*) In order to avoid fractions, the depth of water is always expressed in feet.

Veered, and stood to the southward, to cross the bank which appears to attach the rock E to the main land.

39; 30, sand; 30; 29, *idem.*

| | | | | | |
|---|---|---|---|---|---|
| At 9*h*. 25*m*. from E to .. | D, ...... | 57° | 15′ | | 28, sand and shells. |
| | F, ...... | 12 | 36 | To the right. | |
| | C, ...... | 92 | 6 | | |

25; 20, sand; 17, sand; 19; 24, sand.

| | | | | |
|---|---|---|---|---|
| At 9*h*. 30*m*. from A to .. | B, ...... | 52° | 21′ | 31, mud. |
| | I, ...... | 38 | 40 | |
| | D, ..... | 128 | 3 | |
| | C, after | 94 | 0 | |

39; 45; 50; 56, mud.

| | | | | |
|---|---|---|---|---|
| At 9*h*. 35*m*. from E to .. | D, ...... | 18° | 50′ | 59, mud. |
| | B, ...... | 80 | 35 | |
| | F. ...... | 48 | 2 | |

Veered, and stood to the N. E.; 55; 49, mud; 35, mud and sand; 30; 29.

| | | | | |
|---|---|---|---|---|
| At 9*h*. 45*m*. from A to .. | B, ...... | 43° | 30′ | 24, sand, shells. |
| | I, ...... | 33 | 10 | |
| | C, ...... | 82 | 15 | |

20; 19; 12; 11; 10, sand.

At 9*h*. 48*m*. from B, on with I to A, 39° 20′ 9, rock.

12; 15, sand; 25; 30, sand.

At 9*h*. 50*m*. from C, on with G, to D, 62° 20′ 31, mud.

Veered, with C and G in one, and stood to the S. S. E.: 28; 24; 19, sand; 15.

At 9*h*. 55*m*. from B on with I to D, 93° 40′ 10, rock.

9; 6, rock; 5; 5; 9, *idem*; 15, sand.

| | | | | |
|---|---|---|---|---|
| At 10*h*. 2*m*. from A to .. | B, ...... | 36° | 5′ | 17, sand, shells. |
| | G, ...... | 67 | 25 | |
| | E, ..... | 128 | 15 | |

21; 25: 27, sand.

| | | | | |
|---|---|---|---|---|
| At 10*h*. 6*m*. from E on with D to .......... | C, ...... | 36° | 0′ | 28, sand and mud. |
| | A, ..... | 100 | 20 | |
| | K, ...... | 76 | 15 | |

30; 36; 40, mud; 45; 50, mud.

| | | | | |
|---|---|---|---|---|
| At 10*h.* 15*m.* from E to.. | F, ...... | 72° | 0′ | 51, mud. |
| | C, ...... | 23 | 30 | |
| | A, ...... | 75 | 55 | |

Veered, and stood for the rock, E; 49; 44, mud; 39, mud; 34; 29, sand.

| | | | | |
|---|---|---|---|---|
| At 10*h.* 25*m.* from E to | F, ...... | 81° | 45′ | 28, sand, shells, and coral. |
| | B, ...... | 56 | 5 | |
| | A, ...... | 86 | 55 | |

24, sand; 20, coral; 18, rock; 15; 17; 12, rock; 6; 3; 2.

At 10*h.* 34 *m.* arrived at the shelf E, on a line S. by W. of the flag E. Quitted the shelf E, at 11*h.* 0*m.*, and stood to the southward, sounding. 4; 8; 12, rock; 17, *idem;* 19.

| | | | | |
|---|---|---|---|---|
| At 11*h.* 7*m.* from E to .. | F, ...... | 81° | 10′ | sand and shells. |
| | A, ...... | 75 | 00 | |
| | B, after | 45 | 45 | |

25; 27, sand; 27; 27, sand; 27; 27; 29, sand and mud.

| | | | | |
|---|---|---|---|---|
| At 11*h.* 17*m.* from E to .. | A, ...... | 62° | 10′ | 30, sand and mud. |
| | F, ...... | 85 | 50 | |
| | B, after | 16 | 20 | |

32; 39, sand; 45, mud.

At 11*h.* 25*m.* anchored in 49 feet, mud and broken shells.

| | | | |
|---|---|---|---|
| At 11 *h.* 25*m.* from E to | To the left. | | |
| | A, ...... | 52° | 55′ |
| | G, ...... | 14 | 25 |
| | To the right. | | |
| | D, ...... | 15 | 30 |
| | F, ...... | 73 | 0 |

At 11*h.* 32*m.* weighed and stood to the E.N.E., to ascertain the extremity of the bank adjoining the shelf E.; 44; 39, sand and mud; 39, *idem;* 39; 45, mud.

| | | | | |
|---|---|---|---|---|
| At 11*h.* 40*m.* from E to.. | A, ...... | 47° | 50′ | 45, black mud. |
| | I, ...... | 31 | 6 | |
| | D, ...... | 29 | 30 | |
| | F, after | 83 | 35 | |

From thence stood to the westward, 42; 38; 36, mud; 29, sand.

$$\text{At } 11h.\ 44m. \text{ from E to } \left\{\begin{array}{lrr} \text{A, } \ldots\ldots & 55^\circ & 0' \\ \text{I, } \ldots\ldots & 39 & 40 \\ \text{D, } \ldots\ldots & 21 & 15 \\ \text{F, after} & 88 & 45 \end{array}\right\} \text{ 28, sand.}$$

32, sand; 39, mud; 44; 49, mud.

$$\text{At } 11h.\ 52m. \text{ from E to} \ldots \left\{\begin{array}{lrr} \text{A, } \ldots\ldots & 61^\circ & 50' \\ \text{I, } \ldots\ldots & 49 & 18 \\ \text{F, } \ldots\ldots & 70 & 55 \end{array}\right\} \text{ 51, mud and sand.}$$

Veered, and stood to the N.E.; 47; 47; 36; 31.

$$\text{At } 11h.\ 59m. \text{ from E to } \left\{\begin{array}{lrr} \text{A, } \ldots\ldots & 63^\circ & 0' \\ \text{G, } \ldots\ldots & 15 & 45 \\ \text{F, } \ldots\ldots & 90 & 15 \end{array}\right\} \text{ 29, sand.}$$

24; 20, rock; 17, rock; 22, sand.

At 0*h.* 4*m* from E, on with G, to D, 37° 55′. 29, sand.

32; 36; 40, mud.

$$\text{At } 0h.\ 10m. \text{ from E to} \ldots \left\{\begin{array}{lrr} \text{A, } \ldots\ldots & 38^\circ & 45' \\ \text{D, } \ldots\ldots & 54 & 55 \\ \text{I, } \ldots\ldots & 15 & 35 \end{array}\right\} \text{ 20, hard mud.}$$

Veered, and stood for the bank; 36; 32; 29, sand; G on with F; 26; 23, rock; 17, *idem;* 15, *idem;* 12, *idem;* 10, *idem;* 19, *idem;* 19, *idem;* 20, rock.

$$\text{At } 0h.\ 25m. \text{ from A to} \ldots \left\{\begin{array}{lrl} \text{E, } \ldots\ldots & 85^\circ & 25' \\ \text{I, } \ldots\ldots & 23 & 50 \\ \text{F, } \ldots\ldots & 85 & 25 + 92 \quad 40 \end{array}\right\} \text{ 22, sand.}$$

Veered, and stood for the flag D; 21; 21; 20; 19.

At 0*h.* 29*m.* G on with E, 20, rock; 24, rock; 24, sand; 29; 29; 29; 29.

$$\text{At } 0h.\ 37m. \text{ from D to} \ldots \left\{\begin{array}{lrr} \text{G, } \ldots\ldots & 47^\circ & 50' \\ \text{C, } \ldots\ldots & 52 & 15 \\ \text{E, } \ldots\ . & 114 & 4 \\ & \multicolumn{2}{r}{\text{To the right.}} \\ \text{F, after} & 116 & 25 \end{array}\right\} \text{ 21, sand.}$$

35; 39; 44, mud; 50, *idem;* 55, *idem.*

$$\text{At } 0h.\ 45m. \text{ from D to} \ldots \left\{\begin{array}{lrl} \text{G, } \ldots\ldots & 51^\circ & 45' \\ \text{I, } \ldots\ldots & 83 & 12 \\ \text{E, } \ldots\ldots & 83 & 12 + 52 \quad 25 \end{array}\right\} \text{ 55, soft mud.}$$

Veered, and steered to clear the northern extremity of the shelf E; 52; 45, mud; 40; 36, mud.

| | | | |
|---|---|---|---|
| At 0*h.* 50*m.* from B to .. | E, ...... 57° 50′ | | 32, sand. |
| | C, ...... 33 25 | | |
| | D, ...... 93 20 | | |

29; 26, mud; 23, rock.

| | | | |
|---|---|---|---|
| At 0*h.* 52*m.* from B to .. | A, ...... 23° 10′ | | 20, rock. |
| | E, ...... 74 30 | | |
| | D, ..... 122 20 | | |

17, rock; 15, *idem;* 14, *idem;* 9, rock.

On a line with the points C and G.

| | | |
|---|---|---|
| At 0*h.* 57*m.* from C on with G to .......... | D, ...... 52° 10′ | 7, rock. |
| | A, ...... 73 45 | |

Veered, and stood towards D; 7; 9, rock; 15, sand; 22, sand; 29; 31, sand.

| | | |
|---|---|---|
| At 1*h.* 5*m.* from C to.... | D, ...... 65° 55′ | 32, sand and gravel. |
| | B, ...... 42 0 | |
| | I, ...... 33 45 | |

39; 45, mud; 49, mud; 55, mud.

| | | |
|---|---|---|
| At 1*h.* 14*m.* from C to .. | To the left. | 59, hard mud. |
| | B, ...... 35° 30′ | |
| | I, ...... 21 15 | |
| | To the right. | |
| | D, ...... 88 15 | |
| | H, after 55 0 | |

Veered, and stood to the westward; 55, mud; 50, mud; 49, mud; 49, mud; 49, mud.

On a line with C and G.

| | | |
|---|---|---|
| At 1*h.* 20*m.* from C on with G to............ | D, ...... 67° 45′ | 46, hard mud; good holding ground. |
| | A, ...... 92 25 | |

Altered the course to follow the line CG; 42, mud: 41; 37, mud; 37, mud. At 1*h.* 24*m.* 37; 37, mud; 36, mud; 29, sand.

| | | |
|---|---|---|
| At 1*h.* 30*m.* C on with G to .................. | To the left. | 29, sand and gravel. |
| | A, .... 106° 45′ | |
| | I, ...... 56 28 | |
| | To the right. | |
| | D, ...... 82 35 | |
| | F, after 82 35 + 73° 5′ | |

Continued standing on for the point C; 26; 23, sand; 19, sand; 17; 15, sand; 12.

At 1*h.* 35*m.* arrived at the flag C, and landed to compare our watch with that of the observer of the tides.

Left the shore again at 2*h.* 00*m.* and stood for the flag F, without sounding; when arrived at the rock F, recommenced sounding; from F, stood for the flag D; 12*, on the northern edge of the rock, 15; 19, rock; 21, rock; 26, rock; 29, rock.

| | | | | |
|---|---|---|---|---|
| At 2*h.* 30*m.* from D to .. | E, ...... | 57° | 10′ | 32, sand. |
| | A, ...... | 66 | 45 | |
| | I, ...... | 48 | 45 | |

30; 30, sand; 30, sand; 3[illegible]; 31, sand; 31; 31; 31, sand.

A on with E, 34, sand; 39, sand.

| | | | | |
|---|---|---|---|---|
| At 2*h.* 41*m.* from E to .. | I, ...... | 29° | 30′ | 29, mud and sand. |
| | G, ...... | 51 | 40 | |
| | H, ...... | 77 | 10 | |
| | | To the left. | | |
| | F, ...... | 84 | 30 | |

Stood to the westward; 39, mud; 38; 36, mud; 39, mud; 42, mud; 44, mud.

At 2*h.* 50*m.* from A on with E to D, 89° 10′, 44, hard mud; from thence stood to the southward, 42; 40, mud; 36, sand; 34, sand; 34.

At 3*h.* 5*m.* from the points E, B, and I, in one, to D, 55° 35′, 34, sand; 32, sand; 29, sand; 27; 26, sand; 25, sand; 19, rock; 19, rock; 20, mud.

| | | | | |
|---|---|---|---|---|
| At 3*h.* 9*m.* from E to .. | A. ..... | 22° | 0′ | 24, sand. |
| | D, ...... | 39 | 40 | |
| | F, ...... | 93 | 5 | |

26; 26; 26, sand; 29, sand; 29, sand; 36, mud.

| | | | | |
|---|---|---|---|---|
| At 3*h.* 19*m.* from E to .. | F, ...... | 48° | 55′ | 36, soft mud. |
| | H, ...... | 21 | 45 | |
| | A, ...... | 23 | 50 | |

Veered and stood for the rock F; 35, mud; 28, sand; 27; 26, sand; 26; 24, sand; 22; 22, sand; 20, rock.

* This depth of water is estimated at nine feet above the lowest ebb.

| | | | | |
|---|---|---|---|---|
| At 3 *h.* 25 *m.* from E. to .. | To the left. | | | 19, rock. |
| | A, .. ... | 18° | 45′ | |
| | I, ...... | 5 | 0 | |
| | To the right. | | | |
| | D, ...... | 38 | 55 | |
| | F, ...... | 58 | 38 | |

Continued standing on towards F; 15, rock; 19, rock; 11, rock; 20, rock; 17, rock; 12, rock.

At 3 *h.* 29 *m.* arrived at the south end of the rock F, and stood to the westward; 10; 20; 20; 22; 23, rock; 24; 25, rock; 30, sand; 30, sand.

| | | | | |
|---|---|---|---|---|
| At 3 *h.* 34 *m.* from E to .. | A, ...... | 24° | 35′ | 30, sand. |
| | G, ...... | 15 | 45 | |
| | D, ...... | 44 | 45 | |

Continued on the same course; 32; 35, sand; 35; 38, sand; 39, mud.

| | | | | |
|---|---|---|---|---|
| At 3 *h.* 39 *m.* from E to .. | A, ...... | 33° | 42′ | 41, black mud. |
| | G, ...... | 8 | 00 | |
| | D, ...... | 38 | 50 | |

Tacked, and stood to the southward; 40, mud; 39, mud; 35, sand; 35, sand; 35, sand; 35; 35; 35, sand; 35; 35, sand; 35; 35; 36, sand; 36; 38, mud; 40; 42, mud.

| | | | | | |
|---|---|---|---|---|---|
| At 4 *h.* 0 *m.* from E to .. | A, ...... | 27° | 45′ | To the right. | 47, soft mud. |
| | G, ...... | 2 | 30 | | |
| | D, ...... | 25 | 25 | | |
| | F, ...... | 55 | 40 | | |

Veered, and stood for the flag A; 42; 37, sand; 37; 36, sand; 36; 36, sand; 34; 34, sand; 32.

| | | | | |
|---|---|---|---|---|
| At 4 *h.* 10 *m.* from E to .. | A, ...... | 33° | 0′ | 31, rock. |
| | D, ...... | 27 | 0 | |
| | F, ...... | 73 | 55 | |

33; 35, sand; 35; 35, sand; 35; 35, sand; 36; 37, sand; 41, mud; 41.

| | | | | |
|---|---|---|---|---|
| At 4 *h.* 20 *m.* from E .... | A, ..... | 40° | 30′ | 43, black mud. |
| | D, ...... | 27 | 29 | |
| | F, ...... | 88 | 50 | |
| | I, after | 27 | 0 | |

Veered, and stood to the south-east; 41; 40, mud: 38; 36, sand; 34; 34; 38, sand; 31; 31, rock.

| | | | | |
|---|---|---|---|---|
| At 4 *h.* 24 *m.* from E to .. | A, ...... | 37° | 20′ | 28, rock. |
| | D, ...... | 22 | 45 | |
| | F, ...... | 70 | 5 | |

25; 25; 23, rock; 23; 21, rock; 19; 19; 26, rock; 26, rock; 27.

$$\text{At } 4h.\ 29m. \text{ from E to} \ldots \left\{\begin{array}{lrr} \text{A, } \ldots\ldots & 35^\circ & 15' \\ \text{D, } \ldots\ldots & 21 & 0 \\ \text{F, } \ldots\ldots & 61 & 40 \end{array}\right\} \text{ 29, rock.}$$

31; 34, sand; 33, sand; 35, sand; 35; 37, sand; 38.

$$\text{At } 4h.\ 36m. \text{ from E to} \ldots \left\{\begin{array}{lrr} \text{A, } \ldots\ldots & 32^\circ & 30' \\ \text{D, } \ldots\ldots & 18 & 50 \\ \text{F, } \ldots\ldots & 52 & 0 \end{array}\right\} \text{ 41, mud.}$$

Veered and stood to the north-west; 38; 35, sand; 33, sand; 31, rock.

$$\text{At } 4h.\ 41m. \text{ from E to} \ldots \left\{\begin{array}{lrr} \text{A, } \ldots\ldots & 39^\circ & 10' \\ \text{D, } \ldots\ldots & 16 & 30 \\ \text{F, } \ldots\ldots & 58 & 10 \end{array}\right\} \text{ 31, rock.}$$

31, rock; 31, sand; 35, sand; 37, sand; 41, sand.

$$\text{At } 4h.\ 50m. \text{ from E to} \ldots \left\{\begin{array}{lrr} \text{A, } \ldots\ldots & 46^\circ & 25' \\ \text{D, } \ldots\ldots & 15 & 15 \\ \text{F, } \ldots\ldots & 64 & 53 \end{array}\right\} \text{ 47, mud.}$$

Stood to the south-west; 44, mud; 44; 42, mud; 41; 41; 41; 41; 41; 39, sand; 39; 39, sand; 39; 38, sand; 37; 35, sand; 37; 40; 40; 40; 42, mud; 43; 45.

$$\text{At } 4h.\ 56m. \text{ from E to} \ldots \left\{\begin{array}{lrr} \text{A, } \ldots\ldots & 36^\circ & 56' \\ \text{D, } \ldots\ldots & 12 & 0 \\ \text{F, } \ldots\ldots & 46 & 55 \end{array}\right\} \text{ 51, mud.}$$

Veered, and stood to the N.W.; 47, mud; 43, sand; 40, sand; 38, sand.

$$\text{At } 5h.\ 6m. \text{ from F to} \ldots \left\{\begin{array}{lrr} \text{D, } \ldots\ldots & 40^\circ & 42' \\ \text{E, } \ldots\ldots & 50 & 46 \\ \text{A, } \ldots\ldots & 93 & 35 \end{array}\right\} \text{ 35, sand.}$$

40, sand; 46, mud; 55, mud.

$$\text{At } 5h.\ 10m. \text{ from E to} \ldots \left\{\begin{array}{lrr} \text{F, } \ldots\ldots & 53^\circ & 0' \\ \text{A, } \ldots\ldots & 49 & 15 \\ \text{D, } \ldots\ldots & 7 & 40 \end{array}\right\} \text{ 60, soft mud.}$$

Veered, and stood to the S.W. 59, mud; 58; 57, mud; 52; 52, mud; 52; 52: 51, mud; 52; 52; 53, mud; 53; 54, mud; 54; 57, mud..

$$\begin{array}{l}\text{At } 5h.\ 19m. \text{ from A on} \\ \text{with I, to } \ldots\ldots\ldots\ldots \end{array} \left\{\begin{array}{lrr} \text{E, } \ldots\ldots & 36^\circ & 51' \\ \text{F, } \ldots\ldots & 76 & 20 \end{array}\right\} \text{ 59, mud.}$$

Keeping A and I in one; 57; 57; 57, mud; 57; 57; 57, mud; 57; 57; 58; 58, mud. (At 5*h.* 32*m.* 59; D on with E.) At 5*h.* 32*m.* 59; 61, mud; 60; 66; 68, mud; 69; 69; 69, mud; 69; 69; 69, mud; 68; 67; 64, mud; 64; 64; 63, mud. At 5*h.* 45*m.* H on with C, 63; 58, mud; 49, mud; 39, sand; 34, sand; 24, sand; 16, sand; 13, rock; 11.

Arrived at the flag A, at 5*h.* 52*m.*, and finished the soundings.

A moderate breeze and smooth water all the day.

## OBSERVATIONS OF THE TIDES,

*Made at the Scale placed near the Flag* C, (fig. 23, pl. IX.) 12*th October.*

| H. | M. | Ft. | In. | |
|---|---|---|---|---|
| At 7 | 0 | 7 | 10 | Wind westerly: fresh breezes. |
| | 10 | 7 | 6 | |
| | 20 | 7 | 3 | |
| | 30 | 7 | 0 | |
| | 40 | 7 | 6 | |
| | 50 | 7 | 1 | |
| 8 | 00 | 6 | 8 | |
| | 10 | 6 | 6 | |
| | 20 | 6 | 2 | |
| | 30 | 5 | 10 | |
| | 40 | 5 | 4 | |
| | 50 | 4 | 11 | |
| 9 | 00 | 4 | 7 | |
| | 10 | 4 | 2 | |
| | 20 | 3 | 0 | |
| | 30 | 2 | 10 | Light airs, N.W. |
| | 40 | 2 | 8 | |
| | 50 | 2 | 8 | |
| 10 | 00 | 2 | 8 | Low-water. |
| | 10 | 2 | 9 | |
| | 20 | 2 | 11 | |
| | 30 | 3 | 2 | |
| | 40 | 3 | 4 | |
| | 50 | 3 | 6 | |
| 11 | 00 | 3 | 2 | |
| | 10 | 4 | 11 | |
| | 20 | 5 | 0 | |
| | 30 | 5 | 2 | |
| | 40 | 5 | 6 | |
| | 50 | 5 | 11 | |
| 0 | 0 | 6 | 2 | |
| | 10 | 6 | 6 | |
| | 20 | 6 | 11 | |
| | 30 | 7 | 4 | |
| | 40 | 7 | 9 | |

| H. | M. | Ft. | In. | |
|---|---|---|---|---|
| At 0 | 50 | 7 | 11 | Wind veered round to the westward, with fresh breezes. |
| 1 | 0 | 8 | 3 | |
| | 10 | 8 | 6 | |
| | 20 | 8 | 11 | |
| | 30 | 9 | 2 | |
| | 40 | 9 | 6 | |
| | 50 | 9 | 10 | |
| 2 | 0 | 10 | 1 | |
| | 10 | 10 | 5 | |
| | 20 | 10 | 9 | |
| | 30 | 11 | 0 | |
| | 40 | 11 | 4 | |
| | 50 | 11 | 6 | |
| 3 | 0 | 11 | 11 | |
| | 10 | 12 | 0 | |
| | 20 | 12 | 4 | |
| | 30 | 12 | 8 | |
| | 40 | 12 | 11 | |
| | 50 | 13 | 2 | |
| 4 | 0 | 13 | 4 | High water. |
| | 10 | 13 | 4 | |
| | 20 | 13 | 3 | |
| | 30 | 13 | 2 | |
| | 40 | 13 | 0 | |
| | 50 | 12 | 10 | |
| 5 | 0 | 12 | 7 | |
| | 10 | 12 | 3 | |
| | 20 | 11 | 9 | Wind N.N.W. moderate breezes. |
| | 30 | 11 | 3 | |
| | 40 | 10 | 9 | |
| | 50 | 10 | 3 | Smooth water. |
| 6 | 0 | 10 | 0 | |

When the soundings have been carried on for several days, on the same part of the coast, and, consequently, there is much material collected, it becomes indispensible (on account of the great quantity of lines that must be drawn in placing the points of station) to use a plan similar to that which is represented in *figure* 21, *plate* VII.

All the terrestrial objects, the positions of which have been determined, and by which the angles have been taken to fix the points of station of the boat, should be laid down on this plan; lines must be drawn from one to the other of these objects, and perpendicularly raised at the middle of each of these lines: finally, all the continuous lines of such points as may have been observed in one with each other, during the operation of sounding, must be drawn.

The draught being thus disposed, the surveyor may judge with what degree of facility the points of station may be projected, by either one or the other of the graphic operations already pointed out: this plan will serve to direct the course of the boat when an important point is required to be sounded, or of which it is required to verify the soundings.

The ordinary method of placing the points of station is by means of the circumferences of circles described about the observed distances; because this mode of construction is very prompt. It is commonly performed by a good protractor, with an index of sufficient length to reach the perpendiculars elevated at the middle of the greatest observed distances, which immediately gives the centers of the circles described, without being obliged to draw a single line.

For example, it was required to note on the draught the position of the boat at 4 *h.* 50 *m.*, at which time the angular distances from E

| | | | |
|---|---|---|---|
| were thus .... | To F, .......... | 65° | 60′ |
| | D, .......... | 15 | 20 |
| | A, .......... | 46 | 15 |

First, the diameter of the protractor should be placed on the side EF, and the centre at F; then set the index at 25°, the complement of 65°, and this index will intersect the perpendicular raised at the centre of EF, at the centre *a*, of the circle which would pass through E, F, and the point of station K. In the same manner may be found the centre *b*, of the circle passing through A and E, and the point of station, by placing the diameter of the protractor on the side AE, and the centre at A; the index is then brought to 43° 45′, the complement of 46° 15′.

As the position of the point of station on the draught may be roughly estimated, it is only necessary to describe small arcs *vx*, *yz*, of the circles passing through the points A, E, F, and the point of station. The position K may be verified by means of the angle taken from E to D, in the following manner: from the centre *a*, describe the arc E*d*, on which measure the arc E*e*, equal to double the value of the angle under which the side ED had been observed; draw a line through the points D and *e*, which, being continued, will pass the point of intersection of the circles described on the sides EF and EA; which proves that the point K was the true place of observation at 4*h*. 50*m*. The position of the point K might also be verified by constructing a circle about the side AF, considered as a chord double the value of the two observed angles AKE, EKF, or on one of the sides AD, DE, DF; but the first method is preferable.

Calculation is used, under many circumstances, to find the radii and centres of the circles; but the centres *a* and *b* are more frequently found by means of the scale of equal parts, and a good sector, in the following manner:

To find the centre *a* of the circle, of which the side EF is considered as a chord of $65° \times 2 = 130°$, take the length of $\frac{1}{2}$ EF; that is to say, the line E*g*, with a pair of common compasses; this measure is transferred to the scale of equal parts, on the sector, which is adjusted so as to give this line E*g* (considered as radius,) $= 100$; then, to ascertain the length of the line *ga*, which, in the example, represents the cotangent of 65°, take in the tables the value of this cotangent, which is $= 46, 63$.

If E*g* was made $= 200, 300, 400,$ or 500, equal parts, *ga* would be $= 46, 63 \times 2$, 3, 4, or 5.

The centre *b*, of the second described circle, is found by making, as in the foregoing example, $\frac{1}{2}$ AE, viz. A*h*, $= 100$, 200, 300, 400, or 500, equal parts, and giving *hb* the value of the cotangent of 46° 15′, expressed in parts corresponding with the scale of $\frac{1}{2}$ AE.

The use of the tables of natural tangents, to find the centres of the requisite circles, cannot be too strongly recommended; because it is a very accurate method, when the numerical value of the observed sides is not known, and when time will not admit of determining, by calculation, all the positions from which the angles were observed.

The tables of natural sines are also to be recommended, for finding, without describing the arcs, points, such as *e*, which are serviceable in important projections and verifications.

The position of the point *e* should be shown in this example, either by means of the protractor; by describing from the centre *a*, with the radius E *a*, an angle E*ae*, equal to double the observed angle EKD; or, by making at E, with the side EF, the angle FE*f* = DKF = 49° 40′: then, by measuring on the line E*f*, the distance E*e*, equal to the sine of 15° 20′ × 2 = 26,443 × 2 = 52,886, which should be multiplied by 2, 3, 4, or 5, if the value of the radius was = 200, 300, 400, or 500, equal parts.

When the angle EKD, under which the side ED was observed, is very small, it is then in particular that the natural sines must be used to find the point *e*; they are also necessary in constructing the angles, by means of which the centres of the requisite circles are to be found, when the results obtained by means of protractors are not to be trusted.

If the observed sides were as small as those described on the draught, (*fig.* 21, *pl.* VII,) in many cases the radii, and, consequently, the centres, of the requisite circles might be found by the scale of chords on the sector; but, independent of this method's being rarely practicable, on account of the extent of the observed sides, it has the disadvantage of not being accurate when the observed angle approaches 90°, and, also, when it is very acute; therefore, it is seldom used.

Finally, the centre of a circle to be described, touching the extremities of a given line, might be found without the assistance of the perpendiculars, by laying off, at each extremity of this line, an angle equal to the complement of that under which it has been observed: but this method is not to be trusted, either when the angle is very small, or when it approaches to 90°: it ought, therefore, to be rejected.

So soon as the detail of our day's work, such as that of the 12th of October, is completed, a blank sheet is to be applied to the back of the draught, and the track is transferred to it by pricking through all the points which have been determined by observations, together with the most prominent features of the coast (*fig.* 22, *pl.* VIII,); then we proceed to the reduction of the soundings, which are written on the open or detached draught of the track; from thence the soundings are transferred (after having been reduced to the lowest ebb) to the chart, containing the results of all the operations.

## OF THE REDUCTION OF SOUNDINGS.

To *reduce soundings*, is to deduct from the depth given at all points of a coast, which have been sounded at different days, and at all hours of the tide, the number of feet requisite, to indicate on the Chart only such a depth of water as will be found on these points at the lowest ebb.

To make the reduction of the soundings accurately, the height of the tide should be observed at ten minutes' interval, on a scale placed at low-water mark, during the operations; and the point on this scale, indicating the lowest ebb, should be known: this may be ascertained by observations made during the equinoxes; or a comparison may be made between the scale on which the daily observations were made, and another stationary scale at a little distance from the place where the soundings are carried on.

This comparison, which ought to be repeated several days following, is made by observing, at the same time, the height of tides at the two scales; and, as the stationary scale indicates, each day, how much water remains at low water above the lowest ebb, it is easy to conclude to what point it descends, at lowest, on the scale by which the soundings are to be reduced.

