XVII. *Experimental Inquiries relative to the distribution and changes of the Magnetic Intensity in ships of war.* *By* George Harvey, *Esq.* *Communicated by* John Barrow, *Esq. F. R. S.*

Read Feb. 26, 1824.

It having appeared from many unquestionable experiments, that the variation of this compass, as determined on shipboard, is subject to remarkable anomalies, arising from the unequal influence of the iron distributed through the various parts of a vessel, and from the changeable intensity of the same, occasioned by the different directions of the ship's head, with respect to the magnetic meridian, and from its different situations on the surface of the earth, it seemed desirable that some attempt should be made, to discover in what way the attractive forces are distributed throughout the vessel, and particularly in the vicinity of the binnacle, by a series of careful experiments.

To trace the variations in the intensity of the magnetic forces, under the simplest circumstances possible, the Scylla gun brig was selected, having no other iron in her than what was necessarily employed in her construction, and for the ballast of a ship of her class, when in a state of ordinary. The intensity was estimated in planes* parallel to the decks,

* The term plane has been employed on the ground of convenience. Strictly speaking the decks are not planes, but curved surfaces. In the computations relative to the position of the centre of force, allowances were made for their variations of curvature.

and (excepting in a very few cases, where the peculiar form of a ship prevented) at the constant height of the binnacle above them.

To connect the different stations together, they were so arranged, as to fall in longitudinal and tranverse vertical planes, the positions of which were referred to three rectangular co-ordinate planes, having their common origin at Δ, Plate XV, fig. 1. Of these planes, that which passed in an horizontal direction through ΠΔΣ, was assumed at an elevation of 14.5 feet above the plane of the water section, the draught of water forward being 8.5 feet, and abaft 13 feet. The longitudinal co-ordinate plane passing through ΠΔΨ, Plate XVI, fig. 1, was 16 feet from the middle section, the extreme breadth of the ship being 30.5 feet; and the corresponding transverse plane passing through ΣΔΨ Plates XV, XVI, fig. 1, 2, was 41.7 feet abaft the centre of main mast, on the upper deck.

The first plane supposed to intersect the ship, was one in a vertical position, passing through its principal axis, and consequently parallel to the longitudinal co-ordinate plane. This plane intersected the poop and forecastle in $\alpha' \lambda'$, fig. 1, Plate XV.; the upper deck in $\beta'' \chi''$, fig. 2, Plate XV.; and the lower deck in $\gamma''' \lambda'''$, fig. 3, Plate XV.; the section produced thereby, being fig. 1, Plate XVI. parallel to this plane, and at eight feet from it, on the starboard and larboard sides of the ship, two other planes were supposed to pass; the former intersecting the before-mentioned decks in B′ L′, B″ L″, D‴, L‴, and the latter in $b' l'$, $b'' l''$, d''', l''', fig. 1, 2. and 3, Plate XV., and producing the sections fig. 2 and 3, Plate XVI. From the narrowness of the ship, in the after part of the poop, the fore-part of the forecastle, and the after part of the lower deck, other planes were supposed to pass through the points A, a'; M', m', and C''', c''', the two former being each 7 feet from the middle section, and the latter 6.5 feet.

The before-mentioned planes having been assumed in situations, as remote as possible from the immediate influence of the iron necessarily employed in the sides of the vessel, the masts, &c.; stations denoted by the letters β'', γ'', δ'', &c. B'', C''. D'', &c.; b'', c'', d'', &c., were selected in their several intersections with the decks, so as to be as free as possible from the irregularities of local attraction, and at the same time arranged in planes respectively parallel to the transverse co-ordinate plane. These parallel planes were supposed to meet the sections denoted by figures 1, 2, and 3, Plate XVI, in the lines $\gamma\,\gamma'\,\gamma''\,\gamma'''$, $C\,C'\,C''\,C'''$, $c\,c'\,c''\,c'''$ &c.; intersecting the planes of the decks, denoted by figures 1, 2, and 3, Plate XV, in the lines $c'\,\gamma'\,C'$, $c''\,\gamma''\,C''$, $c'''\,\gamma'''\,C'''$, &c.; the longitudinal co-ordinate plane in $P'\,P''\,P'''$, $X'\,X''\,X'''$, &c.; and the horizontal plane of the same name, in $c\,\gamma\,C$, $l\,\chi\,L$, &c. Each point, therefore, where the intensity was to be determined, being at a given height above the deck, and in a vertical line produced by the intersection of a longitudinal and transverse plane, it's position, with respect to the three co-ordinate planes, could be accurately ascertained; and thence, if necessary, it's actual situation in space.*