### EXAMPLE:

The results of the observations of the tides, made at the scale of the port A, and the scale placed at the flag C.

| *Depth of Water at the Scale of the Port* A, *at low Water.* | | | *Depth of Water at the Scale of the flag* C *at low Water.* | |
|---|---|---|---|---|
| | Ft. | In. | Ft. | In. |
| Oct. 10 .......... | 6 | 9 | 2 | 9 |
| 11 .......... | 7 | 2 | 3 | 4 |
| 12 .......... | 9 | 1 | 5 | 0 |
| 13 .......... | 8 | 3 | 4 | 3 |

If the observations made at the scale of the port A, during the equinoxes, have indicated that the tide fell to the mark 5 ft. 9 in. of that scale, at the lowest ebb, it follows that it stood above this level, to which the soundings are to be reduced:

| | Ft. | In. |
|---|---|---|
| At the 10th October .................... | 1 | 9 |
| 11th .......................... | 2 | 2 |
| 12th .......................... | 4 | 1 |
| 13th .......................... | 3 | 3 |

From these observations it may be concluded, (excepting some small errors proceeding from localities,) that the tide would fall to the mark 1 ft. 1 in. of the scale placed near the flag C, at the time of the equinoxes: and, by these data, the soundings are to be reduced.

When the soundings are carried on through a considerable extent of coast, to be enabled to reduce the soundings accurately, it is not sufficient that the tides be observed by one scale only; for this reason: when I had to construct the chart of the coast of France, from Calais to Flushing, I placed observers of the tides at Dunkirk, Nieuport, Ostend, L'Ecluse, and Flushing; and I reduced the soundings taken between two of these ports by the results of the observations made at both of them at the same instant.

The point of the scale of observation for the tides, to which the water falls during the equinoxes, being known, a table of reductions should be prepared every day, similar to that which follows, and which served for the reduction of the soundings taken on the 12th of October.

### REDUCTIONS TO BE MADE FROM THE SOUNDINGS,

*12th October.*

| | H. | M. | Subtract | | H. | M. | Subtract | | H. | M. | Subtract |
|---|---|---|---|---|---|---|---|---|---|---|---|
| From | 8 | 10 | 5 feet. | From | 11 | 35 | 4 feet. | From | 2 | 10 | 9 feet. |
| to | 8 | 15 | | to | 0 | 10 | | to | 2 | 45 | |
| From | 8 | 15 | 4 | From | 0 | 10 | 5 | From | 2 | 45 | 10 |
| to | 8 | 35 | | to | 0 | 30 | | to | 3 | 25 | |
| From | 8 | 35 | 3 | From | 0 | 30 | 6 | From | 3 | 25 | 11 |
| to | 9 | 5 | | to | 1 | 10 | | to | 5 | 0 | |
| From | 9 | 5 | 2 | From | 1 | 10 | 7 | From | 5 | 0 | 10 |
| to | 11 | 0 | | to | 1 | 40 | | to | 5 | 25 | |
| From | 11 | 0 | 3 | From | 1 | 40 | 8 | From | 5 | 25 | 9 |
| to | 11 | 35 | | to | 2 | 10 | | to | 5 | 45 | |

This table is constructed by subtracting 1 *ft.* 1 *in.* from the depths observed on the scale placed near the flag C, during the operations of October 12th; because the division of 1 *ft.* 1 *in.* is, as we have before stated, that mark to which the water falls on those days when the lowest ebbs occur.

If it had been required to make a table of reductions for soundings taken at the port A, it would then have been necessary to deduct 5 feet from all the heights observed on the scale of that port.

It will be observed that, when it has been found necessary to subtract a given number of feet and a fraction, whole numbers have been always used: thus, when there has been, at any given hour, 2 feet 6 inches to be subtracted, the quantity used has been 3 feet; but when the deduction was 2 feet, 1, 2, 3, or 4, inches, 2 feet only has been the quantity subtracted.

When the operations are carried on between two of the points where the elevation of the sea is noted at ten minutes' interval, the corrections which are given by the two scales, for the corresponding times, are indicated on the table; and, in reducing the soundings, attention must be paid to their positions in reference to the places where the scales are fixed.

Thus, for example, if on the 12th of October the soundings had been carried on between the port A and the flag C, the table of reductions should be arranged in the following manner:—

REDUCTIONS TO BE MADE IN THE SOUNDINGS, OCTOBER 12.

| *Scale at the Flag* C. | | | *Scale of the Port* A. |
|---|---|---|---|
| | H. | M. | |
| At | 8 | 10 subtract 5 feet. | ........ subtract 2 feet. |
| | 8 | 20 ...... 4 .... | ................ 2 .... |
| | 8 | 30 ...... 4 .... | ................ 1 .... |
| | 8 | 40 ...... 3 .... | ................ 1 .... |
| | 8 | 50 ...... 3 .... | ................ 1 .... |
| | 9 | 00 ...... 3 .... | ................ 1 .... |
| | 9 | 10 ...... 3 .... | ................ 0 .... |

An essential point, with which persons not well practised in the operations described in the foregoing pages should be made acquainted, is, that the scales for the observations of the tides should be placed as near to the entrance of the ports as posssible; for, under some circumstance, great differences have been found between the elevation of the sea at the interior of a port and the elevation observed, at the same moment, on scales placed on the open coast.

On each detached draught of the track in sounding, such as that of *fig.* 22, *pl.* VIII, the soundings that have been taken at the moment of observation are underlined, so that they may be recognized, and transferred to the chart, in preference to others when the tracks intersect each other.

When there is a greater number of soundings to place between two stations than the scale of the draught will admit, every alternate or every third sounding is omitted: but the sounding which indicates the least depth of water is always retained for insertion: thus, having taken the following soundings between $5h.$ $10m.$ and $5h.$ $19m.$ 59, 58, 57, 52, 52, 52, 52, 51, 52, 52, 53, 53, 54, 54, 57, those only which are underlined are inserted in the draught. It is almost unnecessary to caution those, who may adopt this method of constructing charts, that it is requisite to determine a great number of points by trigonometric operations, in order to obtain very accurate results: it cannot be too frequently repeated, that, the least neglect on this point may occasion very serious errors.

Unless the soundings are carried on in a line with two marks, or signals, a straight course can never be insured; and it is only by frequent observations, that the deviations in courses, occasioned either by currents or bad steerage, can be estimated. We have found, by experience, that it was necessary to repeat the observations frequently; even when the depth of water did not vary.

After having described the means employed for fixing the positions of soundings, rocks, banks, &c., I cannot too strongly recommend that the greatest care should be taken in the trigonometric operations conducted on shore; for the determination of the positions of signals, and other objects, whose angular distances are used: it is also requisite that the greatest accuracy should be observed in the construction of the chart. In certain cases, the least inaccuracy in the position of a signal might occasion considerable errors in the positions of the points, from which it might have been observed. I ought not to omit observing that, when a signal or mark has been misplaced in the chart, the error was always discovered either in placing the points of station, or in verifying their positions. This is another great advantage which our method of constructing charts has over that which has hitherto been employed.

When the operations required great accuracy, the positions of the signals A, B, C, D, E, F, (*fig.* 23, *pl.* IX,) which are placed near the water's edge, and those of the remarkable objects G, H, I, which are situated either inland or on the coast, were determined by an excellent azimuth circle, made by Lenoir; but, *when despatch was required* in the operations, the reflecting circle was used. The intermediate points of station, 1, 2, 3, 4, 5, 6, 7, &c. &c., which serve to give the outline of the coast, and the topography of the inland parts adjacent, were determined by observations made with the latter instrument.

These intermediate points are laid down on the chart after the same manner as the points of station of the boats, having taken the precaution to describe, on the sketches, the configurations of the intervals of the coast between two of these intermediate points; and these details, together with the views taken at each principal station, give the means of tracing the coast with great accuracy.

There are various other methods of describing the configuration of a coast, but of which I do not consider it necessary to speak; every student in hydrography will acquire sufficient information on this subject, after a few months practice.

I shall conclude, by observing that the reflecting circle is sufficient for the purposes of marine surveying; and I recommend to those students for whom, in particular, this treatise is published, to render themselves expert in the use of it.

## CHAPTER III.

### ANALYSIS OF THE CONSTRUCTION OF THE CHART OF THE ARCHIPELAGO OF SANTA-CRUZ.

After having given an explanation of the means employed to collect the materials for laying down the charts and plans which compose the Atlas of Rear-Admiral Dentrecasteaux's voyage, we shall proceed to give the analysis of the construction of the chart of the archipelago of Santa-Cruz, to show the utility of trigonometric operations carried on under sail, when combined with the results of a series of astronomic observations.

The data which have served for the construction of the chart of the archipelago of Santa-Cruz will be found in the Plates X to XXXII, which accompany this Volume: they have been engraved exactly as they stood on our note-books, in order to give a correct specimen of our particular method of keeping a journal of trigonometric operations, conducted under sail, when there was not any known and determined position on the coast. The bearings which have been deduced from astronomic observations are distinguished, on our views and sketches of the coasts, by the word *azimuth*.

We indicate when the ship was on the meridian of some terrestrial object, by writing N. and S., and the hour when the bearing was taken from that object, whether it be noted in the view of the coast, or on the sketch of the ground-plan.

We indicate that the ship is on the parallel of an object by writing E. and W., and the hour of taking the bearings: these two kinds of observations, with those which have been deduced from astronomic observations, are corrected for variation, and these only; so that, when it is requisite to use other bearings, they must be corrected for variation; for we have noted them on the views of the land, and on the horizontal draughts, exactly as they were observed by the compass.

Whenever two remarkable objects have been observed in one with each other, in opposite directions, we have taken the precaution to note the results of the two observations.

A table is here subjoined, showing the results of the astronomic observations made by M. M. Rossel and Bonvouloir, during the five days we were in sight of the archipelago of Santa-Cruz.*

A second table will show the results of the different observations made during the same interval for determining the variation of the magnetic needle; and, finally, five other tables will give the track of La Recherche.†

* The small differences, which will be found between the longitudes of this table and those of the corresponding days in the second volume, (Dentrecasteaux's Voyage,) proceed from a recalculation of the differences of longitude with a diurnal variation, which differed some tenths of a second from those employed during the voyage.

† The courses have been reduced by the ship's pilot with a sinical quadrant.

## RESULTS OF THE ASTRONOMIC OBSERVATIONS,

*Made by Messrs.* Rossel *and* Bonvouloir, *on the* 19*th*, 20*th*, 21*st*, 22*d*, *and* 23*d*, *of May*, 1793.

### M. ROSSEL.

| H. M. | Latitude. | | | Longitude. | | |
|---|---|---|---|---|---|---|
| *May 19th.* | | | | | | |
| At 7 54 | 11° | 18′ | 00″ | 1° | 36′ | 25″ |
| Noon | 11 | 16 | 03 | | | |
| 3 41 | 11 | 14 | 30 | 1 | 42 | 11 |
| *May 20th.* | | | | | | |
| 8 19 | 10 | 59 | 00 | 1 | 45 | 59 |
| Noon | 10 | 55 | 34 | | | |
| *May 21st.* | | | | | | |
| 6 53 | 10 | 52 | 20 | 1 | 34 | 47 |
| Noon | 10 | 48 | 52 | | | |
| 3 2 | 10 | 50 | 10 | 1 | 18 | 23 |
| 4 32 | 10 | 45 | 40 | 1 | 19 | 18 |
| *May 22d.* | | | | | | |
| 8 5 | 10 | 40 | 20 | 1 | 21 | 48 |
| Noon | 10 | 36 | 44 | | | |
| 4 36 | 10 | 37 | 50 | 1 | 29 | 5 |
| *May 23d.* | | | | | | |
| 9 5 | 10 | 38 | 30 | 1 | 33 | 3 |
| Noon | No observations. | | | | | |

### M. BONVOULOIR.

| H. M. | Latitude. | | | Longitude. | | |
|---|---|---|---|---|---|---|
| *May 10th.* | | | | | | |
| At 8 2 | 11° | 19′ | 40″ | 1° | 35′ | 00″ |
| Noon | 11 | 15 | 38 | | | |
| 4 20 | 11 | 12 | 20 | 1 | 46 | 25 |
| *May 20th.* | | | | | | |
| 8 35 | 10 | 59 | 00 | 1 | 47 | 59 |
| Noon | 10 | 55 | 27 | | | |
| *May 21st.* | | | | | | |
| 6 55 | 10 | 59 | 00 | 1 | 34 | 50 |
| Noon | 10 | 49 | 42 | | | |
| 4 35 | | | | 1 | 17 | 31 |
| *May 22d.* | | | | | | |
| 8 8 | | | | 1 | 20 | 49 |
| Noon | 10 | 36 | 4 | | | |
| 4 30 | | | | 1 | 29 | 29 |

## RESULTS OF OBSERVATIONS OF THE VARIATION OF THE MAGNETIC NEEDLE,

*Made on the* 19*th*, 20*th*, 21*st*, 22*d*, *and* 23*d*, *of May*, 1793.

| | | *Variation* N. E. | | |
|---|---|---|---|---|
| *May 19th.* | | | | |
| At Noon, by a magnectic bearing of the sun, | | 10° | 30′ | 35″ |
| Sunset, by amplitude, | | 9 | 17 | 48 |
| *May 20th.* | | | | |
| Morning, by amplitude, | | 9 | 38 | 10 |
| Morning, by azimuth, | 1st compass, | 9 | 13 | 11 |
| | 2d compass, | 8 | 34 | 13 |
| *May 21st.* | | | | |
| Morning, by amplitude, | | 9 | 5 | 22 |
| Evening, | by azimuth, | 9 | 38 | 15 |
| | by amplitude, | 10 | 10 | 13 |
| *May 22d.* | | | | |
| Morning, by azimuth, | | 10 | 46 | 27 |
| Noon, by a magnetic bearing of the sun, | | 8 | 58 | 13 |
| Evening, by azimuth, | | 8 | 54 | 37 |
| *May 23d.* | | | | |
| No observations. | | | | |

## TRACK OF THE FRIGATE LA RECHERCHE, IN 1793,

### *From the* 18*th to the* 23*d of May.*

*From* SATURDAY, *May* 18, *to* SUNDAY, *May* 19.—*Variation of the Compass,* 9° 32′ N. E.

| Hours. | | Winds. | Courses. | Knots. | Leeway. | Corrected Courses. | Dist. in Miles. | Diff. Lat. | | Departure. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | N. | S. | E. | W. |
| H. | M. | | | | | | | | | | |
| 1 | 0 | E. S. E. | N. N. E. | $4\frac{1}{2}$ | 5° 0′ | N. 27° 2′ E. | 6,25 | 5,50 | .. | 2,80 | |
| 1 | 20 | ...... | ......... | $1\frac{3}{4}$ | .... | | | | | | |
| 2 | 0 | ...... | N. by E. | $4\frac{1}{2}$ | .... | | | | | | |
| 3 | 0 | ...... | ......... | 6 | .... | N. 20° E. | 19,50 | 18,10 | .. | 6,90 | |
| 4 | 0 | ...... | ......... | $5\frac{1}{4}$ | .... | | | | | | |
| 4 | 40 | ...... | ......... | $3\frac{1}{4}$ | .... | | | | | | |
| 5 | 0 | S. E. | S. by W. ½ W. | 1 | 11 15 | | | | | | |
| 6 | 0 | ...... | ......... | 2 | .... | | | | | | |
| 7 | 0 | S. E. ¼ E. | ......... | 2 | .... | S. 37° 39′ W. | 6,25 | .. | 4,94 | .. | 3,81 |
| 7 | 45 | ...... | ......... | $1\frac{1}{4}$ | .... | | | | | | |
| 8 | 0 | N. E. | N. N. W. | $\frac{1}{2}$ | 11 15 | N. 24° 13′ W. | 0,50 | 0,45 | .. | .. | 0,20 |
| 9 | 0 | E. by N. | N. by E. 3° E. | 2 | 11 15 | | | | | | |
| 10 | 0 | East. | ......... | $1\frac{1}{2}$ | .... | N. 12° 32′ E. | 6,0 | 5,86 | .. | 1,30 | |
| 11 | 0 | E. S. E. | ......... | $1\frac{1}{2}$ | .... | | | | | | |
| 12 | 0 | ...... | ......... | 1 | .... | | | | | | |
| 1 | 0 | N. N. E. | N. W. by W. | $2\frac{1}{2}$ | .... | N. 57° 58′ W. | 2,50 | 1,32 | .. | .. | 2,11 |
| 2 | 0 | N. E. by N | E. by S. | $0\frac{1}{4}$ | 56 15 | | | | | | |
| 3 | 0 | ...... | ......... | $0\frac{1}{4}$ | .... | S. 12° 58′ E. | 0,75 | .. | 0,73 | 0,16 | |
| 4 | 0 | ...... | ......... | $0\frac{1}{4}$ | .... | | | | | | |
| 5 | 0 | E. N. E. | S. E. | $0\frac{1}{4}$ | 56 15 | | | | | | |
| 6 | 0 | Calm. | South. | | .... | S. 20° 47′ W. | 0,25 | .. | 0,23 | .. | 0,8 |
| 7 | 0 | ...... | S. S. W. | | .... | | | | | | |
| 8 | 0 | North. | East. | | .... | | | | | | |
| 9 | 0 | N. W. | N. N. E. ½ E. | 1 | 11 15 | | | | | | |
| 10 | 0 | ...... | ......... | $1\frac{1}{2}$ | .... | N. 48° 54′ E. | 3,00 | 1,97 | .. | 2,26 | |
| 10 | 30 | ...... | ......... | $0\frac{1}{2}$ | .... | | | | | | |
| 11 | 0 | West. | N. by W. ½ W. | $0\frac{1}{2}$ | 5 0 | N. 2° 21′ W | 1,50 | 1,49 | .. | .. | 0,61 |
| 12 | 0 | ...... | ......... | 1 | .... | | | | | | |
| | | | | | | | | 34,69 | 5,90 | 13,42 | 6,81 |
| | | | | | | | | 5,90 | | 6,81 | |
| | | | | | | | | 28,79 | | 6,61 | |

Course for the 24 hours, N. 12° 56′ E.
Distance in miles, 29,54.

## *From* Sunday, *May* 19*th, to* Monday, *May* 20*th.*

*Variation of the Compass,* 9° 23′ N. E.

| *Hours.* H. | M. | *Winds.* | *Courses.* | *Knots.* | *Leeway.* | *Corrected Courses.* | *Dist. in Miles.* | *Diff. Lat.* N. | S. | *Departure.* E. | W. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 25 | W. S. W. | N. W. by N. | $0\frac{1}{8}$ | 8° 00′ | N. 16° 22′ W. | 0,12 | 0,11 | .. | .. | 0,03 |
| 2 | 0 | ...... | N. N. W. $\frac{1}{2}$ W. | $0\frac{1}{4}$ | 0 0 | | | | | | |
| 3 | 0 | South. | ........ | $0\frac{1}{2}$ | .... | | | | | | |
| 4 | 0 | ...... | ........ | $0\frac{1}{2}$ | .... | N. 18° 44′ W. | 4,75 | 4,49 | .. | .. | 1,52 |
| 5 | 0 | East. | ........ | 2 | .... | | | | | | |
| 6 | 0 | ...... | ........ | $1\frac{1}{4}$ | .... | | | | | | |
| 7 | 0 | ...... | S. S. E. | $0\frac{1}{4}$ | 67 30 | | | | | | |
| 8 | 0 | E. by N. | ........ | $0\frac{1}{4}$ | .... | S. 54° 23′ W. | 0,50 | .. | 0,29 | .. | 0,40 |
| 9 | 0 | E. N. E. | S. E. | $0\frac{1}{2}$ | 78 45 | | | | | | |
| 10 | 0 | ...... | ........ | $0\frac{1}{2}$ | .... | S. 43° 8′ W. | 1,00 | .. | 0,73 | .. | 0,68 |
| 11 | 0 | East. | ........ | 0,0 | .... | | | | | | |
| 12 | 0 | ...... | N. $\frac{1}{2}$ E. | $0\frac{1}{2}$ | .... | N. 63° 45′ W. | 0,50 | 0,22 | .. | .. | 0,45 |
| 1 | 00 | N. E. | N. by W. $\frac{1}{2}$ W. | $1\frac{3}{4}$ | 16 00 | N. 23° 30′ W. | 3,75 | 3,34 | .. | .. | 1,49 |
| 2 | 0 | ...... | ........ | 2 | .... | | | | | | |
| 3 | 0 | N.E.byN. | E. by S, 3° E. | 1 | 22 00 | S. 50° 22′ E. | 2,75 | .. | 1,75 | 2,11 | |
| 4 | 0 | ...... | ........ | $1\frac{3}{4}$ | .... | | | | | | |
| 4 | 30 | ...... | E. by N. | $0\frac{3}{4}$ | 18 00 | S. 73° 52′ E. | 0,75 | .. | 0,21 | 0,72 | |
| 5 | 0 | N. by E. | N. W. 3° W. | $0\frac{1}{2}$ | 11 15 | | | | | | |
| 6 | 0 | N. N. E. | ........ | $2\frac{1}{2}$ | .... | | | | | | |
| 7 | 0 | ...... | ........ | $3\frac{1}{2}$ | .... | N. 49° 52′ W. | 10,00 | 6,44 | .. | .. | 7,64 |
| 8 | 0 | ...... | ........ | $3\frac{1}{2}$ | .... | | | | | | |
| 9 | 0 | ...... | N. W. by W. | $2\frac{1}{2}$ | 8 00 | | | | | | |
| 10 | 0 | ...... | ........ | 2 | .... | N. 54° 52′ W. | 5,50 | 3,16 | .. | .. | 4,49 |
| 10 | 40 | ...... | ........ | 1 | .... | | | | | | |
| 10 | 55 | ...... | N. W. $\frac{1}{2}$ W. | $0\frac{1}{2}$ | 0 00 | N. 41° 14′ W. | 0,50 | 0,37 | .. | .. | 0,32 |
| 11 | 10 | ...... | N. W. by W. | $0\frac{3}{8}$ | .... | N. 46° 52′ W. | 0,37 | 0,25 | .. | .. | 0,27 |
| 12 | 0 | ...... | W. N. W. $\frac{1}{2}$ W. | $1\frac{1}{8}$ | .... | N. 52° 29′ W. | 1,12 | 0,68 | .. | .. | 0,88 |
| | | | | | | | | 19,16 | 2,98 | 2,83 | 18,17 |
| | | | | | | | | 2,98 | | | 2,83 |
| | | | | | | | | 16,18 | | | 15,34 |

Course for the 24 hours, N. 43° 28′ W.
Distance in miles, 22,30.

## *From* MONDAY, *May 20th, to* TUESDAY, *May 21st.*

*Variation of the Compass*, 9° 5′ N. E.

| *Hours.* | | *Winds.* | *Courses.* | *Knots.* | *Leeway.* | *Corrected Courses.* | *Dist. in Miles.* | *Diff. Lat.* | | *Departure.* | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| H. | M. | | | | | | | N. | S. | E. | W. |
| 1 | 0 | N. E. | N.W. by W. $\frac{1}{2}$ W. | 1$\frac{1}{2}$ | 0° 00′ | N. 52° 48′ W. | 3,50 | 2,11 | .. | .. | 2,78 |
| 2 | 0 | E. N. E. | ......... | 2 | .... | | | | | | |
| 2 | 15 | ...... | W. N. W. | 0$\frac{1}{2}$ | .... | N. 58° 25′ W. | 0,50 | 0,26 | .. | .. | 0,43 |
| 3 | 30 | N. N. E. | W. by N. | 2$\frac{1}{2}$ | .... | N. 69° 40′ W. | 2,50 | 0,87 | .. | .. | 2,46 |
| 4 | 0 | ...... | W. $\frac{1}{2}$ N. | 1$\frac{1}{4}$ | .... | N. 75° 18′ W. | 2,08 | 0,53 | .. | .. | 2,02 |
| 4 | 48 | ...... | ......... | 0$\frac{5}{6}$ | .... | | | | | | |
| 5 | 0 | ...... | W. by N. $\frac{1}{2}$ N. | 0$\frac{1}{4}$ | .... | N. 64° 3′ W. | 0,25 | 0,10 | .. | .. | 0,22 |
| 5 | 45 | ...... | W. $\frac{1}{2}$ N. | 0$\frac{5}{6}$ | .... | N. 75° 18′ W. | 0,83 | 0,21 | .. | .. | 0,80 |
| 6 | 0 | ...... | S. by E. | 0$\frac{1}{4}$ | 45 00 | S. 24° 40′ W. | 0,25 | .. | 0,23 | .. | 0,10 |
| 7 | 0 | N. E. | S. E. | 0$\frac{1}{4}$ | 0 0 | S. 35° 55′ E. | 0,75 | .. | 0,61 | 0,44 | |
| 8 | 0 | ...... | ......... | 0$\frac{1}{2}$ | .... | | | | | | |
| 9 | 0 | E. by N. | S.E. by S. 1° 24′ S. | 0$\frac{2}{3}$ | 11 15 | S. 12° 1′ E. | 2,50 | .. | 2,45 | 0,52 | |
| 10 | 0 | ...... | ......... | 0$\frac{2}{3}$ | .... | | | | | | |
| 11 | 0 | ...... | ......... | 0$\frac{2}{3}$ | .... | | | | | | |
| 12 | 0 | ...... | ......... | 0$\frac{1}{2}$ | .... | | | | | | |
| 1 | 0 | E. by S. | S. by E. | 1 | .... | S. 9° 5′ W. | 1,00 | .. | 0,97 | .. | 0,16 |
| 2 | 0 | ...... | N. E. $\frac{1}{2}$ N. | 1$\frac{1}{2}$ | .... | N. 37° 12′ E. | 4,25 | 3,38 | .. | 2,57 | |
| 3 | 30 | E. S. E. | ......... | 2$\frac{3}{4}$ | .... | | | | | | |
| 4 | 0 | ...... | S. $\frac{1}{2}$ W. | 0$\frac{1}{2}$ | .... | S. 25° 57′ W. | 0,50 | .. | 0,45 | .. | 0,22 |
| 5 | 30 | ...... | S. 3° W. | 2 | .... | S. 23° 20′ W. | 2,00 | .. | 1,83 | .. | 0,79 |
| 5 | 40 | ...... | N. N. E. | 0$\frac{1}{4}$ | .... | N. 20° 20′ E. | 0,25 | 0,23 | .. | 0,09 | |
| 6 | 35 | ...... | N. N. W. $\frac{1}{2}$ W. | 3 | .... | N. 19° 2′ W. | 3,00 | 2,83 | .. | .. | 0,98 |
| 7 | 0 | ...... | N. W. $\frac{1}{2}$ N. | 1$\frac{3}{4}$ | .... | N. 30° 18′ W. | 1,75 | 1,51 | .. | .. | 0,88 |
| 7 | 10 | ...... | N. W. | 0$\frac{1}{2}$ | .... | N. 35° 55′ W. | 0,50 | 0,40 | .. | .. | 0,29 |
| 7 | 25 | ...... | N. W. by W. | 0$\frac{1}{2}$ | .... | N. 47° 10′ W. | 0,50 | 0,34 | .. | .. | 0,37 |
| 7 | 50 | ...... | N.W. by W. $\frac{1}{2}$ W | 0$\frac{1}{2}$ | .... | N. 52° 48′ W. | 0,50 | 0,30 | .. | .. | 0,40 |
| 8 | 0 | Lying-to | | | | | | | | | |
| 8 | 40 | E. by N. | S. E. by S. | 0$\frac{1}{3}$ | 25 00 | S. 0° 20′ W. | 0,33 | .. | 0,26 | .. | 0,02 |
| 9 | 0 | East. | S. S. E. | 0$\frac{1}{3}$ | 45 00 | S. 31° 35′ W. | 0,87 | .. | 0,74 | .. | 0,45 |
| 10 | 30 | ...... | ......... | 0$\frac{3}{4}$ | .... | | | | | | |
| 10 | 45 | ...... | N. N. E. | 0$\frac{1}{2}$ | 25 00 | N. 6° 25′ E. | 0,50 | 0,49 | .. | 0,05 | |
| 11 | 0 | ...... | N. N. E. | 0$\frac{1}{8}$ | 45 00 | N. 13° 25′ W. | 0,12 | 0,11 | .. | .. | 0,02 |
| 11 | 25 | ...... | W. N. W. | 1$\frac{1}{4}$ | .... | N. 58° 25′ W. | 1,25 | 0,52 | .. | .. | 1,06 |
| 12 | 0 | ...... | S. W. $\frac{1}{2}$ W. | 2 | .... | S. 59° 42′ W. | 2,00 | .. | 1,00 | .. | 1,72 |
| | | | | | | | | 14,19 | 8,54 | 3,67 | 16,17 |
| | | | | | | | | 8,54 | | | 3,67 |
| | | | | | | | | 5,65 | | | 12,50 |

Course for the 24 hours, N. 69° 19′ W.
Distance in miles, 13,51.

*From* Tuesday, *May 21st*, to Wednesday, *May 22d.—Variation of the Compass*, 9° 52′ N. E.

| Hours. H. | M. | Winds. | Courses. | Knots. | Leeway. | Corrected Courses. | Dist. in Miles. | Diff. Lat. N. | Diff. Lat. S. | Departure. E. | Departure. W. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 30 | East, | S. W. ½ W. | 2 | 0° 0′ | S. 60° 29′ W. | 2,00 | .. | 0,98 | .. | 1,73 |
| 1 | 20 | ...... | S. W. | 3⅔ | .... | S. 54° 52′ W. | 3,66 | .. | 2,10 | .. | 2,99 |
| 1 | 25 | ..... | S. W. by W. | 0⅓ | .... | S. 66° 7′ W. | 0,33 | .. | 0,13 | .. | 0,30 |
| 1 | 28 | ...... | W. S. W. | 0¼ | .... | S. 77° 22′ W. | 0,25 | .. | 0,05 | .. | 0,24 |
| 2 | 0 | ...... | W. ½ S. | 2¼ | .... | N. 85° 45′ W. | 2,25 | 0,15 | .. | .. | 2,23 |
| 2 | 30 | ...... | West. | 2⅓ | .... | N. 80° 8 W. | 2,33 | 0,39 | .. | .. | 2,29 |
| 2 | 45 | ...... | W. by N. | 1¼ | .... | N. 68° 53′ W. | 1,25 | 0,45 | .. | .. | 1,16 |
| 2 | 53 | ...... | W. N. W. | 0⅔ | .... | N. 57° 38′ W. | 0,66 | 0,35 | .. | .. | 0,56 |
| 3 | 7 | ...... | N. W. by W. | 1¼ | .... | N. 46° 23′ W. | 1,25 | 0,86 | .. | .. | 0,90 |
| 3 | 17 | ...... | N. W. | 0⅚ | .... | N. 35° 8′ W. | 0,83 | 0,67 | .. | .. | 0,47 |
| 3 | 30 | ...... | N. W. by N. | 1¼ | .... | N. 23° 53′ W. | 1,25 | 1,14 | .. | .. | 0,50 |
| 3 | 40 | ...... | N. N. W. | 0¾ | .... | N. 12° 38′ W. | 0,75 | 0,73 | .. | .. | 0,16 |
| 3 | 48 | ...... | N. by W. | 0⅔ | .... | N. 1° 23′ W. | 0,66 | 0,65 | .. | .. | 0,01 |
| 4 | 0 | ...... | N. ½ W. | 0⅚ | .... | N. 4° 15′ E. | 0,83 | 0,80 | .. | 0,06 | |
| 4 | 10 | ...... | N. by W. ½ W. | 0½ | 0 1 | N. 7° 1′ W. | 0,50 | 0,49 | .. | .. | 0,06 |
| 4 | 30 | E. N. E. | North. | 0¾ | 5 0 | N. 4° 52′ E. | 0,75 | 0,74 | .. | 0,06 | |
| 5 | 0 | ...... | N. by E. | 1½ | 5 0 | N. 16° 7′ E. | 1,50 | 1,44 | .. | 0,41 | |
| 5 | 30 | E. S. E. | N. N. E | 1¾ | .... | N. 32° 22′ E. | 1,75 | 1,46 | .. | 0,96 | |
| 6 | 0 | ...... | N.E.byN.3°N. | 1¾ | .... | N. 40° 37′ E. | 1,75 | 1,32 | .. | 1,14 | |
| 6 | 25 | ...... | N. N. E. ½ E. | 1½ | .... | N. 37° 59′ E. | 1,25 | 0,98 | .. | 0,76 | |
| 6 | 35 | ...... | North. | 0¼ | .... | N. 9° 52′ E. | 0,25 | 0,24 | .. | 0,04 | |
| 7 | 0 | ...... | N. by E. | 0½ | 0 1 | N. 21° 7′ E. | 0,50 | 0,46 | .. | 0,17 | |
| 8 | 0 | ...... | N. E. by E. | 1 | 8 0 | N. 58° 7′ E. | 1,00 | 0,52 | .. | 0,84 | |
| 9 | 0 | ...... | N. E. | 1½ | 11 15 | | | | | | |
| 10 | 0 | ...... | ........ | 2 | .... | N. 43° 37′ E. | 5,00 | 3,61 | .. | 3,44 | |
| 11 | 0 | ...... | ........ | 1½ | .... | | | | | | |
| 12 | 0 | ...... | S. ½ E. | 3½ | .... | S. 15° 30′ W. | 4,00 | .. | 3,85 | .. | 1,05 |
| 0 | 15 | ...... | ........ | 0½ | .... | | | | | | |
| 1 | 0 | E. by S. | N. E. by N. | 1 | 11 15 | | | | | | |
| 2 | 0 | E. S. E. | ........ | 1½ | . .. | N. 32° 22′ E. | 6,50 | 5,49 | .. | 3,48 | |
| 3 | 0 | ...... | ........ | 2 | .... | | | | | | |
| 4 | 0 | ...... | ........ | 2 | .... | | | | | | |
| 4 | 30 | ...... | N. E. | 1 | 12 0 | N. 42° 52′ E. | 1,00 | 0,73 | .. | 0,67 | |
| 5 | 0 | ...... | S. 2° 15′ E. | 0¾ | 8 0 | | | | | | |
| 6 | 0 | ...... | ....... | 3½ | .... | S. 15° 37′ W. | 7,75 | .. | 7,45 | .. | 2,08 |
| 7 | 0 | ...... | ........ | 3½ | .... | | | | | | |
| 8 | 0 | East. | N. N. E. ½ E. | 2 | .... | N. 29° 59′ E. | 2,00 | 1,73 | .. | 0,99 | |
| 9 | 0 | E. by S. | N. E. by N. | 2½ | 11 15 | | | | | | |
| 10 | 0 | ...... | .. ..... | 2½ | .... | N. 32° 32′ E. | 7,50 | 6,30 | .. | 4,01 | |
| 11 | 0 | ...... | ........ | 2½ | .... | | | | | | |
| 12 | 0 | ...... | S.byE.1°24′E. | 3½ | .... | S. 8° 28′ W. | 3,50 | .. | 3,46 | .. | 0,51 |
| | | | | | | | | 31,76 | 18,02 | 17,03 | 17,35 |
| | | | | | | | | 18,02 | | | 17,03 |
| | | | | | | | | 13,74 | | | 0,32 |

Course for the 24 hours, N. 0° 19′E.
Distance in miles, 13,75.

## *From* Wednesday, *May 22d, to* Thursday, *May 23d.*

*Variation of the Compass,* 9° 50′ N.E.

| Hours. | | Winds. | Courses. | Knots. | Leeway. | Corrected Courses. | Dist. in Miles. | Diff. Lat. | | Departure. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| H | M | | | | | | | N. | S. | E. | W. |
| 1 | 0 | E.S.E. | S. 3° 45′ W. | 2 | 11° 15′ | S. 24° 50′ W. | 2,75 | .. | 2,49 | .. | 1,15 |
| 1 | 30 | ...... | ......... | $0\frac{3}{4}$ | .... | | | | | | |
| 2 | 0 | S.E. | E.N.E. 4° 30′ E. | $0\frac{3}{4}$ | 12 0 | E. 20° 10′ N. | 4,25 | 1,16 | .. | 3,99 | |
| 3 | 0 | ...... | ........ | 2 | .... | | | | | | |
| 4 | 0 | ...... | ........ | $1\frac{1}{2}$ | .... | | | | | | |
| 5 | 0 | S.S.E. | E. $\frac{1}{2}$ N. | $1\frac{1}{2}$ | .... | E. 7° 47′ N. | 3,00 | 0,40 | .. | 2,97 | |
| 6 | 0 | S.E. by S. | ......... | $1\frac{1}{2}$ | .... | | | | | | |
| 7 | 0 | S.E. | E.N.E. 3° 30′ E. | $1\frac{3}{4}$ | 11 15 | E. 20° 25′ N. | 3,25 | 1,13 | .. | 3,04 | |
| 8 | 0 | ...... | ......... | $1\frac{1}{2}$ | .... | | | | | | |
| 9 | 0 | ...... | E.N.E. 2° N. | $1\frac{1}{2}$ | .... | E. 30° 40′ N. | 7,25 | 3,69 | .. | 6,23 | |
| 10 | 0 | ...... | ......... | $1\frac{1}{2}$ | .... | | | | | | |
| 11 | 0 | ...... | ......... | 2 | .... | | | | | | |
| 12 | 0 | ...... | ......... | $2\frac{1}{4}$ | .... | | | | | | |
| 12 | 20 | S.E. by S. | N.E. by E. | $0\frac{3}{4}$ | 16 0 | N. 50° 5′ E. | 0,75 | 0,48 | .. | 0,57 | |
| 1 | 40 | East. | S.S.E. $\frac{1}{2}$ S. | $2\frac{1}{4}$ | 20 0 | S. 12° 57′ W. | 2,25 | .. | 2,18 | .. | 0,50 |
| 2 | 0 | E. by S. | N.E. by N. 2° N. | $0\frac{1}{2}$ | 25 0 | N. 16° 35′ E. | 4,30 | 4,12 | .. | 1,22 | |
| 3 | 0 | ...... | ......... | 2 | .... | | | | | | |
| 4 | 0 | ...... | ......... | 2 | .... | | | | | | |
| 4 | 30 | East. | N.N.E. | $0\frac{3}{4}$ | 18 0 | N. 14° 20′ E. | 0,75 | 0,72 | .. | 0,18 | |
| 5 | 0 | E. by S. | S. by E. 2° 48′ E | 1 | 20 0 | S. 15° 47′ W. | 5,00 | .. | 4,81 | .. | 1,36 |
| 6 | 0 | ...... | ......... | 3 | .... | | | | | | |
| 6 | 30 | ...... | ......... | 1 | .... | | | | | | |
| 7 | 0 | ...... | S.S.W. | $2\frac{1}{2}$ | .... | S. 32° 20′ W. | 2,50 | .. | 2,11 | .. | 1,33 |
| 7 | 15 | ...... | S.W. by S. | $1\frac{1}{2}$ | .... | S. 43° 35′ W. | 1,50 | .. | 1,08 | .. | 1,03 |
| 8 | 0 | ...... | S.W. by W. | 5 | .... | S. 66° 5′ W. | 12,25 | .. | 4,96 | .. | 11,20 |
| 9 | 0 | East. | .. ..... | $4\frac{1}{2}$ | .... | | | | | | |
| 9 | 42 | ...... | ......... | $2\frac{3}{4}$ | .... | | | | | | |
| 9 | 55 | ...... | W.S.W. | 1 | .... | W. 12° 40′ S. | 1,00 | .. | 0,22 | .. | 0,97 |
| 10 | 19 | E.S.E. | W. by S. | 2 | .... | W. 1° 25′ S. | 2,75 | .. | 0,06 | .. | 2,74 |
| 10 | 30 | ...... | ......... | $0\frac{3}{4}$ | .... | | | | | | |
| 11 | 00 | ...... | N.E. | $0\frac{1}{2}$ | 67 30 | N. 12° 40′ W. | 1,00 | 0,97 | .. | .. | 0,22 |
| 11 | 30 | ...... | ......... | $0\frac{1}{2}$ | .... | | | | | | |
| 11 | 45 | ...... | N.E. | $0\frac{1}{2}$ | 11 15 | N. 43° 35′ E. | 0,50 | 0,36 | .. | 0,34 | .. |
| 12 | 0 | ...... | S.S.W. $\frac{1}{2}$ S. | $0\frac{1}{2}$ | .... | S. 26° 43′ W. | 0,50 | .. | 0,44 | .. | 0,22 |
| | | | | | | | | 13,03 | 18,35 | 18,54 | 20,72 |
| | | | | | | | | | 13,03 | | 18,54 |
| | | | | | | | | | 5,32 | | 2,18 |

Course for the 24 hours. S. 22° 17′ W.
Distance in miles, 5,75.

The original designs of the charts, which accompany the narrative of Dentrecasteaux's Voyage, have all been constructed on the same scale as the trigonometric chart of the archipelago of Santa-Cruz, (*plate* XXXIV,) viz. on a scale of three lines to a minute of the equator. All these charts were drawn at the time of our operations; a constant attention was paid, during the voyage, in constructing, day by day, the charts of those places we were not likely to revisit, and in tracing on the spot an outline of the coasts on which I was in hopes of being able to make fresh observations; and to this, in a great measure, is to be attributed the accuracy of the Work which is now submitted to the judgement of the Public.

If a chart is constructed on the evening of the day of the survey, any errors which may have imperceptibly crept into it, in the course of the operations, are readily detected. The aspect under which the objects presented themselves to the eye is still in the memory, and if an object on which several observations have been made is noted by a different letter or signal from that which had been previously employed, the fault is immediately recognized; it is known with what degree of precision the astronomic observations have been made (in reference to the state of the weather); the degree of accuracy attained in measuring the angles, and taking the bearings of the land, is also known; finally, the surveyor can judge of the degree of confidence to be placed in the dead reckoning.

We have always taken, for the first meridian of our charts, the last place where the rates of the chronometers were ascertained. From this reason the longitudes on the trigonometric chart of the archipelago of Santa-Cruz are reckoned from the meridian of Baladea, in New Caledonia. This method we consider the safest to be adopted, when the longitude of the place, where the rates of the watches have been ascertained, is not exactly known. It is needless to detail the process of preparing our chart for the materials collected at sea, on the 19th, 20th, and 21st, of May; we will content ourselves with observing that, without reference to corrections which future observations may render necessary, we have outlined in the night from the 21st to the 22d of May, the details of the southern coast of the islands of Santa-Cruz: on the 22d of May, in the evening, we commenced the construction of the northern coast; finally, in the afternoon of the 23d, the frigate made sail for the Isles of Solomon; we soon lost sight of the land, and I immediately commenced the definitive compilation of my chart.

The positions of La Recherche, which had been determined, either in latitude or longitude, by astronomic observations, were first placed on the chart as they were given to us by M. de Rossel (vide Table I, annexed to this Chapter); thence our attention was directed to those positions from which the latitudes and longitudes of the capes of the island of Santa-Cruz might be deduced, having reference to circumstances, more or less favourable, which had occurred at each of the astronomic observations.

From this investigation we should have concluded that the position of May 21st, at noon, was extremely favourable for determining the latitude of the southern point of Howe's Island, (I,) and we should certainly have used the latitude which M. M. Rossel and Bonvouloir had observed at that point, had we not feared some error likely to arise from their having been obliged to observe the supplement of the altitude of the sun, owing to the proximity of the vessel to the shore; by which they estimated the error in the latitudes to be at least from one to two minutes.

Not being able to trust to the observation of the 21st at noon, we were obliged to have recourse to the observations of the 20th, to fix the latitude of the principal points of the southern coast of Santa-Cruz, and the longitude of Cape Byron. On that day the weather was particularly favourable [illegible] observations of all kinds; the position at which the horary angles had been observed in the morning at 8*h.* 19*m.* was advantageously situated for determining from thence the longitude of the eastern point of the island of Santa-Cruz; and the position at noon was not less advantageous for determining the latitude of Cape Mendana. (S.)

Being satisfied that it was adviseable to adopt the astronomic observations of the 20th of May for the base of our construction, we proceeded, in the following manner, to determine the position of the point H, which is in the vicinity of Cape Byron, in order to use that position afterwards, for finding the longitude of the ship's position at noon, on the same day.

On quitting the point of station at 8*h.* 19*m.*, which had been placed with a latitude by dead reckoning, we have drawn the bearing taken of the point H; then, having considered that the latitude of this point H could not be properly determined but by means of the bearings taken at noon on the 22d, we have provisionally placed the position of the 22d, at noon, in longitude 1° 25′ 30″, according to the observations of that day; we have traced, on leaving the point of station at noon 22d, the bearing of the point H, from that station, and the intersection of the line of this bearing with that of the bearing which was taken at the station of the 20th, at 8*h.* 19*m.*, has placed the point H in 10° 40′ 40″ latitude, and 1° 39′ 10″ longitude.

The position of the point H, found in the manner here explained, cannot be very far from the truth; because the observation of the 20th, at 8*h.* 19*m.* was very favourable for determining the longitude, and the observation of the 22d, was not less so for determining the latitude of this point H. This first operation gave us the means of ascertaining the longitude of the point of station of the 20th at noon, with a degree of accuracy very superior to that which we might have attained by means of the dead reckoning.

It will be observed, on viewing the chart, that the longitude of the point of station of the 20th of May, at noon, found to be 1° 42′ 30″ by the bearing of the point H, could not differ one minute from the truth; excepting that the provisional position of the point H, had undergone some change, which could not be taken into account; since, to produce such change, some great error must have been committed, either in the latitude of the point of observation for the hour angles at 8*h.* 19*m.* on the morning of the 20th, or in the longitude adopted for the 22d, at noon.

The difference of longitude between the position of the point of observation at noon on the 20th, and the point at 8*h.* 19*m.* of the same day, was found to be 3′ 40″, instead of 4′ 45″, which was given by dead reckoning.

The longitude at the point of station at noon, on the 20th, being fixed provisionally, we used the bearing taken at this station of the Cape Mendana (S,) to determine the latitude of this cape; but, previous to fixing its latitude, it was necessary to determine its longitude, which we obtained in the following manner.

On the 21st, at 3*h.* 2*m.* in the evening, at the moment we had arrived on the meridian of the point T, or Cape Boscawen, M. de Rossel, by observed altitudes of the sun, ascertained the longitude to be 1° 18′ 23″; but, since 1*h.* 30*m.*, the time when we were situated on the meridian of Cape S, until 3*h.* 2*m.*, the time of the observation, the course steered had been nearly west, and the vessel was going at the rate of more than four knots an hour, with smooth water; consequently, we judged these data sufficiently accurate to give the difference of longitude between the capes S and T, very nearly: from this run the eastern point of the cape S has been placed 6′ 30″ to eastward of the cape T, that is to say, in 1° 24′ 53″ east longitude.*

The point at which the line of bearing of the cape S, on the 20th, at noon, intersects the meridian of that cape, gave us its position in latitude, in a manner sufficiently correct; for, in order that it should differ one minute from the

* The longitude of the cape S, thus found, (a longitude which could hardly be erroneous, judging of it from the course steered, and the state of the weather,) has been verified, as will shortly be seen, by bearings taken of this cape on the 19th of May, at 9 *h.* 20 min. *a. m.*, and has been found correct.

truth, it is necessary that the assumed longitude should have an error of about $7\frac{1}{2}'$, or that the longitude of the point of station of the 20th, at noon, should have been affected by an error which we were persuaded could not possibly have existed. We have used the bearing taken of the cape S, at the point of station of the 20th, at 8*h.* 19*m.* in the morning, to verify the latitude of this point of observation, which was determined only by the dead reckoning; and we found that it was given 30″ too far to the northward. The longitude, which was given to me by M. de Rossel, 1° 45′ 59″ east of the meridian of Baladea, is that with which all the longitudes observed on the 19th, 20th, 21st, 22d, and 23d of May, were compared.

The point of station of the 20th, at 8*h.* 19*m.*, being definitively fixed in latitude and longitude, we retraced the bearing of the point H, which gave us the position of this point more correctly than we had it previously; but it differed so little from the former, that it did not occasion more than 20″ difference in the longitude of the point of station at noon, on the 20th.

The point of station at noon on the 20th, instead of being 1° 42′ 30″, was found to be 1° 42′ 10″; so small a difference in the longitude of this important position did not produce any in the latitude of the cape S; and I was satisfied that I had no great errors to fear in the last-found longitude, since it could only be made to vary by a difference of two or three minutes in the longitude of the point of station of the 22d at noon, and still in so trifling a manner as not to influence the position of the cape S in latitude, which it was of importance to ascertain with great exactness.

The meridian difference between the capes S and T being fixed, as above mentioned, and the latitude of the cape S being considered as permanently determined, we then proceeded to determine the position of the cape T, in latitude; and, on leaving the cape S, the bearings of S and T, in one, were traced, as given by the observations of the 21st, at 1*h.* 21*m.*, when to the eastward of cape S, and at 3*h.* 9*m.* when to the westward of cape T.

It is unnecessary to repeat here what has been said in the first Chapter, of the considerable differences which are found in the lines of bearing of the same points, taken in opposite directions, even when the observations have been made with the most scrupulous attention on well-defined objects; it will be sufficient to state, that these bearings should be used circumspectly, although, under many circumstances, great advantages are to be derived from them. In this example the interval between the two points being small, and the difference between the observed bearings being but 2° 30′, the mean bearing may be used without fear of any sensible error.

The position of the cape T being determined as above, the latitude of the point of station of the 21st, at 4 *h.* 32 *m.*, has been deduced from the corrected latitude of the station at 3 *h.* 2 *m.*, and the dead reckoning, and is = 10° 45′ 40″. This latitude cannot be in error more than a few seconds; for that part of the reckoning from which it has been deduced was nearly on a direct course, and was run to leeward of the Island of Santa-Cruz under the most favourable circumstances.

The hour angles observed at 4 *h.* 32 *m.* have been calculated with the above given latitude, and the longitude thence deduced is 1° 19′ 18″; that is to say, the observation placed us 55″ to the eastward of the meridian of the cape T, or, more properly speaking, of the point of station at 3 *h.* 2 *m.* It was easy to perceive that one of the two observations of longitude was erroneous; for at 3*h.* 2 *m.* the bearing of the cape U was taken at N. 34° 35′ W., and at 4 *h.* 32 *m.* I had observed it at S. 25° E.; the course had then been to the westward instead of the eastward, as the astronomic observations seemed to indicate.

To find, by means of the trigonometric operations, the difference of longitude between the points of station at 3 *h.* 2 *m.* and 4 *h.* 32 *m.*, I placed first the cape U, by means of the bearings taken of this cape at 3 *h.* 26 *m.*, and its bearing from cape T, which had been observed, at 2 *h.* 49 *m.*

Having determined the position of the cape U, with as much accuracy as possible, we made use of it to find the longitude of the point of station at 4 *h.* 32 *m.* and the cape V, which had been observed in one with U, at 5 *h.* 0 *m.* The longitude of the point of observation, at 4 *h.* 32 *m.* determined by the trigonometric operations, is 1° 16′ 15″: the observation had given 1° 19′ 18″: thus the results of the hour angles observed at 3*h.* 2 *m.* and at 4 *h.* 32 *m.* differed 3′ 3″. M. de Rossel repeated several times the computations of these observations, but he always obtained the same results; and it was clearly demonstrated that the cause of the difference, which we had found, was to be attributed to the nature of this kind of observation; since the altitudes of the sun had been taken with care, and the weather was very favourable.*

It was of some importance to ascertain, previous to proceeding farther, to which of the two observed longitudes the preference should be given, and we had only the observations of the 19th of May, at noon, to employ for this verification. Consequently, we traced on the chart the parallel on which the ship was situated at noon, on the 19th; we then assumed the longitude, at the same hour, by the bearings taken of Cape Byron, or rather of the point H, which was then in sight. On quitting this point, at noon, we traced the bearings

* See M. de Rossel's observations on this subject, page 35, Vol. II. Dentrecasteaux's Voyage.

of the cape T, deduced from an observed angle, taken at the mast-head; and we discovered that this cape, the latitude of which we were induced to consider as accurately ascertained, should be placed in longitude 1° 16′ 45″, that is to say, about 1′ 30″ to the westward of the longitude deduced from the observation made on the 21st, at 3*h.* 2*m.*

The bearing taken of the cape T, at noon, on the 19th, did not appear, in truth, an observation of sufficient accuracy to warrant the rejection of the longitude that had been observed on the meridian of this cape; but it served, at least, to convince me of the necessity of rejecting the longitude deduced from the hour angles, observed at 4*h.* 32*m.* on the 21st; since, if that longitude had been adopted, the cape T must have been noted 1° 21′ 20″; that is to say, 4′ 35″ to the eastward of the longitude deduced from the bearing taken on the 19th, at noon, and 2′ 57″ to the eastward of that deduced from the observations made in passing the meridian of the cape.

After this investigation, we considered the capes S, T, U, V, properly placed, and also the point of station at 4*h.* 32*m.*, as obtained by the bearings; and thence the results of the astronomic observations made by M. de Rossel at this station were rejected.

From the corrected point of station, at 4*h.* 32*m.*, we traced the bearings taken of the Island of Volcano Z, whose possession it was necessary to fix, in order to rectify the longitude of the station at noon, 22d, and that of the point H. Then we placed, provisionally, the low point K, on Cape Byron, which is about 30″ to the eastward of the point H: then, from this point, we traced its bearings in one with the south-west point of the island Z, which had been observed on the 22d of May, at 8*h.* 5*m.* P.M.; and we thence obtained the position of this point of the island Z sufficiently accurate to be able to deduce from it the longitude of the 22d, at noon, within a few seconds.

The bearing of this same point had been taken twice in the evening of the 21st, in one with the cape V. viz. at 3*h.* 30*m.*, and at 5*h.* 37*m.*; and thence the position of it might have been determined; but the cape V was so very near the point of station at 4*h.* 32*m.*, that it would have been imprudent to have trusted to the results obtained by these bearings.

The longitude of the point of station at noon, on the 22d, found by means of the bearings, taken at that hour, of the south-west point of the island Z, was 1° 24′ 30″, instead of 1° 25′ 30″, as we had at first supposed, from the observed longitudes of the same day.

The point of station of the 22d, at noon, being determined in longitude within a few seconds, we also fixed, definitively, the position of the point H, which scarcely varied in longitude, and was carried about 20″ to the southward of the latitude which had been first assigned to it. In consequence of this slight variation in the position of the point H, the position of the 20th, at noon, was carried some seconds to the eastward; the position of the S.W. point of the Island of Volcano varied likewise almost insensibly, either in latitude or longitude, and it was fixed, definitively, at 10° 24′ 10″ latitude, and at 1° 19′14″ longitude: this new position of the S.W. point of the island Z, gave us the means of rectifying anew the longitude of the 22d, at noon; and it was fixed, definitively, at 1° 24′ 6″

N.B. *In noting the bearing of the eastern point of the Island of Santa-Cruz, taken at noon, on the 22d, the point* H *is designated as the observed extremity of the land; because Cape Byron,* K, *which is extremely low, could not be perceived at that hour; but, as we knew the position of that cape from other observations, we have placed it* 30″ *to the eastward of* H. *This is one of the considerations to which the attention could not be directed, except when the charts are constructed immediately after losing sight of the objects; for how are the details of a survey to be retained in the memory after a long interval of time, when only a cursory view could have been obtained of those parts of the coast on which the observations were made.*

So soon as we had definitively fixed the positions of the N.E. and S.W. points of the Island of Santa-Cruz, and also several stations in the ship's track, we next proceeded to place the cape Q, which is the northernmost point of that island; because the position of this cape would afterwards serve to determine the latitude of the north point of the Island of Trevanion, as we had observed these points in one with each other, bearing nearly true east and west. The cape Q would also serve in fixing the position of the point of observation of the 22d, at 8*h.* 5*m.* A.M.

After having traced the bearing of the point K from the cape Q, which had been observed at the point of station at 9*h.* 5*m.* A.M. on the 23d, we fixed this point of station in longitude 1° 32′ 30″, by the bearing taken, at the same hour, of the centre of the Island of Volcano, Z.

The point of station of the 23d, at 9*h.* 5*m.*, being fixed, we placed that of 8*h.* 33*m.* by means of the bearing taken of the cape K, and the difference of longitude, by account, from 8*h.* 33*m.* to 9*h.* 5*m.*; then, with the bearing taken of the cape Q, at the point of station, at 8*h.* 33*m.*, we assigned the position of this cape; by the assistance of which, as we have already said, we should be able to fix that of the northern point of the Island of Trevanion.

We consider the latitude of the cape Q, as deduced from the foregoing operations, as being very correct; for, to produce a variation in it of 10″ or 12″, there must be an error in the position of the station at 8*h*. 33′, of a mile at the least; which appears to be impossible; since the bearing of the cape Q, taken at noon on the 22d, gives it the same position as the bearing taken at 8*h*. 33*m*.

From the cape Q, we then traced its line of bearing with the north point of the Island of Trevanion, and we obtained the latitude of that point more accurately than we could have done by the operations of the evening of the 21st, and noon on the 22d. The north point of the Island of Trevanion is in latitude 10° 39′ 50″, and the longitude 1° 20′ 25″.

We then fixed the point of station of the 22d at 8*h*. 5*m*., by means of the bearings taken of the cape Q, the cape V, and the S. W. point of the island Z. We verified the position of the north point of the Island of Trevanion by the bearings taken at 8*h*. 5*m*., and had the satisfaction to find the most complete accordance between the operations by means of which it had been placed, and those which had been used to verify its position. We have used the bearings taken of the S. W. point of the island Z and the cape K, to place the sattion of the 22d at 4*h*. 36*m*. P.M., which was in latitude 10° 37′ 35″, and longitude 1° 26′ 22″. From the point of station at 4*h*. 36*m*. we verified the position of the north point of the Island of Trevanion a second time, and we found that this point was placed with the utmost accuracy that could be obtained from the data used in the construction of our chart.

The point of station of the 21st, at 8*h*. 5*m*. A.M., deduced from our operations, being, as we have before mentioned, in longitude 1° 19′ 30″, while the astronomical observations gave 1° 21′ 48″; hence it occurs that the trigonometric operations placed us at 8*h*. 5*m*., 2′ 18″ to the westward of the longitude obtained by the chronometer. The trigonometric operations, by which the point of station, of the same day, at 4*h*. 36*m*. P.M. was placed, indicated also that the result of the astronomic observations made at this hour was 2′ 43″ too far eastward; for this station was found to be in longitude 1° 26′ 22″, whereas the watch gave 1° 29′ 6″.

These differences between the results of the astronomic observations of the 22d of May, and the results of the trigonometric operations, which were of the same nature, and nearly the same in quantity, as the difference found between the longitude given by the chronometer at 4*h*. 32*m*. and the longitude adopted for that point of station, occasioned a renewal of our fears, that there must be some error in the result of the observations of the 21st, at 3*h*. 2*m*.; consequently,

M. de Rossel recommenced the calculations of these hour angles; but he found the same longitude. I also revised my chart, and, after having made a small correction in the point of station, at noon 19th, rendered necessary by a previous correction in the point H, we still found that it was necessary to suppose an error so great, as to be impossible, in reality, in the observed latitudes of the 19th and 20th of May, or in the angular distance taken from the mast-head at noon 19th, to admit of our rejecting the result of the observation of longitude at 3*h.* 2*m.* P.M. on the 21st of May. In other respects, the observation made by M. de Rossel, at the point of station at 9*h.* 5*m.* A. M., 23d May, which gave the longitude 1° 33′ 3″, was but 33″ to the eastward of the longitude obtained by the bearings, and confirmed the accuracy of the astronomic observations, which had been used to fix the position of the island Z; it was then indispensably necessary to reject the longitudes deduced from the observations made on the 21st, at 4*h.* 32*m.* P.M., and also of the 22d, at 8*h.* 5*m.* A.M., and at 4*h.* 36*m.* P.M.