The positions therefore of the different points, at which it

* It affords me pleasure to bear testimony to the liberal assistance I received from Sir BYAM MARTIN, and Sir ROBERT SEPPINGS, by furnishing me with the drawings of the various ships I found it necessary to examine, during the prosecution of these inquiries.

was desirable to ascertain the intensities, being known, the same was determined at all the stations in the three different positions of the vessel; first, when the principal section of the ship was in the plane of the magnetic meridian, and her head due north; secondly, when the same section was at right angles to that plane, and her head due east; and lastly, when the same section formed an angle of forty-five degrees with the magnetic meridian, and her head north-west.* The vessel was moored in the first situation, to discover the diversities existing in the magnetic intensity at the different stations assumed; and in the succeeding positions, to determine the changes produced in those intensities, from the immediate alteration which every individual force underwent from a change of position with respect to the primary magnetic plane.

The instrument employed for determing the intensity was similar to that denominated the apparatus of COULOMB; consisting of a magnetized cylindrical bar, two inches and a half long, and $\frac{3}{80}$ths of an inch in diameter; delicately suspended by a single fibre of the silk-worm to the extremity of an adjusting screw, which worked in the cap of the glass vessel inclosing the bar. A brass wire likewise passed through the cap, having its lower end bent into an angular form, for the purpose of placing the bar in a direction at right angles to the magnetic meridian, previous to its being allowed to oscillate.

On the different days devoted to the experiments, before visiting the ship, the time of making fifty vibrations of the

* Captain FILMORE, Commander of the ships in ordinary, at Plymouth, with the utmost readiness, moored the Scylla in the above positions.

bar, was determined in the centre of a meadow, and of which the substratum was clay slate,* by a mean of six sets of experiments, performed with the utmost care; the time being registered to quarter seconds. The instrument was then taken on board, and placed in succession at the different stations previously assumed in the ship, and the mean of six sets of experiments determined at each station, with the same care as on land. The times of performing the oscillations on shore, and at each of the assumed points in the ship, necessarily gave the magnetic intensity at each station in terms of the terrestrial intensity, and which, in this case, was represented by 100.

The succeeding table contains the results of the mean intensities of the stations assumed on the poop, forecastle, the upper and lower decks of the vessel, for the positions in which she was successively moored.

* It is of importance in magnetic inquiries, to attend to the circumstances of the place in which the experiments are performed. With a delicate apparatus, like that here alluded to, the proximity of houses has a sensible effect. Even in different rooms of the same house a change of intensity has been observed, when no other iron has been near the instrument than what might have existed in the partitions and floors. When the intensity as determined in one house was denoted by 100, the same needle in another house, two hours after, gave only a result of 93.2. This was determined more than once. Each house was built on clay slate.

Table of Mean Intensities.

Direction of the Ship's Head.	Larboard Section.	Middle Section.	Starboard Section.	Mean of the three Sections.
Poop.				
North,	101.19	101.96	102.77	101.97
East,	90.76	97.88	93.14	93.93
North-west,	101.70	98.64	101.78	100.71
Forecastle.				
North,	98.44	96.87	106.30	100.54
East,	91.56	95.45	104.28	97.10
North-west,	103.86	101.89	104.31	103.35
Upper Deck.				
North,	98.51	94.45	98.51	97.15
East,	100.90	96.37	93.23	96.83
North-west,	99.55	96.46	102.72	99.58
Lower Deck.				
North,	99.77	93.56	95.83	96.39
East,	88.26	98.16	106.70	97.71
North-west,	107.34	94.03	92.40	97.92

If the preceding results be examined, it will be found that on the poop, and forecastle, the mean intensities of the three sections were the least, when the ship's head bore east; and the same property will be also found to exist in the starboard section of the upper deck, and the larboard section of the lower. But in the larboard and middle sections of the upper deck, and the middle section of the lower, they were the least when her head was north; and in the starboard section of the lower deck when it was north-west.