Finally, if the observation which was made on the 21st, at 3*h.* 2*m.*, in passing the meridian of the cape T, is not so exact as we have supposed, the errors with which it would be affected would sensibly influence the position with regard to the latitude of the island of Volcano Z only; which would be found to have been carried about 1° 30″ too far North: but all the positions of the western coast of Santa-Cruz, and the position of the island of Volcano, would be carried about 2′ 30″ too far West.

When the verifications above mentioned were finished, we considered the positions of the capes Byron K, Boscawen T, and the Island of Volcano Z, as permanently fixed; and we placed the intermediate points of station, of the 22d and 23d of May, by the bearings that had been taken of these three points. We then proceeded with the bearings of the 19th, 20th, and 21st, of May.

The S.W. point of Howe's Island, I, has been placed with the greatest accuracy, by a bearing taken on the 20th, at noon, and the line of bearing between this point and the cape S, which had been observed on the 21st, at 1*h.* 43*m.*, the point I then served, with the cape S, to determine the points of station of the 20th, at 3*h.* 28*m.*, and at 5*h.* 45*m.*, likewise the station of the 21st, at noon.

The line of bearings between the points I and L, and the bearing taken at 5*h.* 45*m.* P.M., on the 20th, of the point L, served to find the position of this latter point; then, by means of the bearings taken of the cape S and the point L, the station of the 21st, at 6*h.* 53*m.* A.M., was placed in longitude 1° 34′ 15″. M. de Rossel had observed the hour angles at the same point, and had found it to be in longitude 1° 34′ 47″, that is to say, the watch placed us 32″ to the eastward of the position given by the bearings.

This difference of 32″, which may be considered as nothing, shows that there exists a great accordance between the trigonometric operations and the astronomic observations, which we have adopted to fix the positions of the most remarkable points on the Island of Santa-Cruz, and confirms the accuracy of the observed longitude on the 21st, at 3 *h.* 2*m.* in passing the meridian of the cape T.

The latitude of the point of station at noon, on the 21st, determined by the trigonometric operations, is 10° 51′ 15″. If we had deduced the longitude of the cape T from the observations of the 21st, at 4 *h.* 32 *m.* P. M., we should have had for the 21st, at noon, latitude 10° 52′ 10″; but this last result differs too much from the observed latitude to admit of its being adopted; and this is another proof that we were right in rejecting the longitude of the 21st, at 4 *h.* 32 *m.* The latitude on the 21st of May, by M. de Rossel, was 10° 48′ 52″, and by M. Bonvouloir, 10° 49′ 42″; the difference between these latitudes and the latitude deduced from the trigonometric operations will not appear extraordinary, when it is taken into consideration that the supplement of the sun's altitude was observed; but it will show to what degree of accuracy it is possible to attain, in employing the method we have followed in the construction of hydrographic charts.

In fact, if the magnetic bearings had been the only means we were possessed of, for laying down the chart of the archipelago of Santa-Cruz, it would have been impossible for us to have discovered the error of the observed latitudes at noon on the 21st, and we should have been obliged to employ the mean result, since those latitudes differed from each other only 50″.

With the bearings taken at noon on the 19th, and at 8 *h.* 19 *m.* A. M. on the 20th, we have placed, permanently, the mount C, on Lord Edgecumbe's Island, and the mount D on the Isle of Ourry. We then used bearings taken of these same mounts, and of the eastern point of the Island of Santa-Cruz, to place the stations of the 19th of May at 7 *h.* 54 *m.*, and at 9 *h.* 20 *m.* A.M., and that at 3 *h.* 41 *m.* P.M.

The bearings taken at 7 *h.* 54 *m.* served only to fix the ship's position, and to indicate the effect of the currents; but those of 9 *h.* 20 *m.* furnished us with a proof of the accuracy of the longitude of Cape Mendana, S.

At 9 *h.* 20 *m.* an angular distance between Cape Mendana and Cape Boscawen T was taken from the mast-head, which indicated that this cape ought to be carried 2′ to the westward of the longitude we have adopted: but this angle was marked doubtful on the journal; and the bearing of this cape could not be otherwise deduced, but by means of an observation made with the compass; we therefore dispensed with it altogether.

It was not the same with the bearing of the cape T, taken on the 19th, at noon; nevertheless I thought proper to reject it, in order to retain a longitude for this cape, which was nearly the mean between that deduced from the trigonometric operations of the 19th of May, and the longitude resulting from the astronomic observations of the 21st, at 4*h.* 32*m.*, and those of 22d of May.

From the point of station, at 9*h.* 20*m.*, we took the bearing for the first time of the island F, or La Recherche, at a great distance. From the point of station, at noon, on the 19th, we took the bearing a second time of the same island, and afterwards lost sight of it. From the small interval between the two points of station from which the bearings of the island F were taken, I was led to fear that this island was not accurately placed. The longitude of the point of station of the 19th, at 3*h.* 41*m.* P. M., as deduced from our bearings, is 2′ 50″ to the eastward of the longitude deduced from the observations of M. de Rossel, which would make it appear that we had carried the eastern point of the Island of Santa-Cruz 2′ or 3′ too far eastward: but, as the point of station at 3*h.* 41*m.* had been fixed by means of a bearing taken with the compass, we have not noticed this difference, which is of a nature contrary to the differences found between the longitude of the 21st, at 3*h.* 2*m.*, and the observed longitudes on the 22d.

It would now remain for us to speak of the use we have made of the numerous materials which had been collected for tracing the configuration of the coasts; but this part of our labour is too simple to render it necessary to enter into details which would not fail to become fastidious. It may be imagined that it is extremely easy to trace the outlines of a coast, when the principal points, and the positions of the stations from which the bearings have been taken, are determined.

We have indicated by lines all the bearings which have been adopted in the construction of the chart we have selected for an example; the lines of bearings of remarkable points seen and taken in one with each other are there distinguished by lines formed of slight strokes or pecks.

After having described the methods we employed for fixing the latitudes and longitudes of the most remarkable positions in the archipelago of Santa-Cruz, and for determining the intermediate points of station by means of bearings taken of these positions, we have to add, that we have followed the same plan in constructing all the charts that have been laid down from observations made under sail, during the course of our voyage.

Among persons who are in the habit of constructing hydrographic charts, those who have never been afloat, and cannot be aware of the inaccuracies which creep into the charts, arising from the slight errors almost inevitable in the astronomic and trigonometric observations, would perhaps consider themselves justified in censuring us for preferring graphical operations instead of calculations, for noting the principal positions of the coasts we have visited. We are not apprehensive that intelligent seamen will partake of this opinion; we fully trust, after having read the preceding analysis, that they will be convinced that we have used the surest method of attaining the greatest degree of accuracy that it is possible to acquire in constructing charts with materials collected under sail.

In fact, if the great number of suppositions, more or less accurate, which we have been obliged to make use of, in placing some of the points of the archipelago of Santa-Cruz be taken into consideration, the conclusion will be, that, in such an undertaking, it would be useless to enter into calculations which would be, in some measure, interminable; since they would be founded on bases, which might be varied to infinity, without ever being certain of having arrived at the desired degree of accuracy: on the contrary, in laying down the charts according to the method we have adopted, the whole of the work being constantly under the eye, operates as a guide in the combinations which it is necessary to make; a thousand combinations present themselves, as it were, in an instant, and that which, without giving a perfect result, unites in itself, at least, the greatest number of probabilities, may be selected.

To this method we are indebted for the incalculable advantage of being able to lay down, day by day, the charts of the parts of the coasts surveyed; an advantage which must necessarily be renounced, if we employed calculations instead of graphic operations.

We have no hesitation in stating, that our proceedings for the determination of latitudes and longitudes of remarkable points of coasts are preferable to those which have been used by former navigators; for every one must be aware that, to reduce by calculation the geographical positions from the astronomic observations made afloat, the dead-reckoning has hitherto been used, or elements still more vague, such as distances estimated by the eye.

We agree that, after having in a manner exhausted all the combinations, in order to place, graphically, several principal points of the archipelago of Santa-Cruz, it would be practicable to take the latitudes and longitudes of the points thus found on the trigonometric chart, and use them as data, for calculating the latitudes and longitudes of the points still to be determined: but I leave it to the judgment of all intelligent and impartial men to decide, whether the results of calculations, wherein the data must be collected from graphical operations, would be more accurate than these operations themselves. It was only in constructing charts from astronomic and trigonometric observations made on shore, that we had recourse to calculation to fix the positions of the principal points; therefore, we have calculated the positions of the remarkable objects in Dentrecasteaux's Channel, in the Straits of Boeton, and generally in all the places we have touched at: and these positions may be considered as determined with great accuracy.

We have reduced the longitude of the principal points of the archipelago of Santa-Cruz to the meridian of Paris, by means of the longitude (corrected) at ship on the 19th of May, 20*h.* 19*m.* 47 *s. astronomic*, or the 20th of May, 8*h.* 19*m.* 47*s. civil.* This longitude is 163° 50′ 46″, east.—(See Dentrecasteaux's Voyage, Vol. II. pages 570 and 571.)

The longitudes at noon, each day, such as are given on our charts, have been corrected by the bearings, and they seldom agree with the longitudes given in the log-book, because the longitudes noted in the log have been concluded from the results of the astronomic observations carried on to noon by the dead reckoning.

We cannot answer for the accuracy of the configuration of those coasts which we have passed at a distance of two leagues; but we believe we can give assurance that all the remarkable points are fixed with precision on our charts. Nevertheless, whenever any points have been observed at great distances, or under unfavourable circumstances, we have taken the precaution to indicate by the letters P. D., that their positions were doubtful.

# APPENDIX.

## I.—ESSAY ON THE MOST COMMODIOUS METHODS OF MARINE SURVEYING.

*By ALEXANDER DALRYMPLE, Esq.* 1771.*

IT often happens that people are prevented from making any observations of the lands they see, from a persuasion that they shall not have opportunity to make observations sufficient to form even a sketch of these lands; and, therefore, that their labour would be in vain. Others are prevented by diffidence; but most are, from negligence or ignorance, remiss in the observations requisite to complete the art of hydrography. The intention of this essay is to assist and exhort the former; to encourage the diffident; to shame the careless, by shewing with how little trouble useful observations may be made; and to instruct the ignorant in the practice of a few useful rules.

It is possible nothing new may be found here; it is, however, imagined, some things uncommon will be met with, and others disposed in their proper place, instead of being lost in the heap of practical questions.

Experience has fully convinced me, that bearings, taken by compass, cannot be safely trusted to, in making a correct draught. I have found not only a difference of 3° or more in different compasses, but in the same compass at different times: I do not say the effect had no cause, but there was no sensible one which I could discover: and I have heard other people say, their observations gave room to believe that there is a casual deviation, consequent to the state of the atmosphere, or some other occult influence.

Sometimes the observations made with the compass will correspond very well with each other: it is not therefore my intention to condemn the use of it entirely; but, if the sea be rough, it is very troublesome taking many bearings by the compass, as it requires much time to be sure the compass stands true; so that the use of the compass, besides other inconveniences, is attended with delay, whereby the lands lose their reciprocal situations; and by this mean, being as it were taken from different stations, if the objects be near, the angles do not coincide in plotting the draught. Besides, the rigging and sails often intercept the sight of the objects from the only convenient part of the ship where the compass can be placed.

* It may be proper to remark that, in this copy, two or three paragraphs, *now* superfluous, have been omitted.

Hadley's quadrant is as much preferable to the compass for taking angles in facility, as exactness. In the common observation for finding the latitude, the quadrant being held upright, the index is slided forward till the image of the sun, by reflection, touches the horizon seen by direct vision. For taking angles, the quadrant is held horizontal, and one object by reflection brought, by moving forward the index, to coincide with another seen by direct vision.

*If the compass could be relied on,* bearings taken by it have one advantage over the angles taken by quadrant, viz.: that these bearings, being the angles from the magnetic meridian, are easily laid down by the meridian in the chart; for supposing A to bear N. 20° E. and B, N. 20° W. from an unknown station, laying off the reversed bearings S. 20° W. from A, and S. 20° E. from B, (*fig.* 1, *pl.* XXXIII,) the intersection would give the station, which cannot be found by two objects with any other instrument; all instruments for measuring angles, except the compass, requiring three objects to determine the station: indeed, the north point of the compass may be considered as a third object when this instrument is used. The compass is also very useful in setting points as they come in one; but there are many occasions when a compass cannot be used with any accuracy, where a quadrant is extremely commodious and equally exact.

All compass observations made in boats are liable to great objection: the motion of a boat will ever prevent exactitude in compass-bearings, and the extremities of shoals and the depths in intricate channels (for determining which boats are usually employed) require the minutest exactness. In such cases, the use of the quadrant removes every difficulty; for, if the reciprocal situations of any three objects are known, the compass bearings are not necessary; and if there are not three objects which can be used for this purpose, the bearing of the boat may be taken from the ship on making a signal; and this, reversed, will give the bearing of the ship from the boat, which may then use the ship as an object, and lay off the other angles equally, as if they could have been taken exactly by compass.

All bearings or angles of very near objects are liable to incertainty from the sheering of the ship, as that alteration will make a difference in the position of *very near* objects. Observations made in boats at anchor are less liable to error, as the change of place is smaller; and, either in a ship or boat, the observations made by quadrant will be more exact than those by compass, as performed more expeditiously.

In surveying, the real distance is the direct distance from one place to another; the apparent distance is the angle under which two objects are seen. The most useful problem in surveying is, "to find a station, by observed angles of three or more objects, whose reciprocal distances are known, but distance and bearings from the place of observation unknown."

Two objects, A B, (*fig.* 2, *pl.* XXXIII,) will appear under the same angle from every part* of a circle passing through these objects: and these objects can be seen under that angle only, from some part of this circle.

* This is true only from every part of the greater segment of the circle; for, in the less segment between A and B, they will not appear under this angle: but, although the assertion is not mathematically, it is practically true, as the object must be seen from behind for the case not to answer the proposition; and therefore it seemed improper to perplex the practice by useless niceties.

These two objects, A B, (*fig.* 3, *pl.* XXXIII,) will appear from the centre of the circle, under double the angle under which they appear from the circumference: for an angle at the centre is always equal to double the angle at the circumference.

Suppose A B, (*fig.* 4. *pl.* XXXIII,) to be seen under an angle of 30°, from some unknown station, S; these objects will be seen under an angle of 60°, at the centre of a circle passing through A B and S.

The three angles of a right-angled triangle are equal to two right-angles, or 180°; and therefore the difference between 180°, and double the angle observed, will be the sum of the two other angles.

The half of this, laid off from each object, will intersect at the centre; and a circle drawn from this centre through the two objects will be the circle in some part whereof the observation must have been made.—*Example*; subtract the angle at centre C (always double the observed angle) from 180°, and half the remainder (120) will be the ∠ B A C = 60°, and ∠A B C = 60°, which angles laid off from A and B, the intersection will be the point C, which is the centre of a circle, passing through A B S.

It is therefore obvious, that, as the station S, (*fig.* 5, *pl.* XXXIII,) must be somewhere in this circle, if the same operation was repeated with the angle, under which two objects whose reciprocal situations to A and B are known, that the intersection of this circle with the former would give the point of observation S.

One of the objects A or B may be used in the second operation, but it may be performed by two new objects, D E. (*fig.* 6, *pl.* XXXIII.)

But if the three or more objects are in the same circle, (*fig.* 7. *pl.* XXXIII,) there will be no solution; as the centre will be a common centre to both circles; and therefore no intersection to determine in what part of the circle the point S will fall.

It must also be obvious, that, in using four objects, the two circles will intersect each other in two places; but there can be no difficulty in determining which intersection is the station.

Although this is a very simple solution of the problem by projection, I think the following, by the Logarithm Tables, is preferable:

Sin. ∠ ASB : rad. :: AB : diameter of circle ABS, half of which sum is the distance from A to C and from B to C.

This distance laid off from A and B, (*fig.* 8, *pl.* XXXIII.) by a scale of equal parts, the intersection will be the point C, which is the centre of a circle passing through ABS.

Mr. Michell, in a paper on this subject, says, if the line drawn from A to B, (*fig.* 9, *pl.* XXXIII.) be bisected by an indefinite right line perpendicular to AB; the tangent of the angle between the observed angle and 90°, laid off on this indefinite line, from the point of bisection, will on that line give the centre of a circle passing through AB and S, or place of observation. It must be obvious, if the observed angle be 90°, the point of bisection will be the centre of the circle; if the observed angle be more than 90°, the difference between it and 90° must be laid off on the indefinite line on that part beyond the line AB.

This method of Mr. Michell appears preferable to all others; because the centres of the circles or segments corresponding to every observed angle are easily deduced, after the first operation of drawing the indefinite line perpendicular to AB, by marking on this line the tangent of the angle between the angle observed and 90°; whereas, in the other modes, the same operation is to be performed to find a centre to every circle, without any assistance being derived from the former centres found. Besides, in Mr. Michell's having found the centre to the segment of one angle, the intersection of the indefinite line by that segment gives the centre of a segment corresponding to half that angle. Thus, the point, (*fig.* 10, *pl.* XXXIII,) where the segment of 90° intersects the indefinite line, is the centre of a segment of 45°, or half the angle. Where the segment of 45° intersects the indefinite line, is the centre of a segment of 22° 30′, &c.

It has been already observed that, no instrument is so commodious for taking angles as Hadley's quadrant. It is used with equal facility at mast-head as upon deck, and therefore the sphere of observation is by this instrument much extended. For, supposing many islands are visible from mast-head, and only *one* from deck, no useful observations can be made by any other instrument; because compass-bearings from mast-head can be taken only very vaguely, and a small error in the bearing of a distant object makes a great error in its position; but, by the quadrant, the angles may be taken at mast-head, from the *one* visible object, with the utmost exactness. Besides, taking angles from heights, as hills, or a ship's mast-head, is almost the only way of exactly describing the extent and figure of shoals.

It has been objected to the use of Hadley's quadrant, for surveying in general, "that it does not measure the horizontal angles, by which alone a plan can be laid down." This objection is true in theory, but may be removed in practice, by a little caution, which, in the observations made from heights, is very requisite.

If an angle is measured between an object on an elevation, and another near it in a hollow, (*fig.* 11, *pl.* XXXIII,) the difference between the base, which is the horizontal angle, and the hypothenuse, which is the angle observed, may be very great; but, if these objects are measured, not from each other, but from some very distant object, (*fig.* 12, *pl.* XXXIII,) the difference between the angles of each, from the distant object, will be very nearly the same as the horizontal angle. Besides, a correction may be made by measuring the angle, not between an object on a plane and an object on an elevation, (*fig.* 13, *pl.* XXXIII,) but between the object on a plane, and some object in the same direction as the elevated object, of which the eye is sufficiently able to judge.

In describing shoals from an elevation, the greatest attention to this matter is requisite; but it is so obvious in practice, that nothing more than a caution on the subject is necessary.

The horizon being an equidistant line, the reciprocal distances may be found by the depression of the horizon to objects seen within it.

Although Hadley's quadrant will show, by the depression of the horizon, the reciprocal distances, it will not give any data for laying places down; which, however, may be done by a land-quadrant, as the level gives a parallel line to the surface of the sea, to which the zenith will be at right angles, and the angle of depression of the horizon and other objects will intersect the line of the surface of the sea at the distances where these objects lie; for measuring which distances, the perpendicular elevation of the place from whence the observations are made, will be a scale; and this elevation will be shown by the barometer.

For this purpose, a card with a graduated circle, and the diameter divided into equal parts, will be very useful for marking on the spot where objects fall. This card will also be very useful in determining the extent of objects from their bearings and distances, in which the eye is generally mistaken, by supposing the extent greater than the angle will admit, particularly in the extent of breakers.

As an example of the method of expressing the angles taken by Hadley's quadrant, I shall give those taken from the top of the island Corejidor, at the entrance of Manilla Bay, as a proof how very near the sum of all the angles will be to 360°, even where the objects are very much out of the horizontal plane; for although the elevation of Corejidor above the sea is very considerable, and the altitudes of the objects observed very unequal, and some of them greatly depressed under the horizon, the sum of the angles is only 0° 15′, or ¼ of a degree deficient of the complete circle 360°.

As the object by reflection is used for several angles, I mark it *, and set down the observed angles to the right and left, as below:

* 1st, Limbones Ears, per compass, S. 23° ¼ E.

| | | | | | |
|---|---|---|---|---|---|
| *R.* 36° | 30′ | Fortun * 5th | *L.* 48° | 10′ | Po. Cavallo * 2d |
| | | * 5th Fortun | | | * 2d Po. Cavallo |
| *R.* 71 | 20 | Monja, per compass, W. 5° S. | *L.* 91 | 45 | Cabcaben Point * 3d |
| | | | | | * 3d Cabcaben Point |
| 107 | 50 | | *L.* 90 | 40 | Dolphin's Nose * 4th |
| 251 | 55 | | | | * 4th Dolphin's Nose |
| | | | *L.* 21 | 20 | Monja |
| 359 | 45 | | | | |
| 360 | 00 | | 251 | 55 | |
| 0 | 15 | Deficient. | | | |

I have not inserted any angles here but such as were used for continuing the observations. As the quadrant will not measure more than 90°, it is requisite, when it will measure no farther, to change the line of observation, which I mark * 2d, * 3d, &c. In this example the angles are all set down just as they were observed, except that between Limbones Ears and Fortun; the angle measured from Fortun was not to Limbones Ears, but to Frail, which was 49° 30′; but as Frail was found to be from Limbones Ears 13° 0′ the other way, the difference of these two angles, 36° 30′, must consequently be the angle from Fortun to Limbones Ears.

I shall not give any further example, but observe that it is not only satisfactory, but useful, to continue the angles round the circle; because, if the sum of all the angles does not amount to 360°, it points out an error in some of the angles of those objects used as lines of observation.

It is further to be observed that, neither a near object nor a low point should ever be used as a line of observation; for the difference of refraction of the air, or the elevation and depression of the ship by the tide, or even by the send of the sea, will change the latter; and, consequently, make the whole chain of angles, taken from this fluctuating line of observation, disagree; and the sheering of the ship will have the same effect in the former case.

The best object for an observation line is a sharp peak, a bluff point, or any remarkable thing at a distance, which can at all times be certainly distinguished.

Having now discussed the use of the quadrant, I shall briefly mention some other matters, which, though extremely useful in practice, may not occur to every one.

The basis of all surveying is in determining a distance; for, unless some base is found, or assumed, no chart can be made.

It very seldom happens that there is an opportunity of measuring so long a base ashore as to be useful in constructing a chart; but the result of small triangles from a short base, will form one with sufficient exactness. This method, though obviously preferable to observations merely from ship-board, is not recommended in any Treatise of Marine Surveying; which may, perhaps, arise from a presumption that it would naturally occur. It is, however, liable to exception where the coast is low or circular; it is also impracticable where the coast is in a direct line, unless there be remarkable lands in-shore: however, in all coasts which have deep trenchings or islands in the offing, and, consequently, amongst islands, it is very commodious.

There is a very eligible and convenient method of surveying a river, particularly where there is ground to imagine offence might be taken at any open remarks, viz. by warps, whose length, being known, gives a base. A like method is useful in determining the extent of small shoals, by letting-go a grappling on the extremity, and veering away till the boat reaches the other end.

* * * * * * * *

Captain Plaisted's practice of using, for determining the course and distance in soundings, a lead instead of a log to his line (the stray-line corresponding to the depth of water) seems to be a good method of correcting the log.*

Middleton, who was employed in the N.W. discovery, mentions his being accustomed to try the current when laying-to under a main-sail: the Hudson's Bay ships commonly try it in easy weather by a current log. "This is a quadrant of a circle about 30 inches diameter, slung like a common log, with lead let into the circle rim sufficient to sink it; then, at the distance of 70 or 80 fathoms, on the line, is fastened a cork, or any light thing that will ride the log that is sunk, and to this buoy the line is to be fastened, as in common use, to the log, with sufficient stray-line to go clear of the ship or boat; the remainder of the line being marked as the log-line, it will be easy to determine the ship's course by the bearings of the float, and the line gives the distance."

It is necessary to take care that the line on board does not check the float: but this is equally necessary in using the common log. The Hudson's Bay ships use a stone bottle for the float.

This method gives the ship's drift, but does not show what is the direction and velocity of the current. For determining this, Middleton informed me, he, at the same time, hove the common log, and by it found the ship's course and distance without any allowance for current; and, consequently, the difference of the two measurements is the current. He also told me that his log-reel had brass cogs.

Perhaps nothing is more easy or more exact than this method; but, in justice to Middleton's memory, I must say, I never heard of any body else using it. In his publications he does not explain what means he used, but very freely communicated his method of practice to me, on a visit I made to him for this information.

* See farther, upon this subject, Mr. Livingston's Remarks, in Purdy's Memoir to accompany the Chart of the Atlantic Ocean, 4th Edit. pages 234, 5, 6.

There is another very useful method of correcting the log in sight of land, which first occurred to me on the coast of Celebes, in 1761, viz. by the bearings of the land. An example will render this familiar :—

| | | | |
|---|---|---|---|
| At noon—An island A. bore | E. 34° | 30′ | S. |
| Rock B, | E. 20 | 30 | S. |
| Course per log to noon following | E. 11 | 00 | S. |
| A. then bearing | E. 55 | 30 | S. |
| B. | E. 15 | 00 | S. |
| The course made good was evidently between | E. 34 | 30 | S. |
| And | E. 20 | 30 | S. |
| (instead of E. 11° S. as per log;) for | | | |
| A, now bearing 21° more to the southward than before, the course must have been less southerly than its bearing | E. 34 | 30 | S. |
| Rock B, bearing now only | E. 15 | 00 | S. |
| or 4° 30′ less southerly than its former bearings, evinces the course to have been more southerly than its bearings | E. 20 | 30 | S. |
| Suppose at the first noon C. bore | E. 25 | 00 | S. |
| and to have the same bearings at the second noon, it would show the course to have been | E. 25 | 00 | S. |

but even supposing no object remained in the same bearings, the estimated distances would show nearly the true course, by a comparison of the alteration of the bearings of the different objects. This method pursued, will give the course very nearly exact: for, if several objects be set, it may be possible to determine the course to as great a precision as hydrography requires; and, if the course be well determined, the bearings taken from frequent stations will, with care and repeated trials, work themselves right. For this purpose it is recommended to repeat the several bearings every hour, by which means the number of stations will greatly facilitate the result. It is not necessary to take more than one bearing from each station by compass; the other angles may be taken by quadrant.

And here it may be proper to observe, that the angles taken by quadrant are useful, although the reciprocal situations of the objects whose angles are taken be not known; as these observations may be made use of whenever the reciprocal situations of those objects are found. I mention this chiefly with a view to soundings, as a very little trouble, taken with the boats of every ship which passes the Straits of Malacca, &c. would afford materials to construct a very accurate chart.

I think it would be very useful in hydrography, besides the chart describing the coasts, soundings, &c. to have one, on the same scale, of lines and points only. For, as it is almost impossible in a chart to have every place or sounding fixed with equal precision, it is certainly expedient to show upon what authority every part is determined.

1. I would have the data for determining the several stations marked by strong black lines.

2. The bearings from these stations for determining the several points, or objects, in faint black lines.

3. The points, or objects, whose situations are determined with the utmost precision, I would mark thus *.

This kind of chart would enable any persons to lay down their stations and soundings, to be transferred into the other chart, that it might be completed and corrected.

The observator ought to be very minute in his soundings, taking, if he can, the angles by quadrant of three (*asterisked*) * objects, separated from each other at least 20°. If one bearing be taken by compass, it will facilitate the projection; but, if the soundings be of consequence it will be most eligible to project them from the angles taken by quadrant only: the same to be observed in determining or correcting the situation of any remarkable point unasterisked. If three proper * objects cannot be had for determining any station, more than three unasterisked objects ought to be taken; and, in general, it is to be observed, the greater number of angles are taken, the greater will be the probability of exactness.

It must be obvious the things requisite to complete such a chart would be,

1. Observations to corroborate or correct unasterisked points, that they might be * (*asterisked.*)
2. Observations to complete the soundings.
3. Observations to determine the situation of places not before laid down.

All require great care, but none so much as the observations to * (asterisk) an object, as an error here might induce many, by using this object for determining other stations.

## II.—DESCRIPTION OF OBSERVATIONS BY WHICH THE LONGITUDES OF PLACES ON THE COASTS OF AUSTRALIA, &c. HAVE BEEN SETTLED; BY CAPTAIN MATTHEW FLINDERS, R. N.

[Reprinted as given in the Notes to Purdy's Tables, prefixed to the '*Oriental Navigator*,' 1816.]

CAPTAIN FLINDERS has given, in the INTRODUCTION to this valuable Work, a particular account of all prior discoveries on the different coasts of Australia; commencing with the earlier navigators, and concluding with the singular expeditions of Mr. George Bass, surgeon of his Majesty's ship Reliance, and his own previous surveys and discoveries, in 1795, 6, 7, 8, 9. The skill and perseverance manifested by the author, the plan, arrangement, and execution, of the work, constitute a noble example to all future explorators. The part of the book directly applicable to our purpose is comprised in an account of the observations by which the longitudes of places have been settled: and this is given nearly as follows:—

The lunar distances and other observations, taken in the Investigator's voyage, having been ordered, by the Commissioners of the Board of Longitude, to be re-calculated by a professional astronomer, with every degree of correctness which science has hitherto been able to point out as necessary; this delicate, but laborious, task was assigned to Mr. John Crosley, formerly assistant at the Royal Observatory at Greenwich; a gentleman who formed part of the expedition as far as the Cape of Good Hope, but whose ill health had then made it necessary to relinquish the voyage, and return to England.

For the satisfaction of the geographer, and more especially for that of the seaman, the results of the lunar distances, observed upon each coast, are added, in the form of an Appendix, to the volume wherein that coast is described. It is by these results that the time-keepers have been regulated; and, consequently, the longitudes deduced therefrom.

To appreciate the degree of confidence to which these results may be entitled, it is requisite to know the circumstances under which the observations were taken; the methods used in the calculations; and the corrections which have been applied beyond what is usual in the common practice at sea: of these the following is a general statement:—

1st. The instruments used in taking the distances were, a nine-inch sextant, by Ramsden, and three sextants, of eight inches radius, by Troughton; the latter being made, in 1801, expressly for the voyage. On board the ship, the sextant was necessarily held in the hand, and the distances were sometimes taken on shore; but, in most of the latter cases, it was fixed on a stand, admitting of the sextant being turned easily in any direction. The telescopes were of the largest magnifying powers which the motion of the ship and state of the atmosphere would admit. Each longitude is the result of a set of observations, most generally consisting of six independent sights, taken either by the Captain or by Lieutenant S. W. Flinders.

2d. Preparatory to the reduction of the apparent to the true distance, the four following corrections have been applied:—

From the *sun's semi-diameter*, as given in the Nautical Almanack, 3 seconds have been subtracted. In the almanacks of the years comprehending our observations, the semi-diameter was stated from *Mayer's* Tables, which gave it 3″ too great, owing to the imperfection of the telescope with which Mayer observed.

The semi-diameters of the sun and moon being less in the vertical than in the horizontal direction, from differences in the refraction, they have been reduced, proportionally, to these differences, and to the angles at the points of contact in measuring the distance. This correction is called *contraction of the semi-diameter*.

Before using the moon's horizontal parallax in the Nautical Almanack, where it is calculated for the equator, it has been corrected by a number of seconds depending upon the latitude of the place, and upon the assumed position that the earth is a regular spheroid, whose polar axis is to the equatorial axis as 320 to 321. This and the preceding correction are unnecessary, unless where great exactness may be required.

The *refraction* of the heavenly bodies, given in the Tables, being calculated for a mean height of 50° of Fahrenheit's thermometer, and 29,6 inches of the barometer, it has been corrected for the difference between these means and what was the state of the atmosphere at the time of observation.

3d. In reducing the apparent to the true distance, Mr. Crosley has used the method of Joseph Mendoza de Rios, Esq., F.R.S., given with his Nautical Tables, second edition, 1809; and the tables, from which the corrections were taken, and the computations made, are those of the same valuable work.

4th. The reduced distance, found as above, has been corrected to the spheroidal figure of the earth, according to the theory explained in the *Philosophical Transactions* of the Royal Society, of 1797; and, for doing which, rules are given by Mr. Mendoza, with his *Nautical*

*Tables*, of 1801. This calculation is tedious; and the correction, more especially in low latitudes, too small to be necessary in common cases.

5th. In the Nautical Almanack, the distances are given to every three hours; but the irregularities of the moon's motion being such as to cause some inequality in the different parts of this interval, the distance at the hour preceding, and at the hour following, the time of observation, was found, by interpolation, from the two nearest given on each side: and, having the distances at Greenwich for each hour, the observed distance can never fall more than half an hour from one of them; and the moon's inequalities do not then produce any sensible error in the corresponding time, as obtained from common proportion. The correction arising from this process is seldom so important as to be required in sea-observations.

6th. The longitude deduced from a comparison of the true distance at observation with the hourly distances at Greenwich, is contained in Captain Flinders' Tables, under the head of *Longitude from Nautical Almanack.* But, as it frequently happened that the observation was not taken exactly in the place which it is intended to fix, this longitude is reduced to that place by the application of the difference shown by the time-keepers to have existed between the two situations. In ascertaining this difference, the rates of going allowed to the time-keepers are generally those found at the place which is to be fixed; whether applied to observations taken before arriving at, or after quitting, that place. This, however, could be done only at those stations where rates had been observed; at the intermediate points, where the result of lunar distances is given principally as an object of comparison with the time-keepers, the rates allowed in the reduction are those found at the station previously quitted; but then the difference of longitude is corrected by the quantity consequent on the following supposition:—that the time-keepers altered their rates from those at the previous to those at the following station, *in a ratio augmenting in arithmetic progression.* The difference of longitude, thus corrected when necessary, is given under the head of *Reduction by Time-keepers:* and the longitudes reduced by it to the place intended to be fixed, are taken to be of equal authority with those resulting from observations made in the place itself.

7th. But these longitudes, whether reduced to, or observed in, the place to be fixed, still require a correction, which is of more importance than any of those before mentioned. The theories of the solar and lunar motions not having reached such a degree of perfection as to accord perfectly with actual observations at Greenwich, the distances calculated from those theories, and given in the Almanack, become subject to some error; and, consequently, so do the longitudes deduced from them. The quantities of error in the computed places of the sun and moon have been ascertained, at Greenwich, as often as those luminaries could be observed; and Mr. Pond, the astronomer-royal, having permitted access for this purpose to the Table of Errors, kept in the Observatory, Mr. Crosley has calculated the corresponding effects on the longitude, and proportioned them to the time when our observations were taken. The combined effect of the two errors forms a correction to the longitudes obtained from the sun and moon; but, when the moon was observed with a star, then the moon's error alone gave the correction. But it has sometimes happened that there were many days' interval between the observations of the moon at Greenwich; and that the errors preceding and following are so extremely irregular, that no accuracy could be expected in reducing them by proportion: in these unfortunate cases, that part of the error belonging to the moon has been taken absolute, such as it was found on the day nearest to the time of observation; but the sun's error is always from proportion. These corrections, with the interval in the Greenwich observations of the moon, are given under their proper heads.

8th. The longitudes thus computed, reduced to the intended point, and corrected, are placed in Captain Flinders' tables under each other; and the mean of the whole is taken to be the true longitude of that point, unless in certain cases where it is otherwise expressed. The mean is also given of the longitude *uncorrected* for the errors of the sun and moon's places, that the reader may have an opportunity of comparing them; and some sea-officers, who boast of their having never been out more than 5, or at most 10, minutes, may deduce, from the column of corrections in the different tables, that their lunar observations could not be entitled to so much confidence as they wish to suppose; since, allowing every degree of perfection to themselves and their instruments, they would probably be 12, and might be more than 30, minutes wrong.

In the Nautical Almanacks for 1814 and 1815, the distances are computed from the new tables of Burg for the moon, and of Delambre for the sun; and it is to be hoped that the necessity of correcting for errors in the distances at Greenwich will have ceased, or be, at least, greatly diminished. Should the computed places of the sun and moon be happily found to agree with actual observation, and supposing that our results may be taken as the average of what practised observers, with good instruments, will usually obtain when circumstances are favourable; then lunar observations taken in 1814 and afterwards may be entitled to confidence within the following limits:

From one set of distances, consisting of six independent sights, the error in longitude may be 30 minutes on either side, but will probably not exceed 12′.

From six sets on one side of the moon, each set consisting as above, the error may be 20 minutes; but not, probably, more than 8.

Twelve sets of distances, of which six on each side of the moon are not likely to err more than 10 minutes from the truth; and may be expected to come within 5′.

The error in sixty sets, taken during three or four lunations, and one half on each side of the moon, will not, I think, (says Captain Flinders,) be wrong more than 5 minutes; and will, most probably, give the longitude exact to 1′ or 2′. This degree of accuracy is far beyond what the hopes of the first proposers of the lunar method ever extended, and even beyond what astronomers accustomed only to fixed observatories will be disposed to credit at this time; but, in thinking it *probable* that sixty sets of lunar distances will come within 1′ or 2′ of the truth, when compared with correct tables, I conceive myself borne out by the following facts.

In Port Lincoln, I observed an eclipse of the sun, with a refracting telescope of forty-six inches focus, and a power of about 200. It was re-calculated by Mr. Crosley from Delambre's and Burckhardt's Tables; the one made 4, and the other 10, years afterwards. The longitude deduced from the beginning differed only 1′ 31″,5 from that at the end, and the mean of both only 1′ 17″ from *thirty* sets of lunar distances corrected from the errors of the Tables.

The Spanish admiral Espinosa observed emersions of the first and second satellites of Jupiter, in 1793, at Port Jackson, and also an eclipse of the sun, which he re-calculated by the tables of Burg. He deduces thence the longitude of Sydney Cove to be 151° 12′ 45″; and, from *forty-four* sets of lunar distances by Lieutenant Flinders, it would be 151° 11′ 49″ E.

At Port Louis, in the Isle Mauritius, the Abbe de la Caille observed an eclipse of the sun, the transit of Mercury over the sun's disk, and several occultations of Jupiter's satellites; M. D'Aprés also observed several occultations; and this place should, therefore, be well determined. Its longitude in the Requisite Tables is 57° 29′ 15″ east; and, from *twenty-seven* sets of distances, taken whilst a prisoner there, I made it, when corrected from the errors of the tables, 57° 29′ 57″ East.

In appreciating the degrees of accuracy to which a small or larger number of lunar distances may be expected to give the longitude, I suppose the observer to be moderately well practised; his sextant, or circle, and timekeeper, to be good; and his calculations to be carefully made; and it is also supposed that the distances in the Nautical Almanack are perfectly correct. As, however, there may still be some errors, notwithstanding the science and the labour employed to obviate them, it cannot be too much recommended to sea-officers to preserve all the data of their observations; more especially of such as may be used in fixing the longitudes of places but little, or imperfectly, known. The observations may then be re-calculated, if requisite; the corrections found to be necessary may be applied; and the observer may have the satisfaction of forwarding the progress of geography and navigation, after having contributed to the safety of the ship, and benefit of the particular service in which he may happen to be engaged.

THE END.

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39. Memoir, Descriptive and Explanatory, to accompany the Chart of the Northern Ocean, &c. and comprising Instructions, General and Particular, for the Navigation of all those Seas. This Work contains, 1. Tables of the determined Positions of all the principal Points, &c., with the Authorities; illustrated by Notes: including Remarks on the Variation of the Compass: 2. The General Phænomena of the Northern Ocean; the Atmosphere, Winds, Ices, Colour of the Sea, and best Places for Fishing, Currents, &c.: 3 Particular Descriptions of the Coasts and Islands; with Directions for Sailing, &c. This Section includes the Eastern Coast of Great Britain; the Islands of Orkney; Islands of Shetland; the Fishing-Banks of Scotland, particularly those about Orkney and Shetland; the Voyage from England to the White Sea, Archangel, and Onega; the Voyage from England to Spitzbergen, including that of the Hon. Captain Phipps, 1773, and of Captain Buchan, 1818; Island of Jan Mayen; the Faröerne, or Faröe Islands; Iceland; and the Voyage of Captain Ross, with Lieut. Parry, around Baffin's Bay, &c. Also, Directions for Hudson's Straits and Hudson's Bay: 4. A Description of Rocks and Shoals in the Northern Ocean; with the Authorities on which they have been inserted in the Chart. By John Purdy, 8vo. boards, 5*s*.

40. A General Chart of the Bay of Biscay, chiefly from Surveys made, respectively, by Order of the Governments of France and Spain, with Fourteen particular Charts of its Harbours, &c. executed in the same manner as those of the Channel, No. 17, by Mr. J. Outhett; and dedicated to the Right Hon. the Lords Commissioners of the Admiralty: The particular Charts are—1. The Bay of Brest, &c. 2. Port L'Orient: 3. Mouth of the Loire, or River of Nantes: 4. Basque Roads, with the Gironde or River of Bourdeaux, &c.: 5. Port Passage: 6. Bay of St. Sebastian: 7. Bay of Bilboa: 8. Harbour of Santona: 9. Harbour of Santander: 10. Port of Rivadeo: 11. Port Vivero: 12. Inlet of Vares: 13. Harbour of Cedeira: 14. Harbour of Corunna. *With a new Book of Directions for the Bay, Coast of Portugal*, &c., 10*s*. 6*d*.

41. The Coasts of Spain, Portugal, and Barbary, from St. Sebastian to Cape Blanco, North; constructed from the Surveys, &c. of Tofino and other distinguished modern Navigators, by John Purdy: and comprising also, on a large Scale, particular Charts of the Inlets of Ferrol, Corunna, and Betanzos, the Inlet of Vigo, the Harbours of Lisbon, Porto, Setubal, and Cadiz, the Strait of Gibraltar, the Bay of Gibraltar, &c.; with numerous Views of the principal Headlands. *A new Edition, materially improved*, 8*s*.

42. The Coasts of Greece and the Archipelago, with the Ionian Islands, and the Sea of Marmora, to Constantinople: compiled and drawn from the Surveys and Observations of D. A. Galiano, and those of Messrs. Chabert and Borda; compared with the Surveys, &c. of Captain Edmonds, Mr. Thomas Curtis, Mr. J. Wilson, and other Officers, of the British Navy. With particular Charts of the Harbours of Corfu, Cephalonia, and Zante, Paxo and Antipaxo, the Passage of the Dardanelles, the Channels of Paros, the Harbours of Macri, Scopea, Marmorice, and Karagatch, the Strait of Scio, &c., 10*s*. 6*d*.

43. The Azores, or Western Islands, Madeiras, and Canary Islands, with Part of the Coasts of Portugal and Africa, from the Borlings to Cape Bojador, constructed by John Purdy. With Plans of Harbours, Views, &c., 8*s*.

44. The Cape Verde Islands, regulated by numerous scientific Determinations; with Views and Directions on the Plate. Second Edition, elegantly engraved, 3*s*. 6*d*.

45. Chart of the Northern Coast of Brasil, from Seara to the Island of St. Joaö, or St. John, including the Port of Maranham, &c.; with an original Survey of the Harbour of Maranham; and a Book of Directions. By Lieut. William Hewett, R. N., 7*s*. 6*d*.

46. The Eastern Coast of Brasil, from Seara to Santos; including the Island of Fernando Noronha, with the Harbours of Pernambuco, Bahia, or St. Salvador, Rio de Janeiro, &c. Adjusted from the Observations and Surveys of Lieut. William Hewett. With Views, &c., 7*s*. 6*d*.

47. Harbours of Brasil: viz. the Road and Harbour of Pernambuco, as surveyed by Lieut. Hewett; the Harbour of Bahia, or St. Salvador; that of Rio de Janiero, &c. by the same; uniform with the last two preceding Charts, and accompanied with a Book of Directions for the whole of the Eastern Coast and its Harbours, 7*s*. 6*d*.

Plate I. *Figures 1 to 4.*

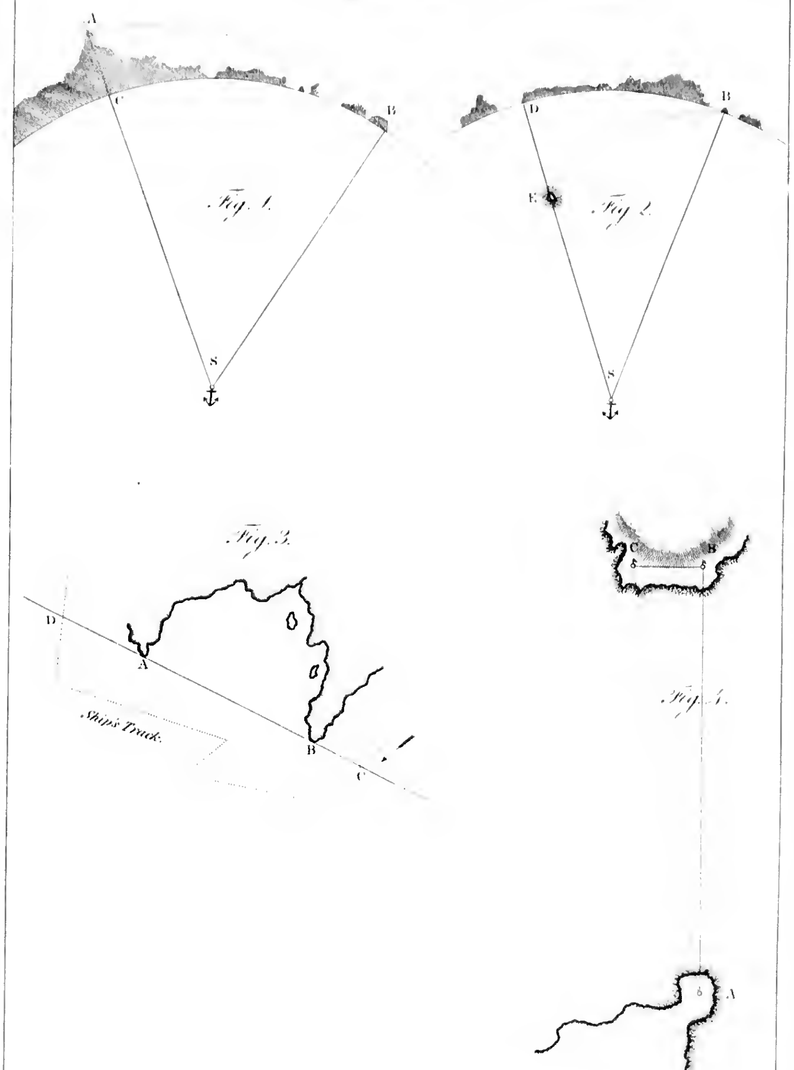


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Plate II. *Figures 5 to 9.*

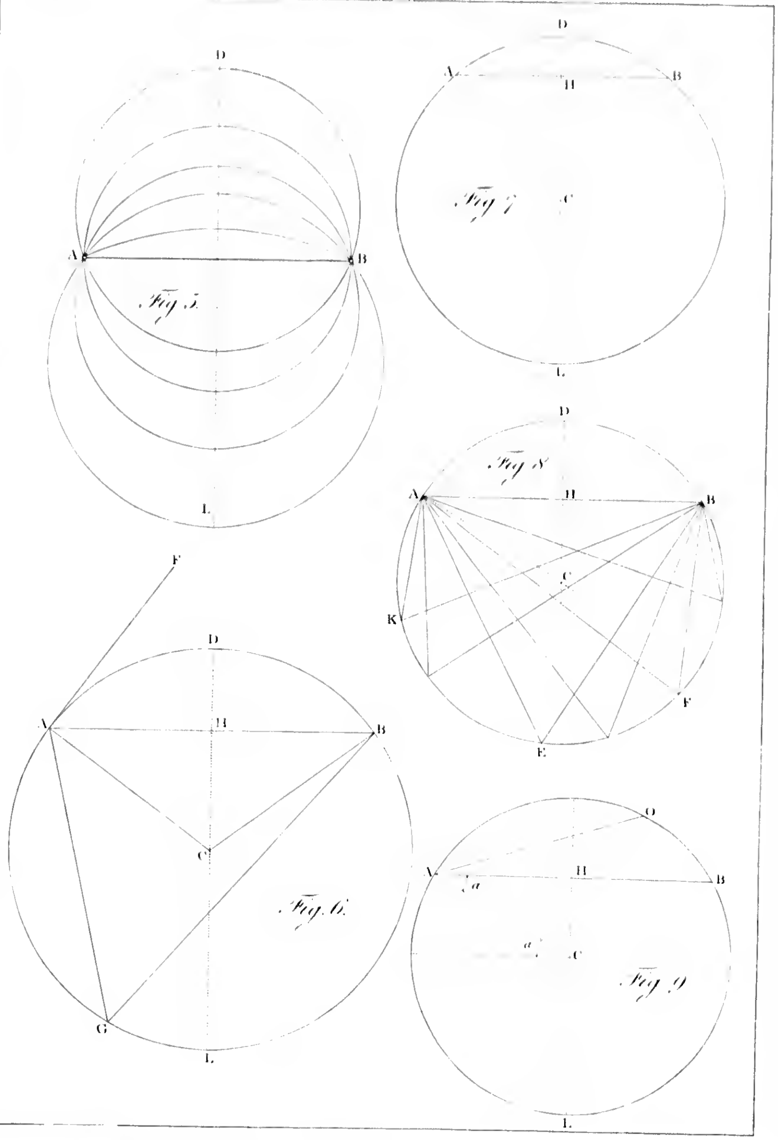

Plate III. _Figures 10 to 12.

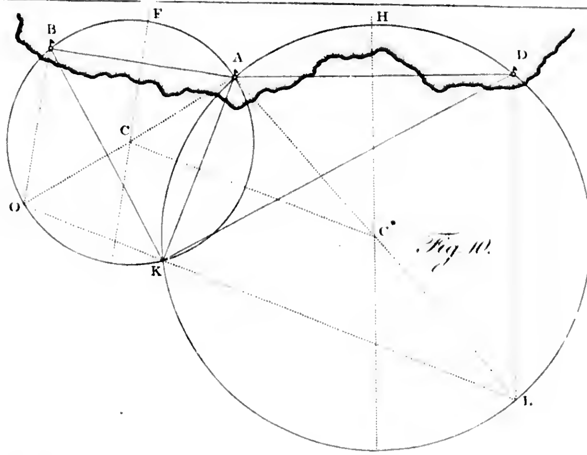

Fig 10.

Fig 12.

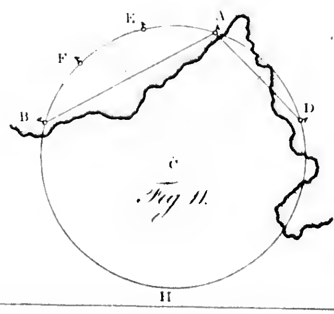

Fig 11.

Plate IV. *Figures 13, 14.*

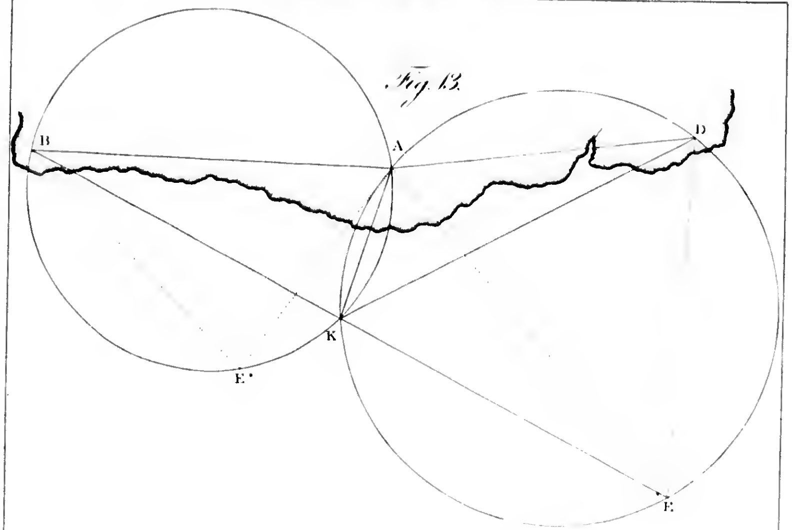


*Fig. 13.*

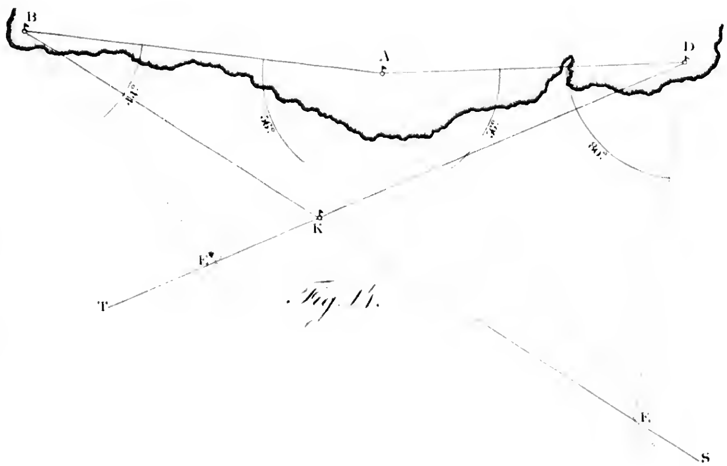


*Fig. 14.*

Plate V. *Figures 15. 16.*

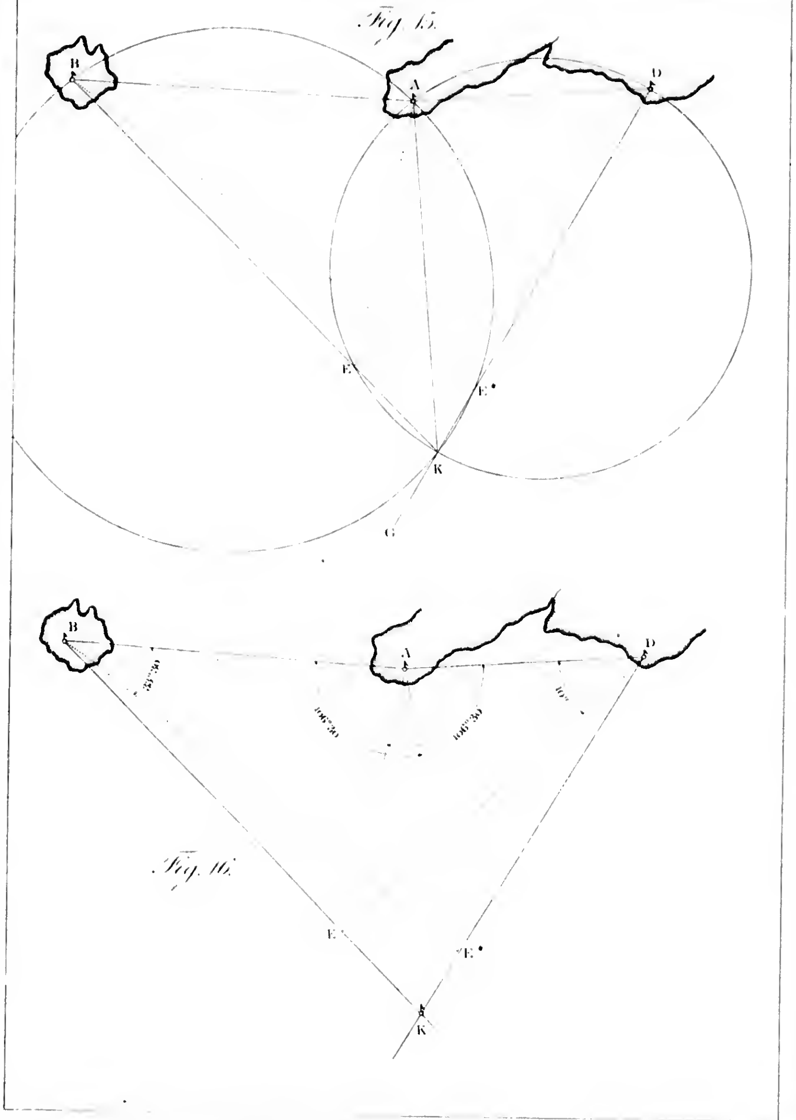


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Plate VI. *Figures 17. 18. 19. 20.*