Of the column devoted to the mean of the intensities of the three sections, it may be observed, that on the poop, forecastle, and upper deck, the mean results were the least when her head bore east; and on the lower deck, when it was north. The maximum result was also found on the poop, when her head was north; and on the forecastle, upper, and lower decks, when north-west. It may also be remarked, that the mean of the intensities of the three sections on the upper and lower decks were all below the assumed terrestrial intensity; and that the closest approximation to equality was found in the mean intensities of the three sections of the lower deck.

By comparing the mean intensities of the starboard and larboard sections of the upper deck, when the vessel was moored due north, it will be perceived that the results are precisely the same. This equality, however, will be found no longer to exist in the eastern and north-western positions of the ship, the larboard section having the ascendancy in the former situation of the vessel, and the starboard section in the latter. On the lower deck also, and when the ship's head was north, the difference between the mean intensities of the two lateral sections was 3.94; but when the vessel was moored easterly, this difference was increased to 18.44; and when north-westerly, it became 14.94; the excess being found on the starboard side in the former position, and on the larboard side in the latter.

Some remarkable inferences may also be drawn from a comparison of the intensities of the upper and lower decks, in corresonding positions of the ship's head, as recorded in the following table.

Variations of Intensity from Upper to Lower Deck.				
Direction of the Ship's Head.	Larboard Section.	Middle Section.	Starboard Section.	Mean of the three Sections.
North,	+ 1.26	— 0.89	— 2.68	— 0.76
East,	— 12.64	+ 1.79	+ 13.47	+ 0.88
North-west,	+ 7.79	— 2.43	— 10.32	— 1.66

The intensity of the larboard section, for example, will be found to have increased 1.26 from the upper to the lower deck, when her head was north; to have undergone a diminution amounting to 12.64 when it became east: and afterwards to have increased 7.79 when the bow bore north-west. In the middle section likewise, a minute decrease of 0.89 was perceptible from the upper to the lower deck in her first situation; a rather greater increase of 1.79 when her head was east; and a diminution of 2.43 when it became north-west. So also in the starboard section, the magnetic influence was found to decrease from the upper to the lower deck, when her head was north, by the small quantity 2.68; and on the contrary, to undergo a rapid increase of 13.47 when it became east; and lastly, a considerable diminution, amounting to 10.32, when her head bore north-west. If the means of the intensities of the three sections be compared, with relation to the two decks, it will be found that the magnetic influence suffered a small decrement of 0.76 from the upper to the lower deck, when the vessel's head was north; but received an increment of 0.88, when her head became east;

and decreased by the quantity 1.66 when her head bore north-west. It also appears from the same table, that the alterations of intensity are the least in the middle section, and greatest in the starboard section. In the two lateral sections also it is the greatest when the ship's head was east, and in the middle section when it was north-west.

The following table also illustrates the changes of intensity which each line of stations on the respective decks underwent as the ship passed from one situation to the other. Thus, in the third column, the degree of diminutions which the mean intensity of the starboard section underwent as the head of the ship passed from north to east, amounted to 5.28; and as it's head passed from north to north-west, the increase was 4.21. It also appears from an inspection of the same table, that with the exception of the middle section on the upper deck, the changes of intensity were the greatest in the transition of the ship from north to east. The variations of intensity of the lower deck likewise much exceed those of the upper.