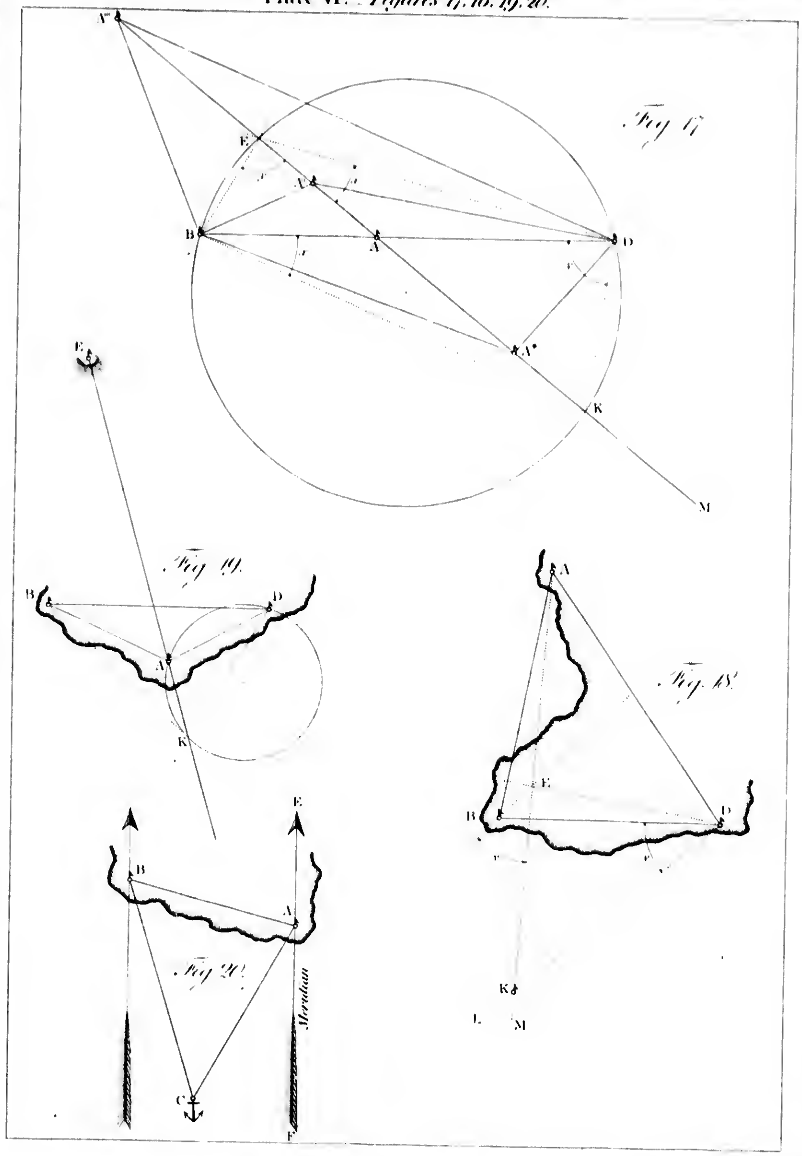


Plate VII. *Figure 21.*

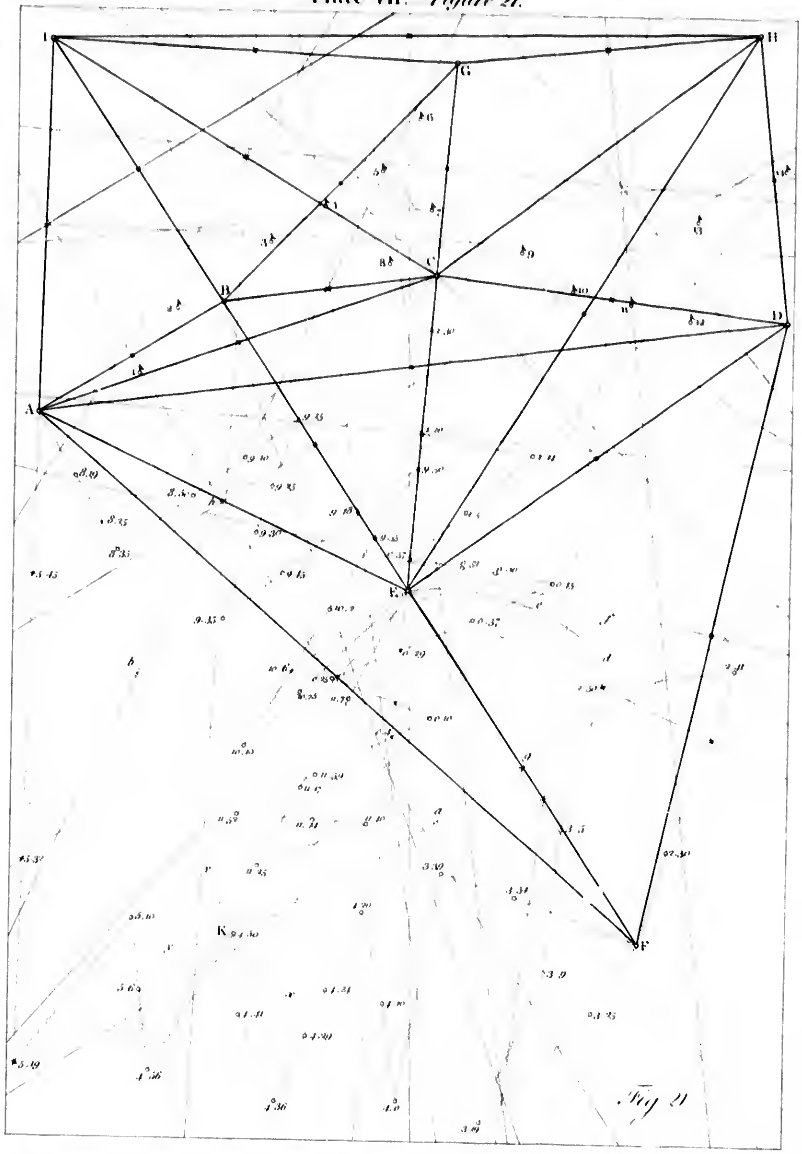


Plate VIII *Figure 22.*

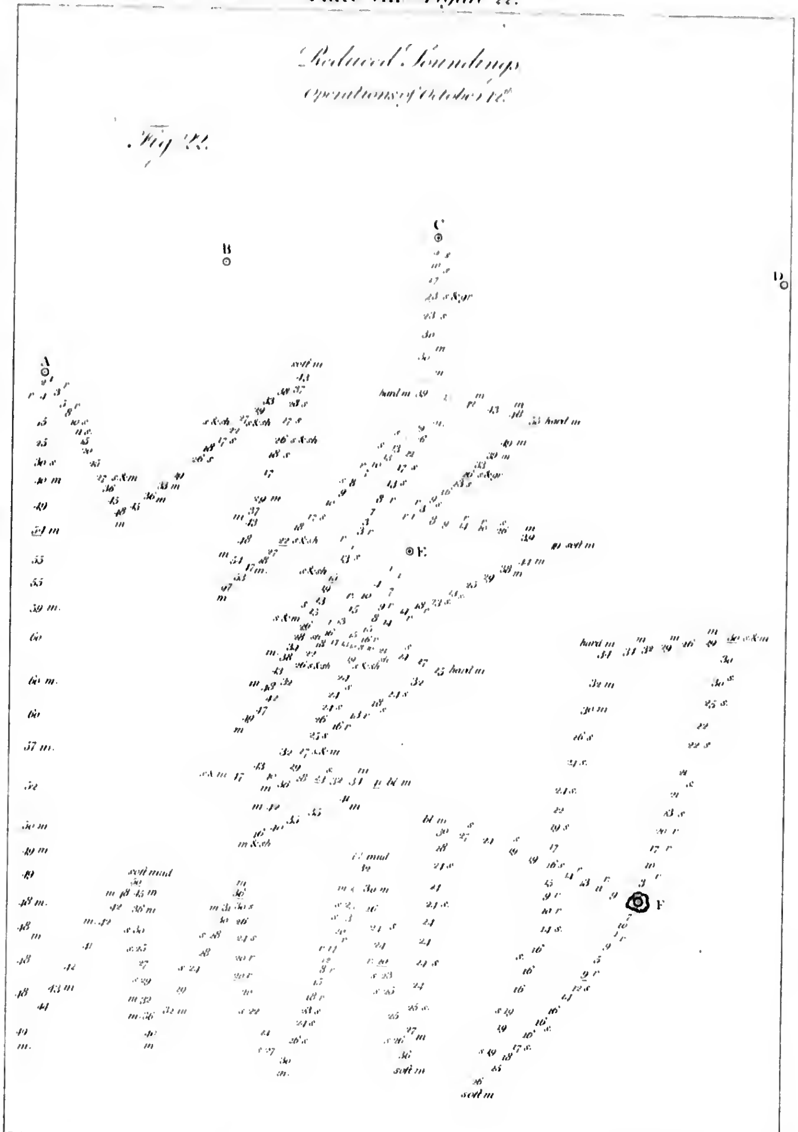


Plate IX. *Figure 23.*

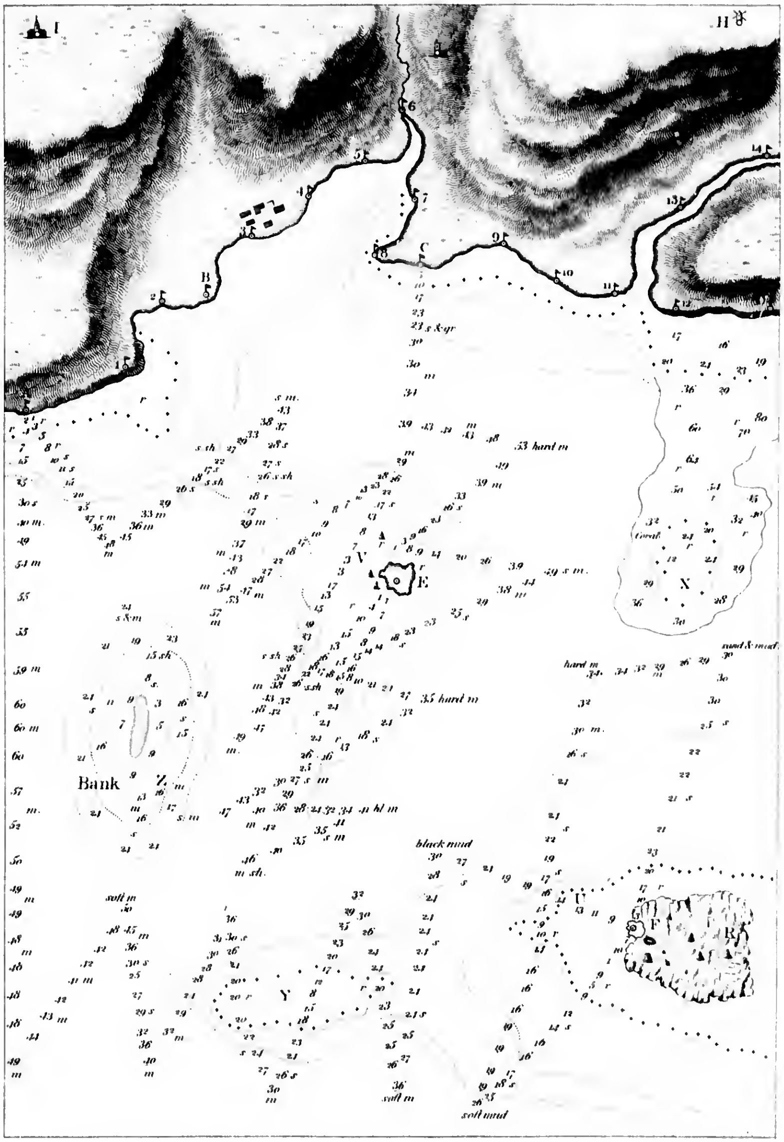
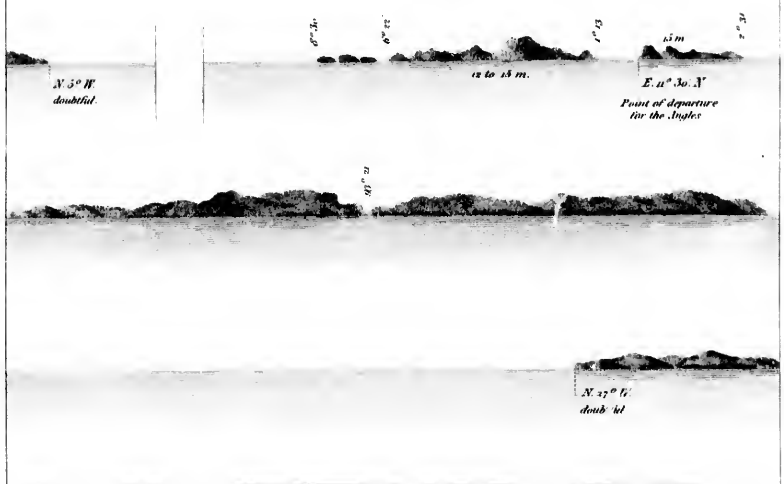


Plate X. *Detail of the Survey.*

*May 19th 1793.*

*First View of the Archipelago of Santa Cruz*

*at 7h. 0m A.M.*




*At 7h. 54m a. m. time of the Astronomic Observations made by M. Rossel*

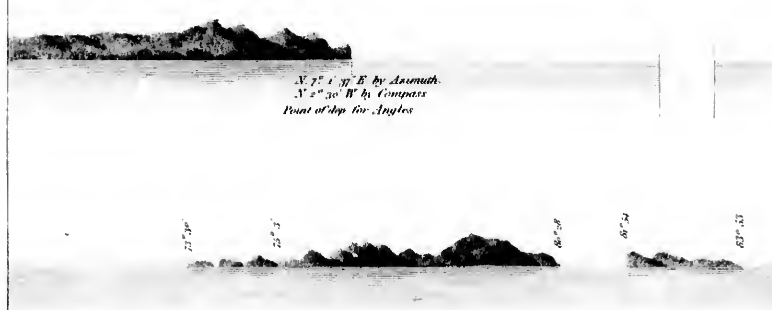



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Plate XI. Detail, &c.

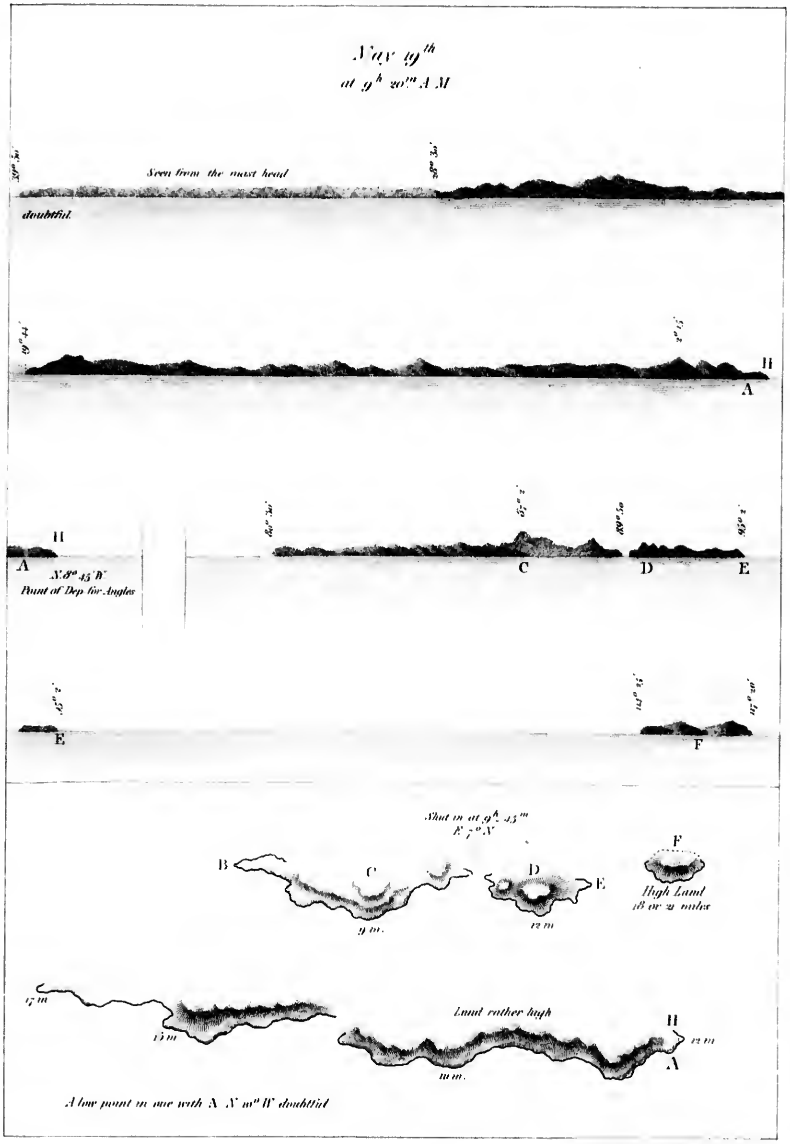

Plate XII. *Detail, &c.*

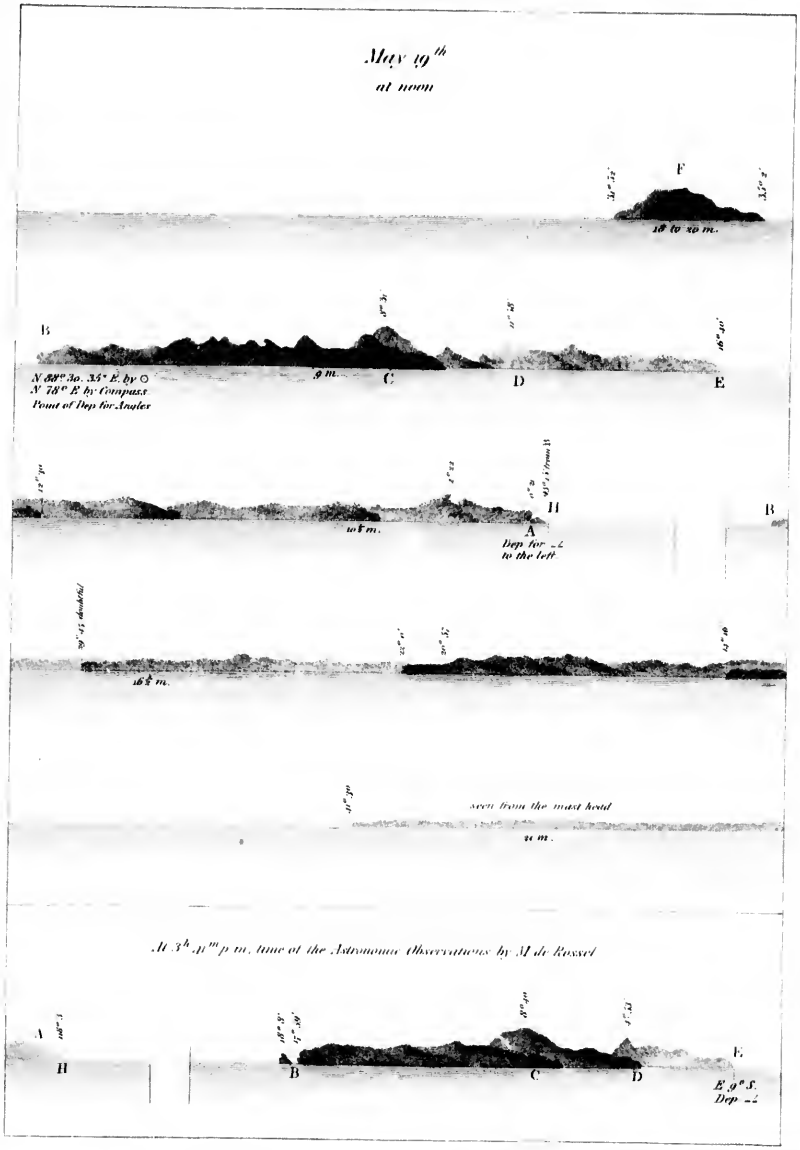

Plate XIII. *Detail, &c*

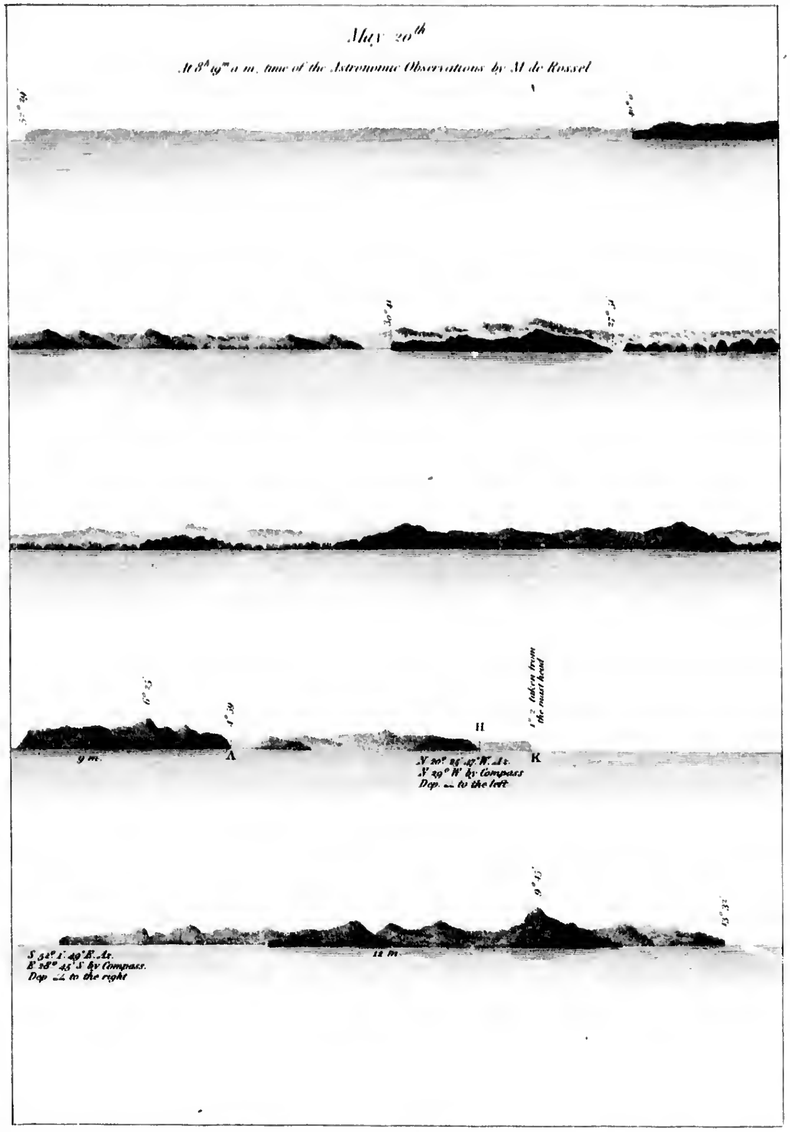


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Plate XIV. Detail &c

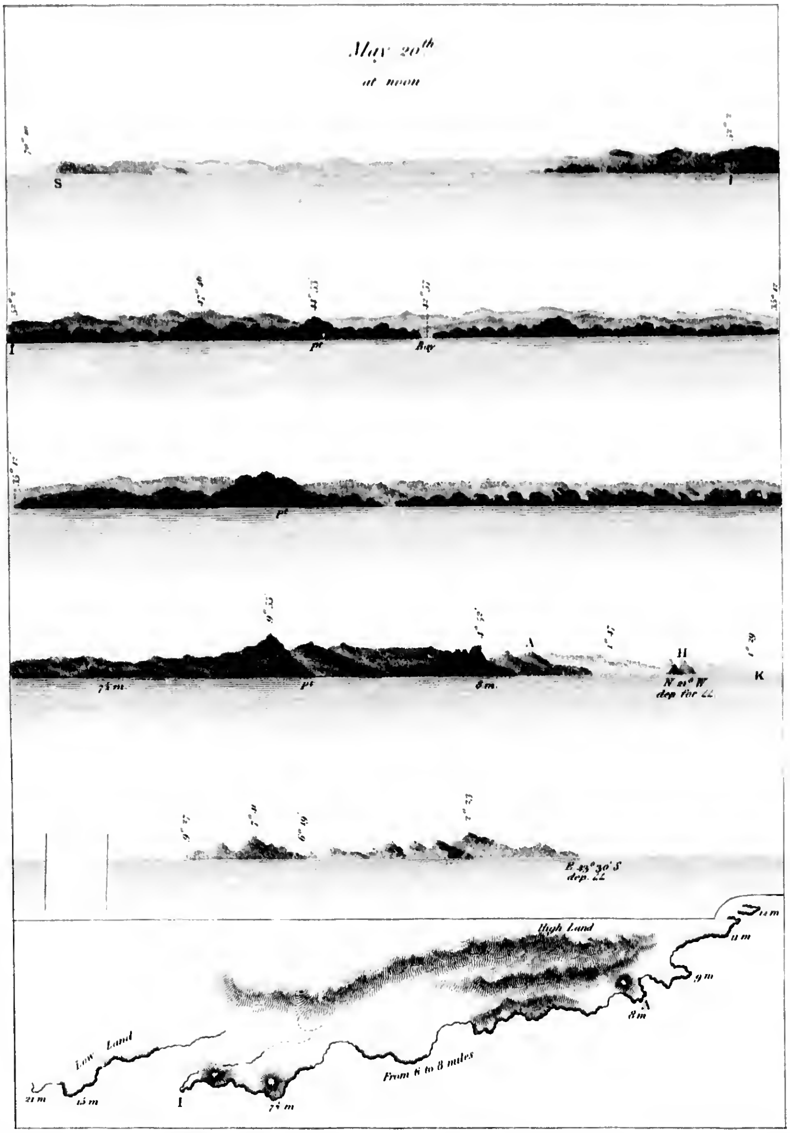


Plate XV. *Detail &c*

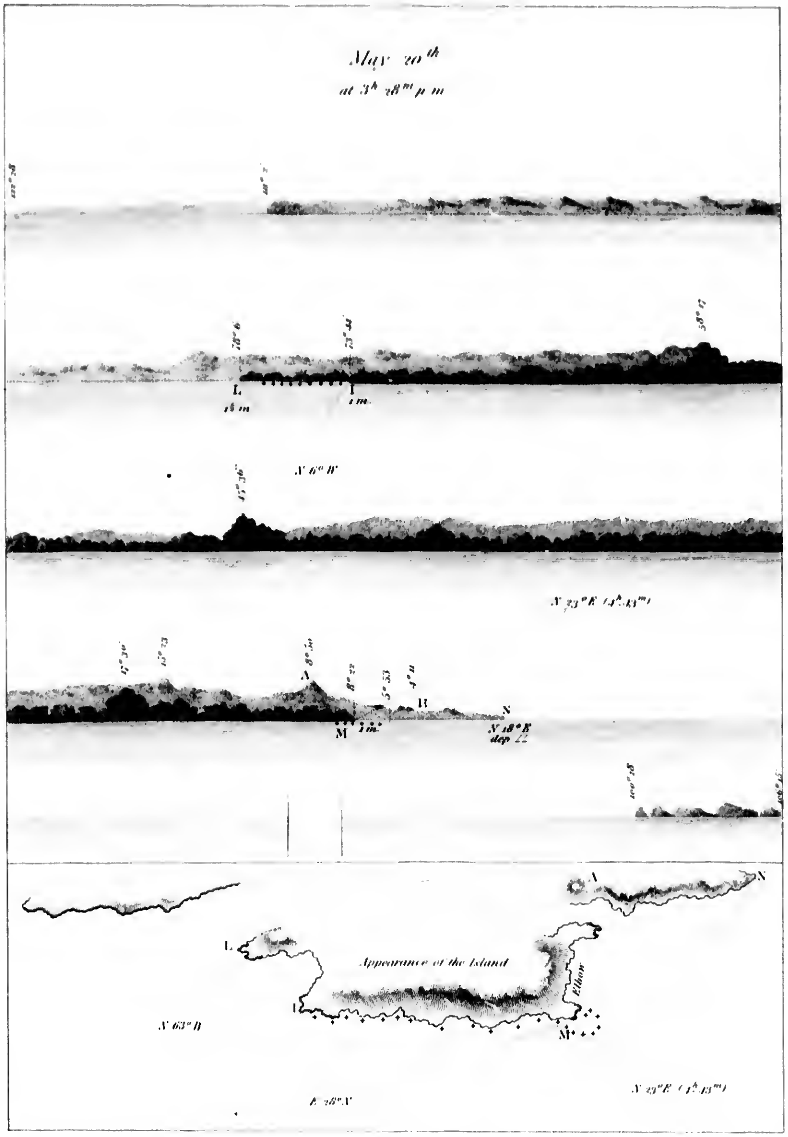
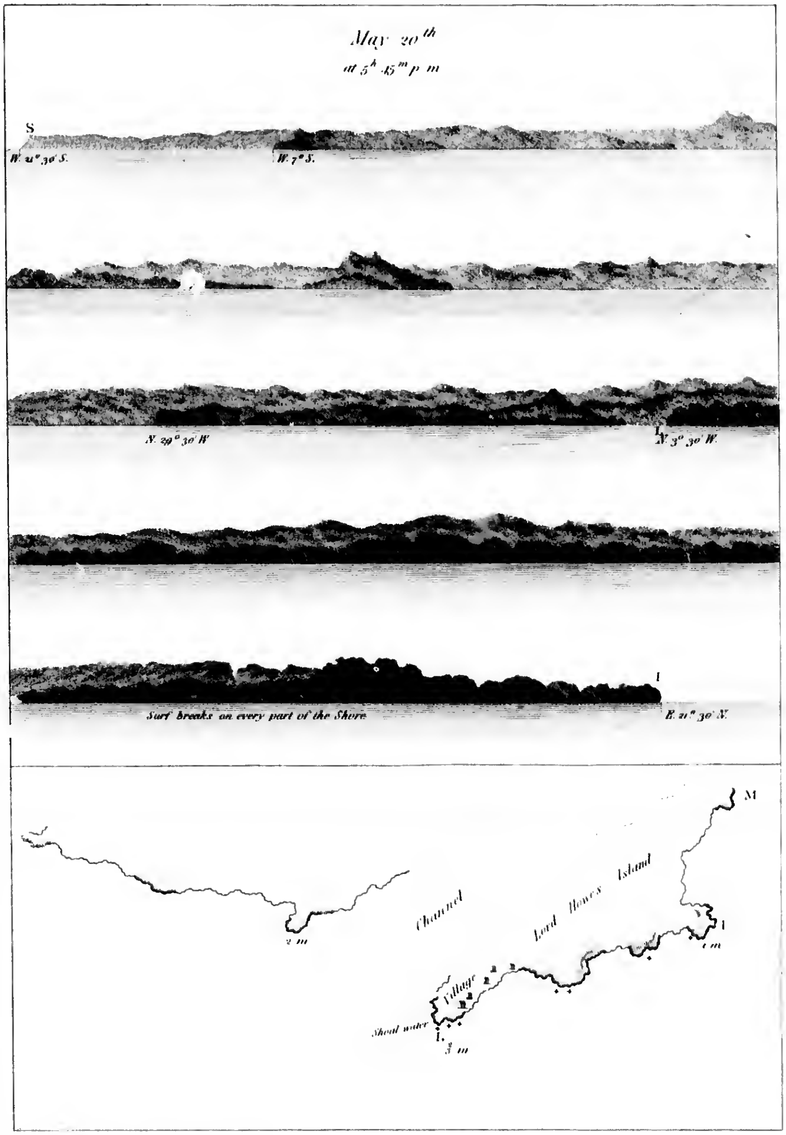


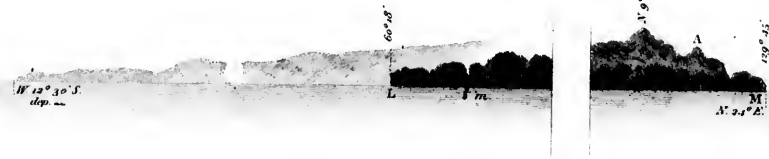
Plate XVI. *Detail, &c*

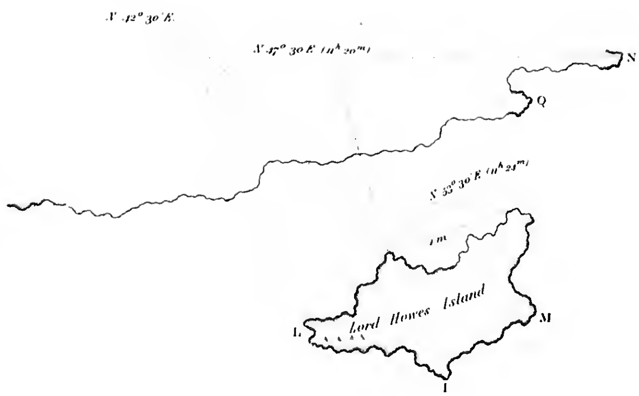


# Plate XVII. *Detail, &c.*

*May 21st*

*At 6h 53m a.m. time of the Astronomic observations by M. de Rossel.*




*At 7h 10m the Mount C, bore S. 57° E.*

*At 11h 10m the Point L, in one with the Mountain A, N. 30° E. the Point L being distant 1 mile, and the Mountain A 7½.*

*At 11h 24m the Mountain A bore N. 33° 30' E.*

*No bottom was found with a line of 40 fathoms, in the Channel which separates the Isles of Santa Cruz and Lord Howe.*

*London Published by R. H. Laurie No. 53, Fleet Street June 20th 1823*

Plate XVIII.— *Detail, &c.*

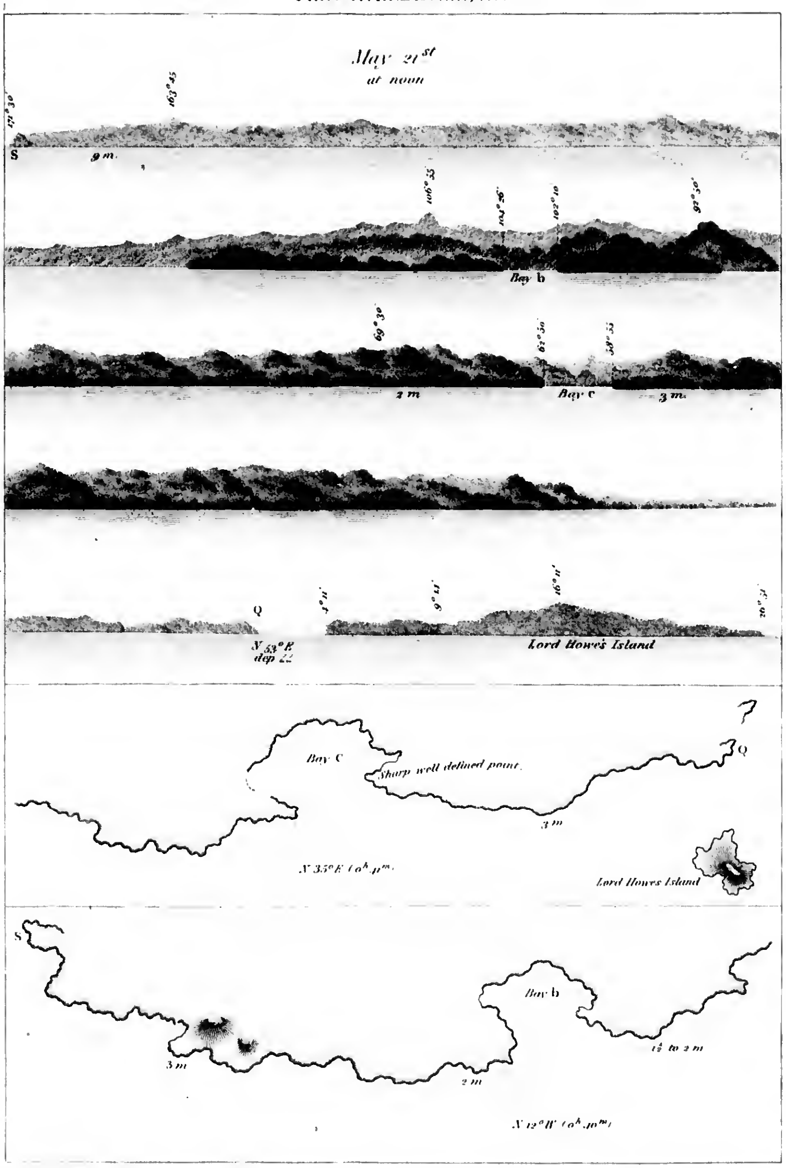
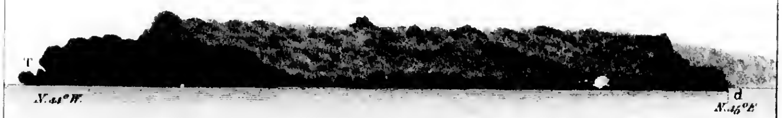


Plate XIX.. *Detail, &c.*

*May 21st*

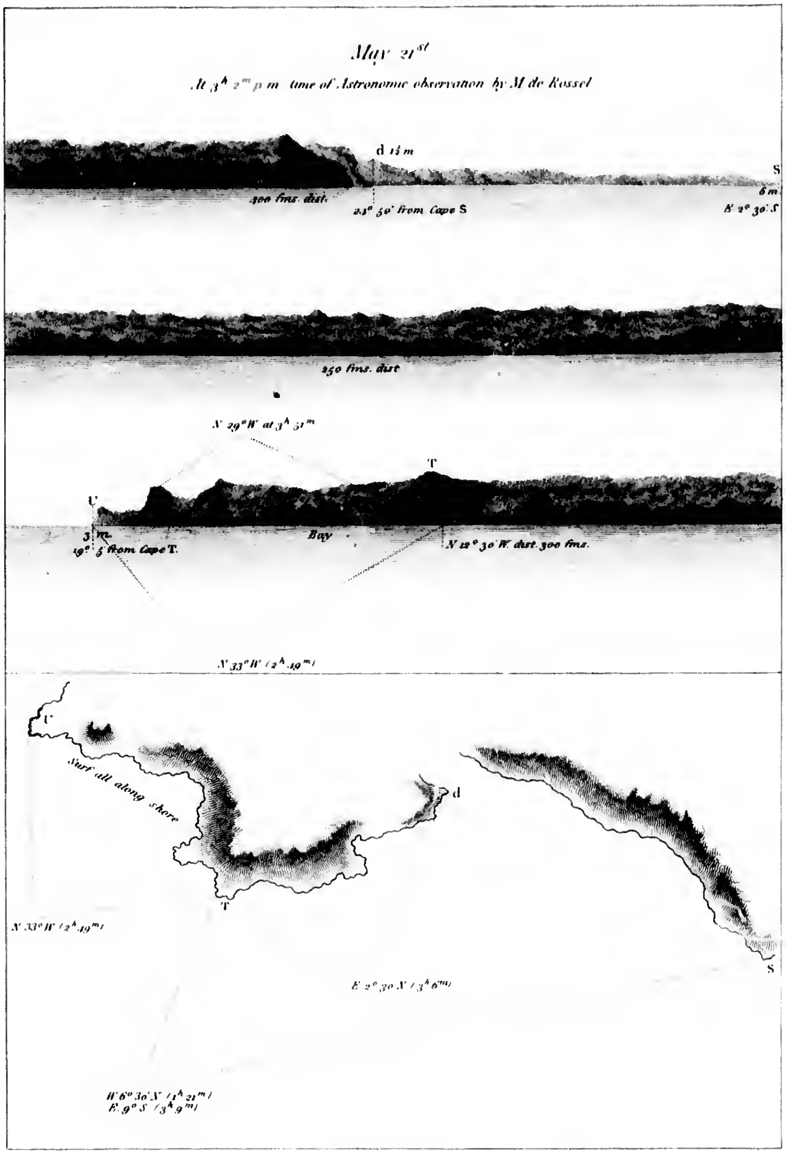
*At 2h 40m p m*



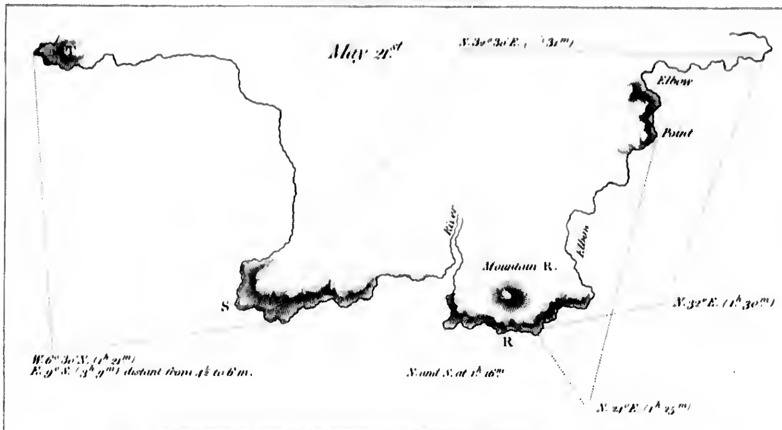


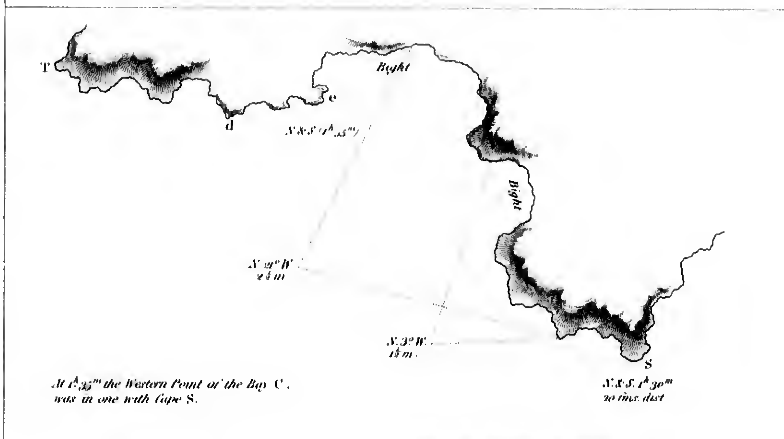

*At 2h 49m the Cape T bore N.33°W in one with a Cape V, which appeard to be 5 miles distant; we were then half a mile from Cape T.*

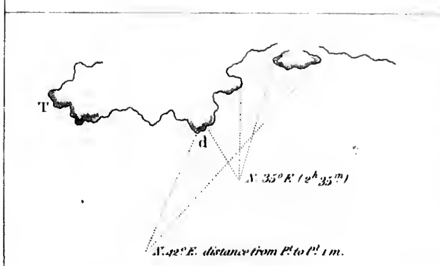
Plate XX. *Detail &c*



## Plate XXI. – *Detail, &c.*




*At $1^h 37^m$ Cape Q, on with Cape S, N. 56° 45' E.*

*At $1^h 38^m$ North Point of Lord Howe's Island on with Cape S, N. 58° E.*

*At $1^h 43^m$ South Point of Lord Howe's Island on with Cape S. E. 20° 3' N.*

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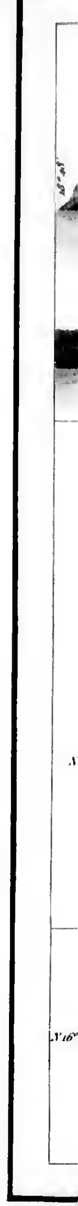


Plate XXII. Detail, &c.

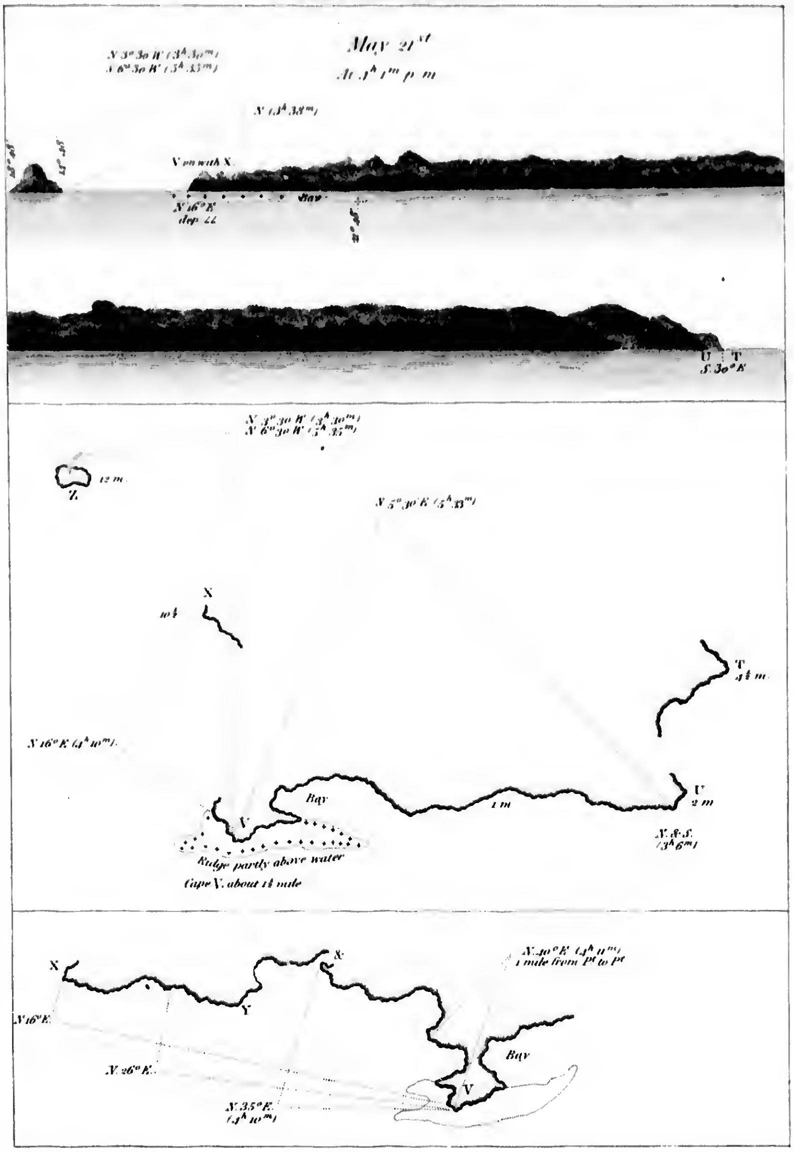


Plate XXIII. _ Detail, &c.

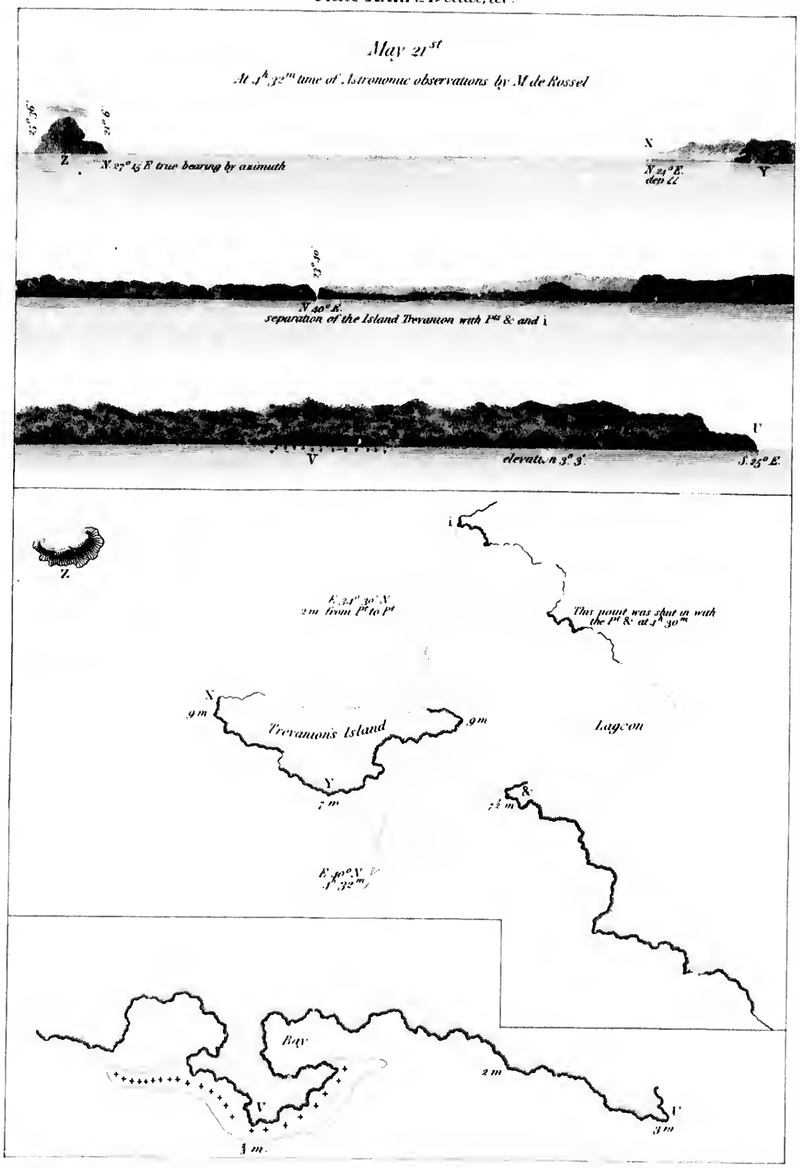


Plate XXIV._*Detail, &c.*

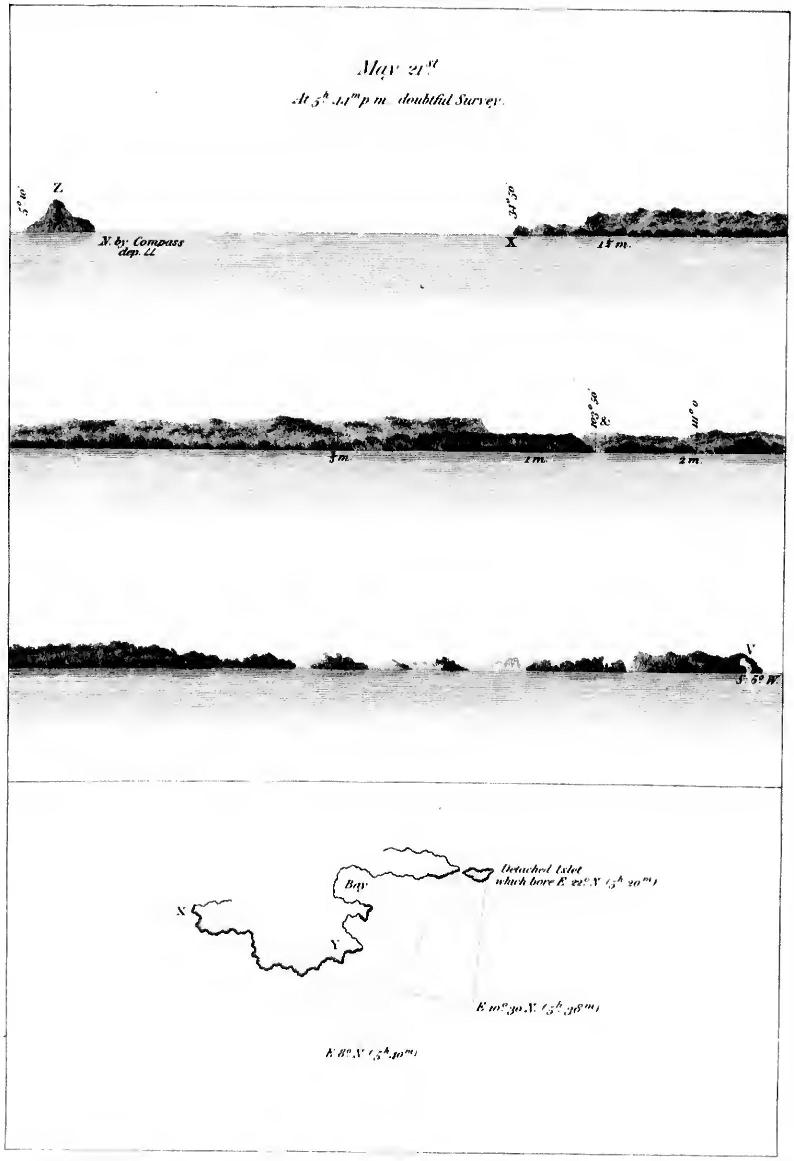
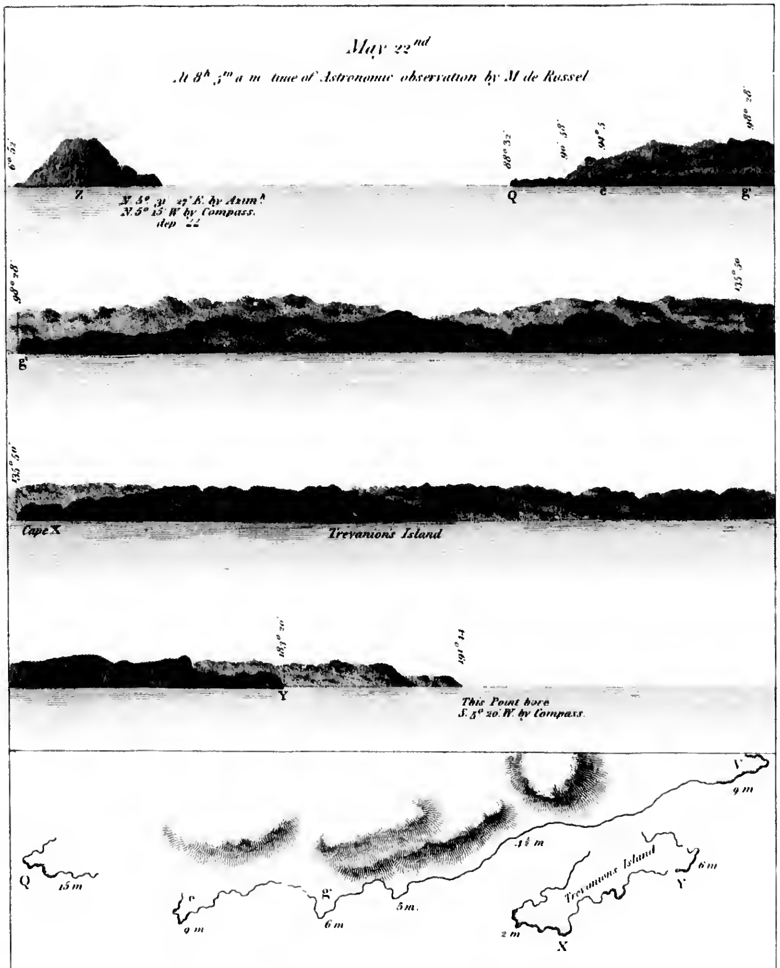


Plate XXV_ *Detail, &c*




*Cape Y, on the western Coast of Trevanions Island, on with the middle of the Island of Volcano (Z.) N 7° 30' W S 7° 30' E.*

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Plate XXVI. *Detail &c*

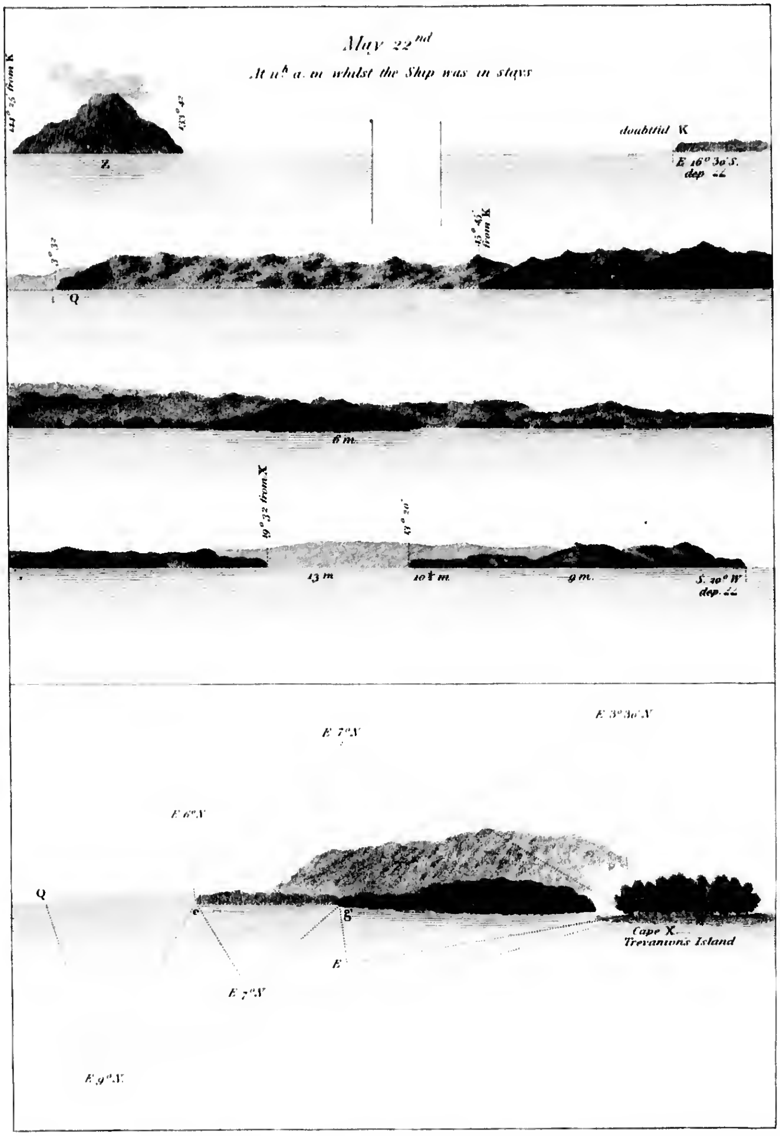
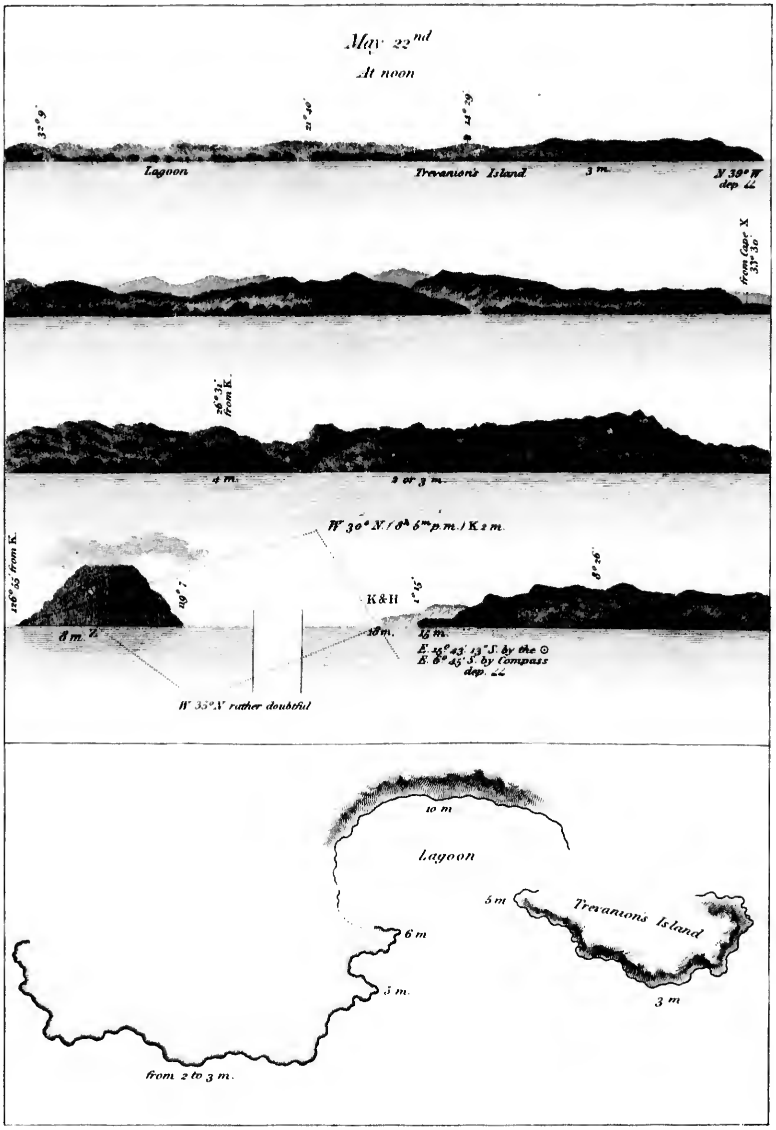


Plate XXVII._ *Detail, &c.*



## Plate XXVIII. *Detail, &c*

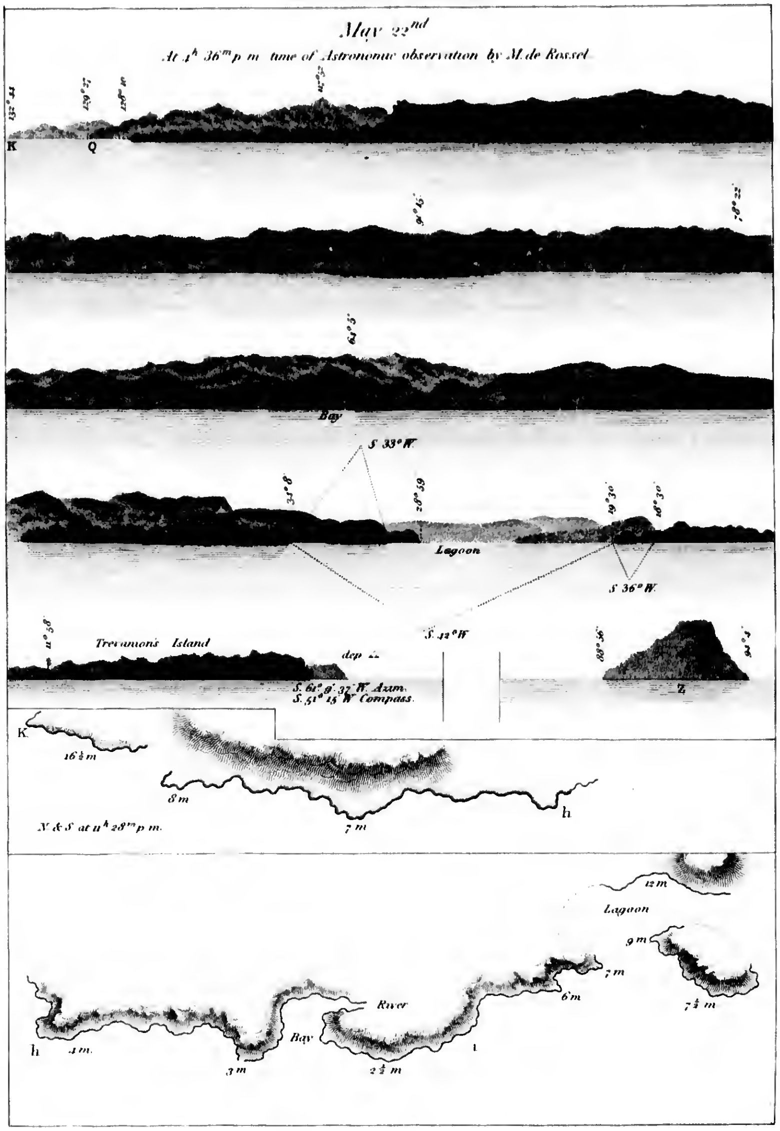


Plate XXIX. *Detail &c.*

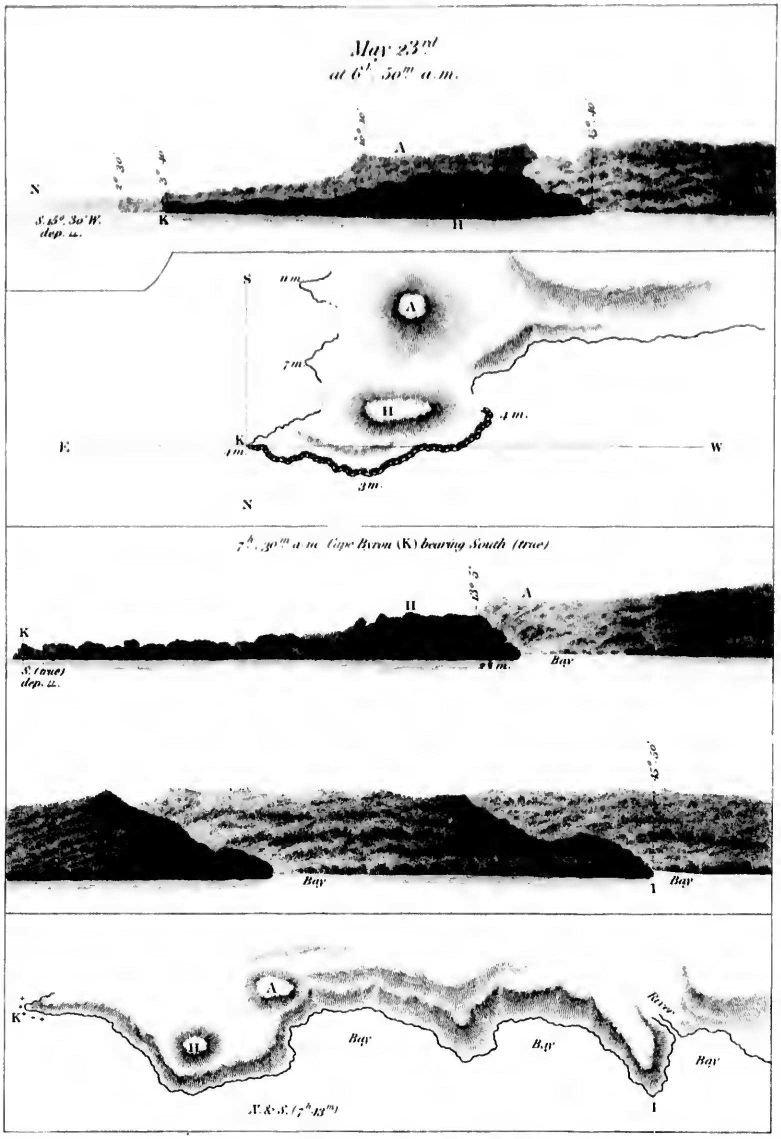



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Plate XXX. *Detail, &c.*

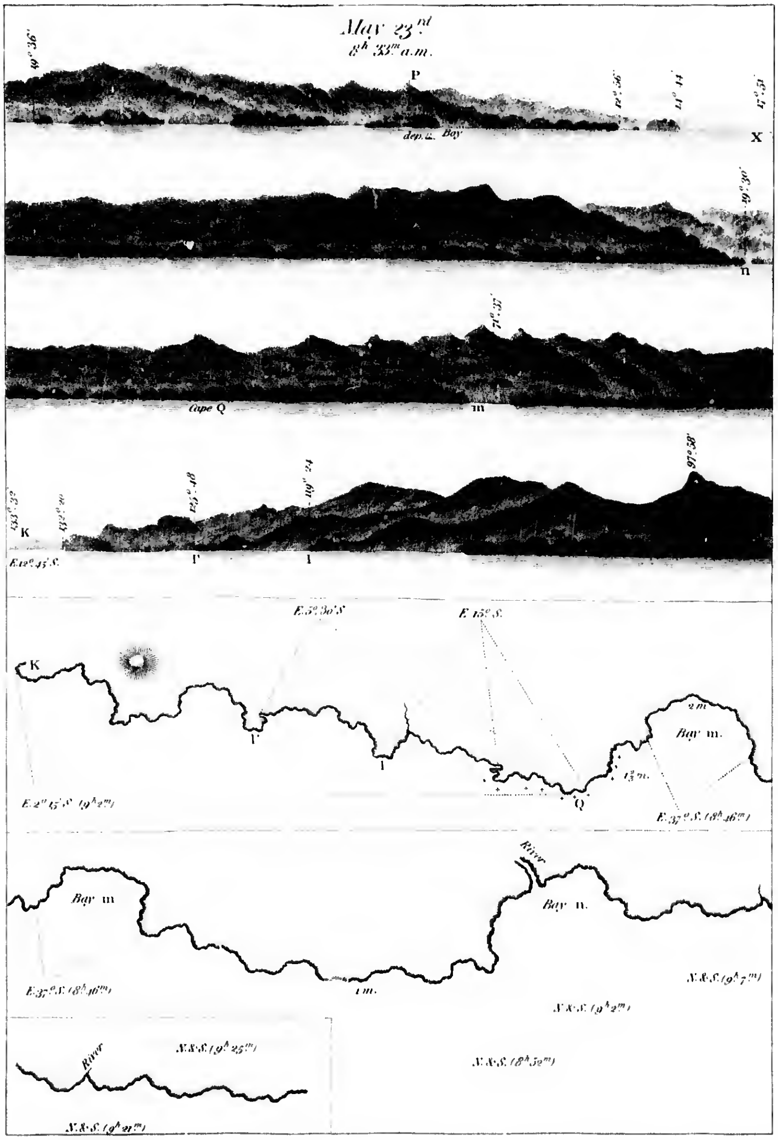


**Plate XXXI.** *Detail. &c.*

## *May 23rd*

*At 9h 5m a.m. time of Astronomic Observation by M. de Rossel.*

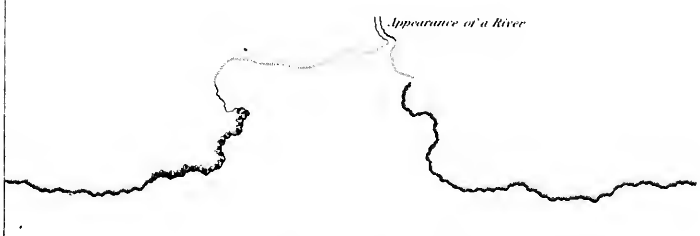
*Cape* Q, *on with Cape Byron,* (K) *E. 2°. 30′ S.*

*Middle of the Isl.d of Volcano* (Z) *N. 48°. 30′ W.*

*Mountain* P, *S. 52° W.*

*Mountain* A, *E. 26°. 30′ S.*

*Sketch of the Bay, N.° 3.*




*This Bay appeared to be half a mile in breadth, and the same in depth.*

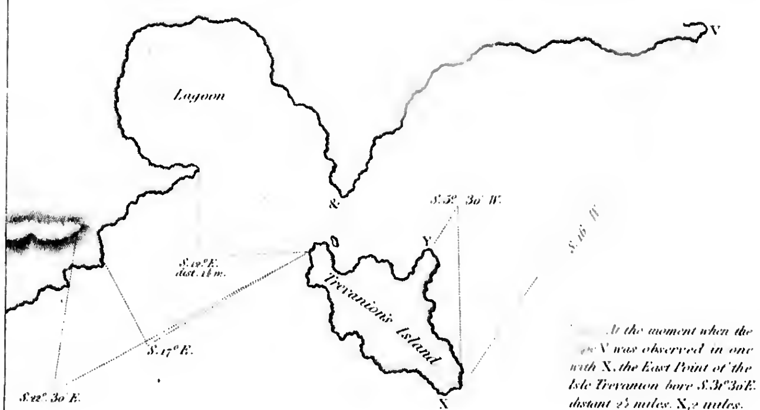


Plate XXXII. *Detail, &c.*

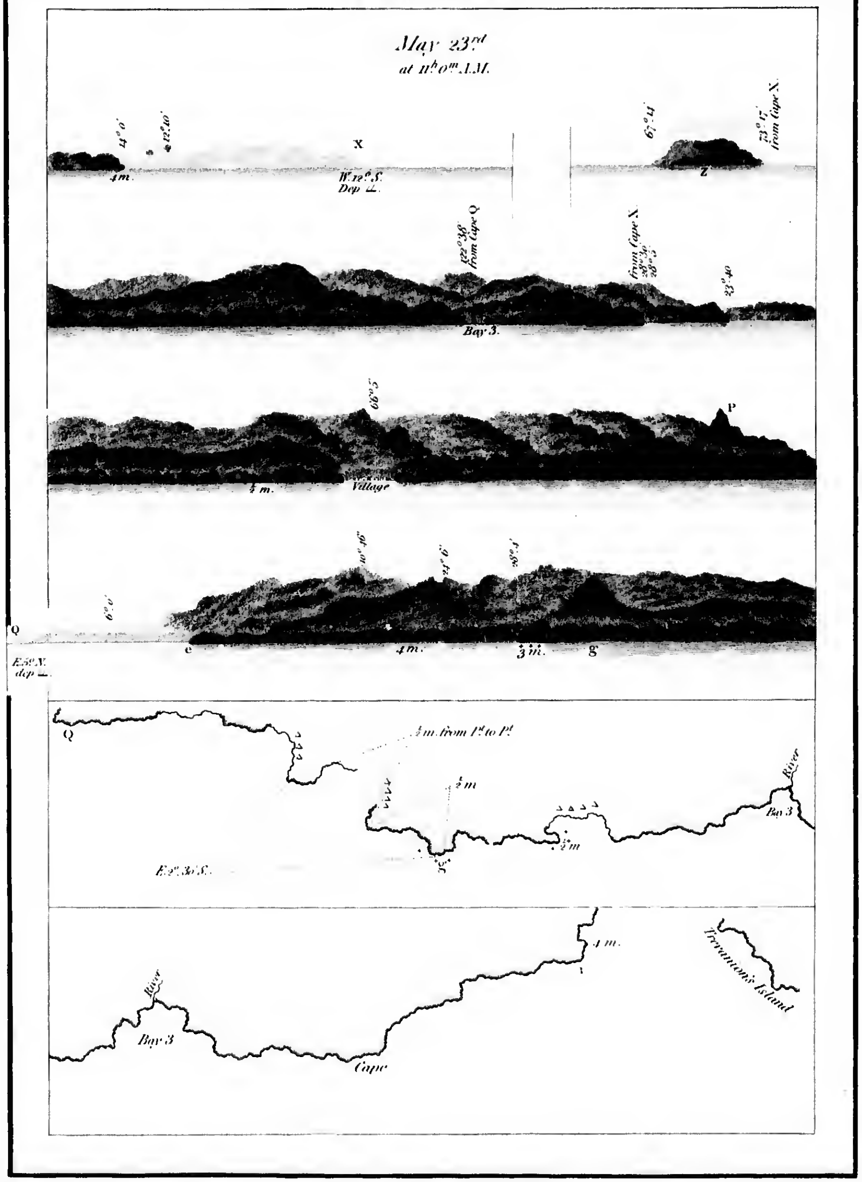
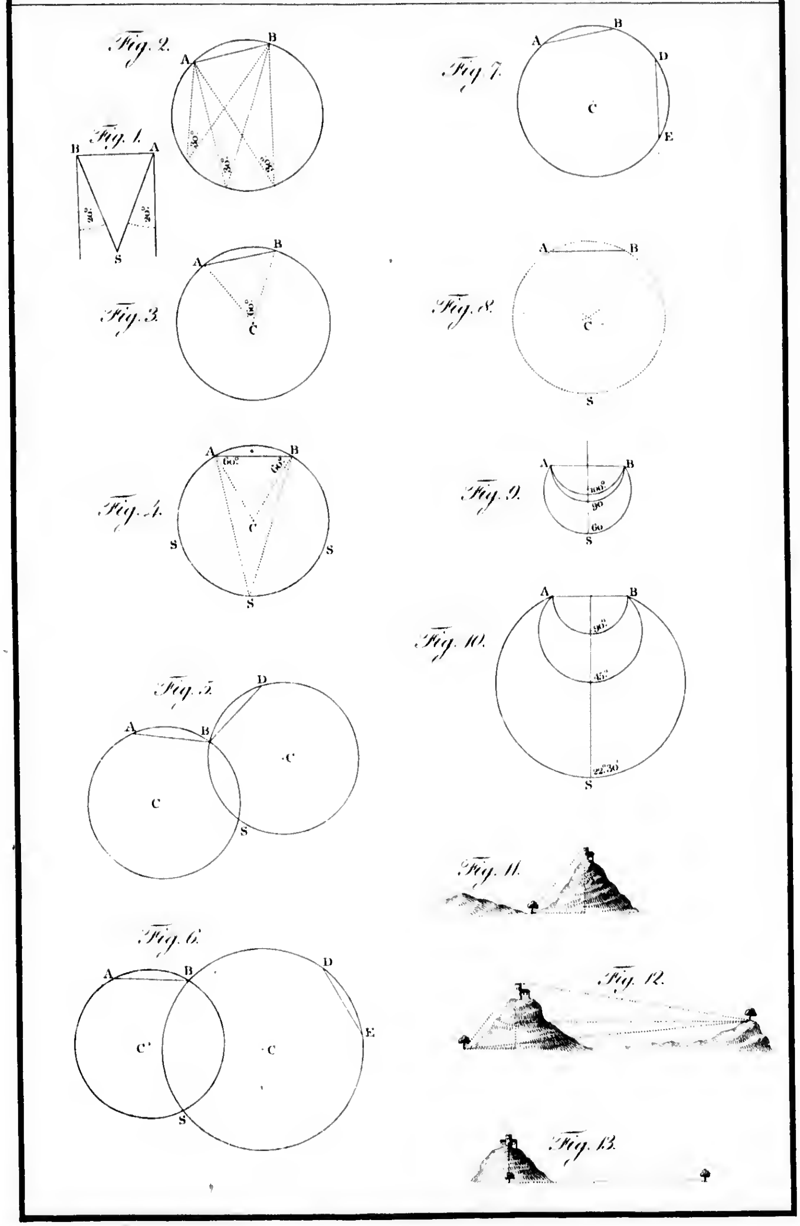
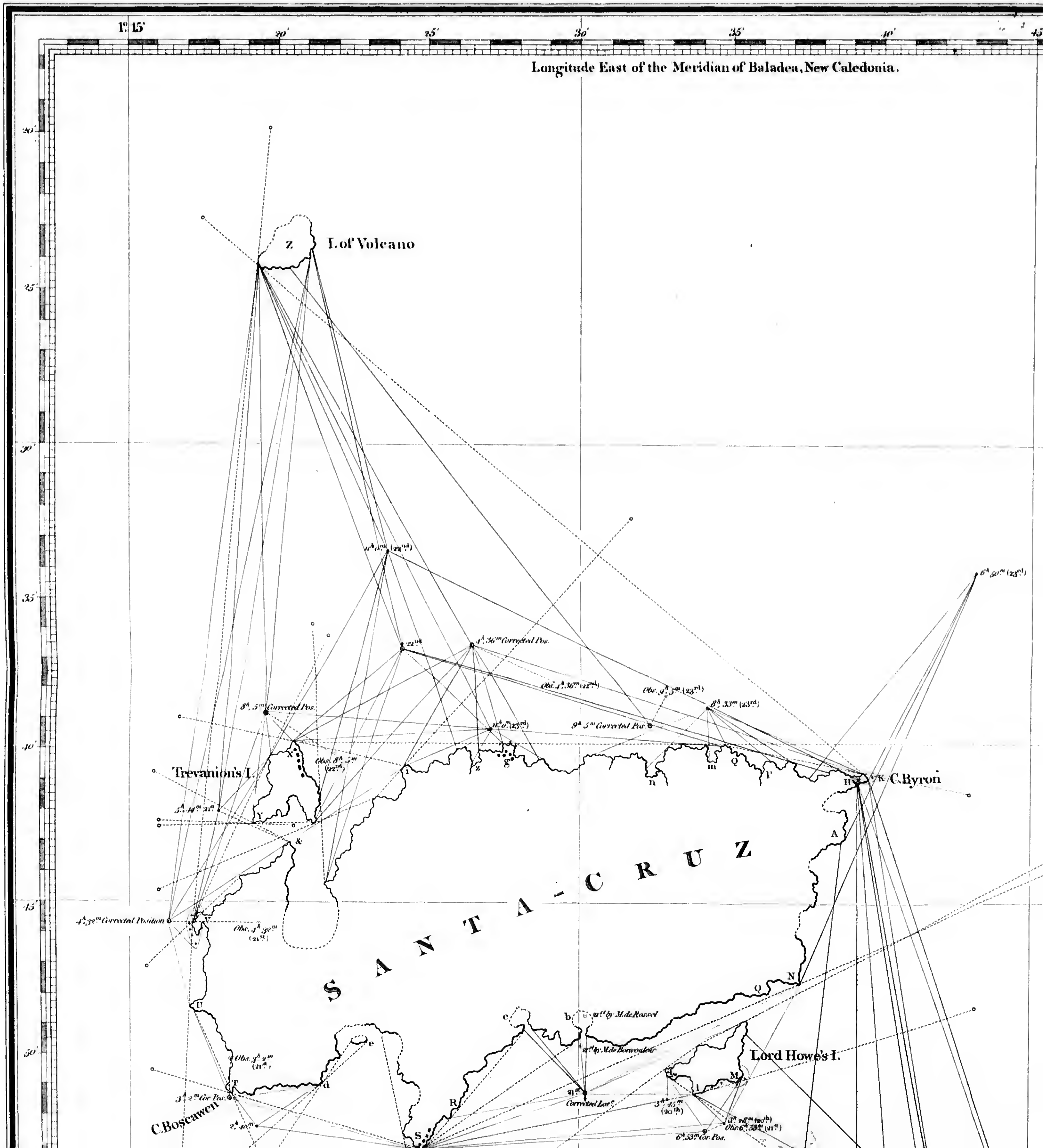


**Plate XXXIII. — Appendix. — *Dalrymple's Essay.***





Longitude East of the Meridian of Baladea, New Caledonia.
I. of Volcano
Trevanion's I.
SANTA-CRUZ
C.Byron
Lord Howe's I.
C.Boscawen
4h 36m Corrected Pos.
8h 5m Corrected Pos.
9h 5m Corrected Pos.
4h 32m Corrected Position
Corrected Lat.

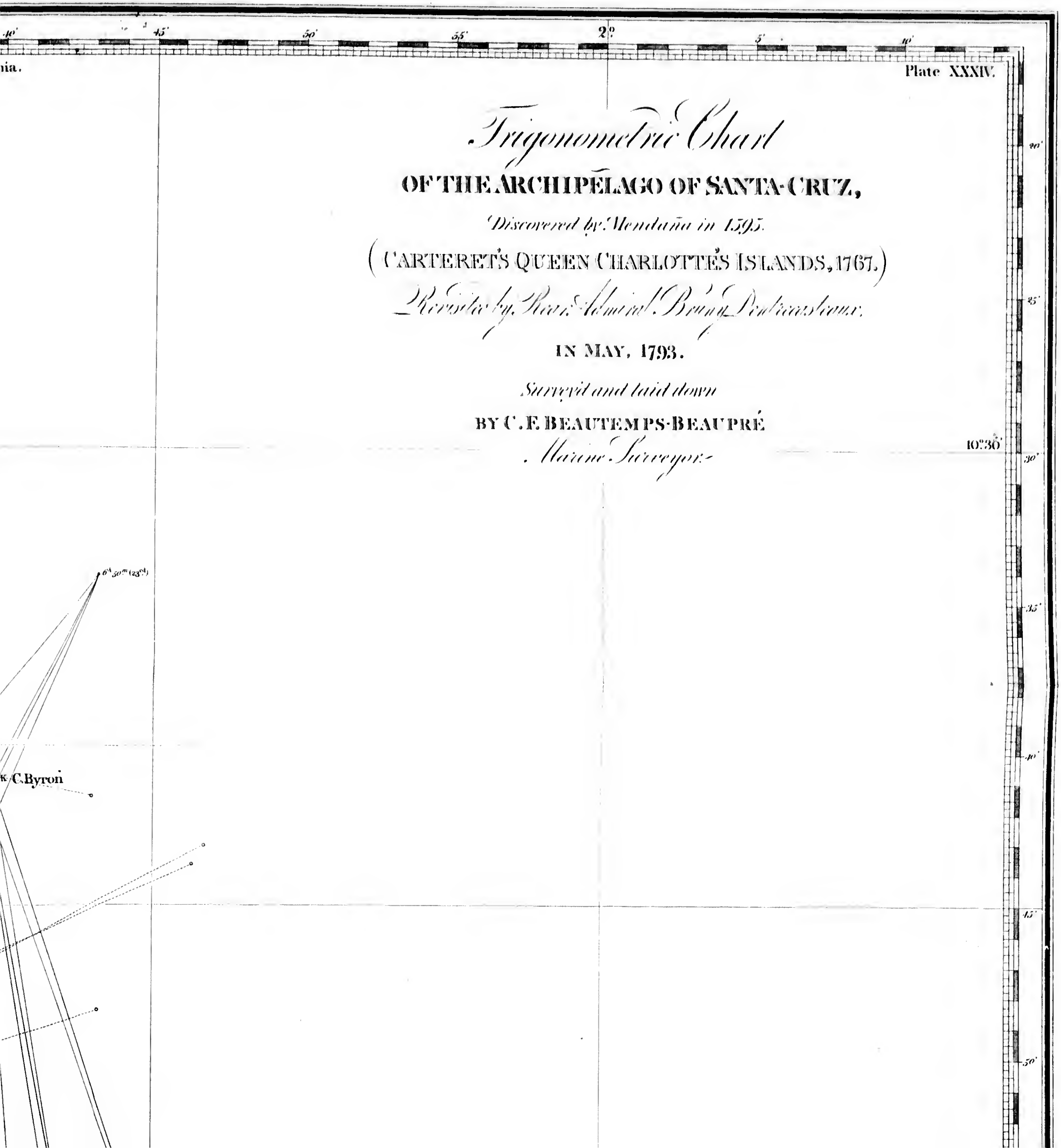
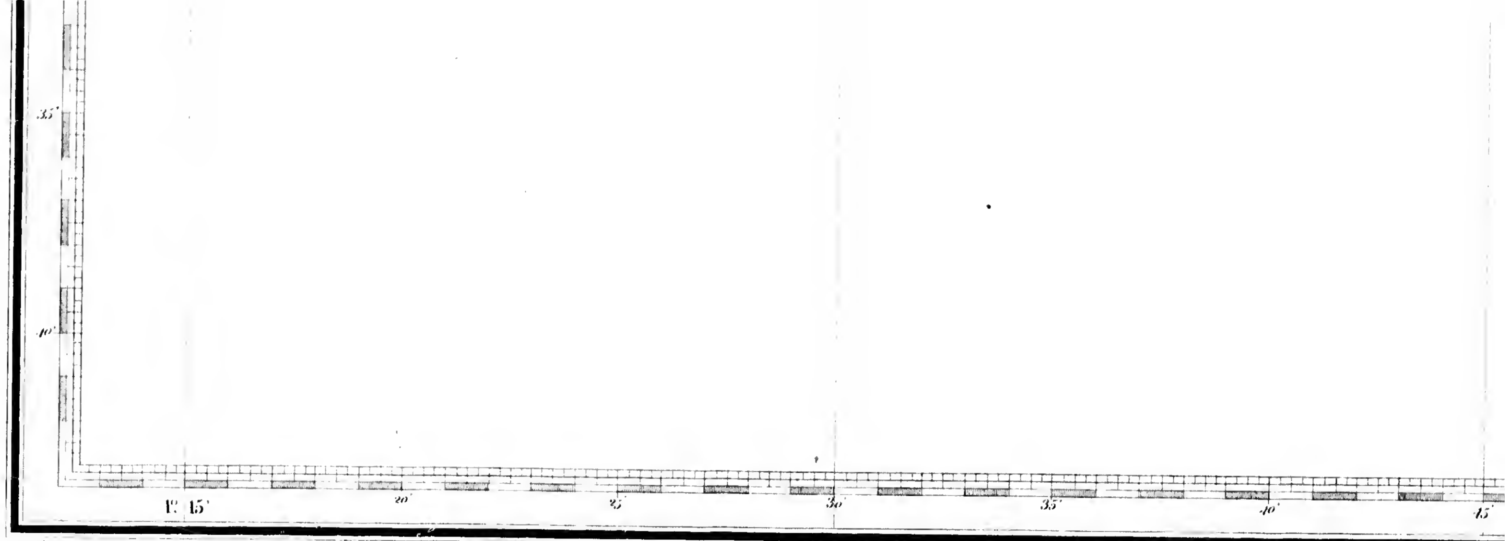


Plate XXXIV.
Trigonometric Chart
OF THE ARCHIPELAGO OF SANTA-CRUZ,
Discovered by Mendaña in 1595.
(CARTERET'S QUEEN CHARLOTTE'S ISLANDS, 1767.)
Revisited by Rear Admiral Bruny Dentrecasteaux:
IN MAY, 1793.
Surveyed and laid down
BY C. F. BEAUTEMPS-BEAUPRÉ
Marine Surveyor.
C. Byron
10°30'
2°




Richd Copeland, Delt

Published by R.H.Laurie, No 53, Fleet Street, Lo

## REFERENCES.

The Ships position deduced from the Hour Angles, calculated with an estimated Latitude

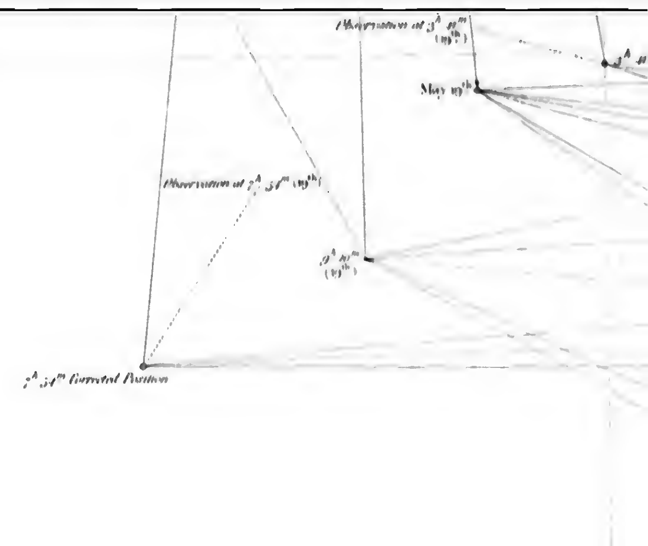
Ships position deduced from the Hour Angles, calculated with an estimated Latitude and combined with the trigonometric operations.

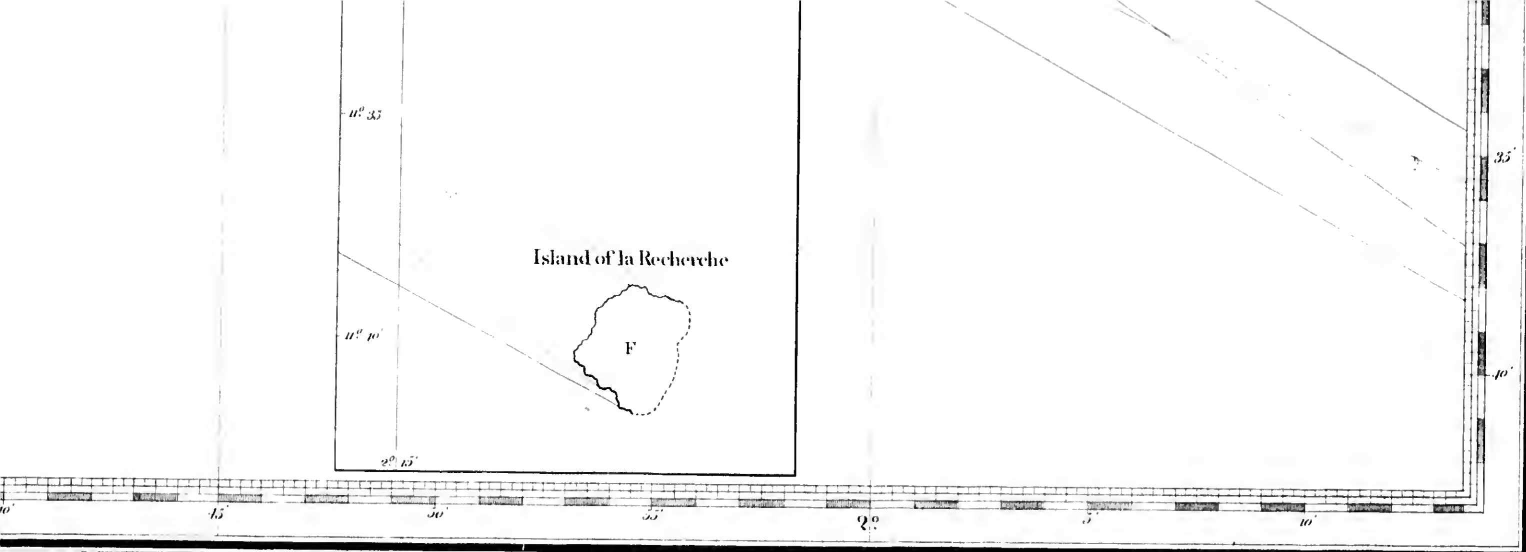
Ships position at Noon, Latitude observed, Longitude deduced from the trigonometric operations.

Ships position, determined by the trigonometric operations.

The Lines thus indicate the Points taken in one with each other.

The Lines thus, drawn from the different positions of the Ship, indicate such of the trigonometric Operations as have been adopted for the construction of this Chart






by R.H.Laurie, No. 53, Fleet Street, London, May 5th 1823.

A.Findlay, sculp.