Upper Deck.				
Change of Position of the Ship's Head.	Larboard Section.	Middle Section.	Starboard Section.	Mean of the three Sections.
From North to East,	+ 2.39	+ 1.92	— 5.28	— 0.32
From North to North-west,	+ 1.04	+ 2.01	+ 4.21	+ 2.43
Lower Deck.				
From North to East	— 11.51	+ 4.60	+ 10.87	+ .032
From North to North-west,	+ 7.57	+ 0.47	— 3.43	+ 1.53

The succeeding table indicates the positions of the points of maximum and minimum intensity in the three sections, for the successive positions of the ship's head:

Positions of the Stations of Maximum and Minimum Intensity.			
Direction of the Ship's Head.	Larboard Section.	Middle Section.	Starboard Section.
		Poop.	
North.	c' 109.09 a' 90.68	β' 102.19 γ' 101.51	C′ 108.47 A′ 96.85
East,	c' 101.73 a' 79.59	γ' 99.30 β' 96.85	B′ 94.49 C′ 91.63
North-west,	b' 104.96 c' 99.63	β' 100.84 γ' 97.69	C′ 111.25 A′ 92.02
		Forecastle.	
North,	m' 109.34 l' 87.54	γ' 100.62 x' 93.13	M′ 123.06 L′ 89.55
East,	l' 94.49 m' 88.63	x' 101.17 λ' 89.74	M′ 106.15 L′ 102.41
North-west,	m' 116.86 l' 90.87	λ' 111.77 x' 92.02	M′ 117.28 L′ 91.34
		Upper Deck.	
North,	b'' 122.46 f'' 89.92	δ'' 103.21 ι'' 86.91	L″ 103.79 F″ 93.68
East,	d'' 109.34 b'' 74.68	ι'' 99.96 θ'' 92.70	K″ 98.12 D″ 88.35
North-west,	b'' 131.07 h'' 92.02	δ'' 103.44 η'' 88.72	L″ 108.59 F″ 90.68
		Lower Deck.	
North,	e''' 122.02 g''' 78.43	ϵ''' 104.73 η''' 46.60	E‴ 109.34 G‴ 78.43
East,	k''' 99.19 c''' 77.38	λ''' 109.34 η''' 81.25	C‴ 128.79 G‴ 92.12
North-west,	e''' 131.23 g''' 89.64	κ''' 109.85 η''' 54.85	K‴ 102.87 L‴ 82.63

Several curious relations may be traced among the results of the preceding stations. Thus, in the middle and starboard sections of the poop; in the three sections of the forecastle; in the starboard section of the upper deck, and in the middle and larboard sections of the lower deck, the stations at which the greatest and least intensities were respectively found, when the bow of the vessel was due north, still maintained the same property when her head was afterwards moored north-west; but in the larboard section of the poop, and the starboard section of the forecastle, the same principle was only found to hold good when the bow of the ship bore due east. In the middle and larboard sections of the upper deck, however, the points of maximum intensity were found to preserve their situations in the northern and north-western positions of the ship; but the points of minimum intensity were observed to change, approaching nearer the bow in the latter situation. A similar property with respect to the least intensities, was also found in the middle and starboard sections of the lower deck, when the vessel was moored with her head to the north and east. It may also be remarked, that in the two positions of the vessel last alluded to, the points of greatest and least intensity mutually exchanged places at some of the stations; the point of maximum intensity in the northern position of the ship becoming in the eastern that of minimum intensity, and the converse. These singular changes were observed in the middle and starboard sections of the poop; the middle and larboard sections of the forecastle, and the larboard section of the upper deck. The station η''' in the middle section of the lower deck preserved its minimum intensity in each position of the vessel.

The situation of the binnacle was nearly mid-way between the stations γ'' and δ''; and it is remarkable, notwithstanding it is generally supposed, that this part of the ship is less influenced by iron than any other,—that the maximum intensity should have been found at the latter station, both in the first and third positions of the vessel: a proof, that sufficient care is not at all times displayed, in the employment of copper fastenings, &c., to a sufficient extent in the neighbourhood of the binnacle. A greater uniformity was also observed to prevail in the stations of the middle section, on the upper deck, when the ship's head was east, than in the other positions of the vessel.

Notwithstanding the absence of the guns, shot, and other iron stores, from the vessel under consideration, the intensities were found of a very diversified kind; and in the passage of the ship from one position to the other, the attractions were found to change in a very irregular manner;—from greater to less, and from less to greater. If therefore the different magnetic intensities, as determined in each position of the ship, be regarded as so many parallel forces, referred respectively to the three rectangular co-ordinate planes before assumed, it follows, that the position of the centre of force, corresponding to each system of intensities, may be readily determined for each co-ordinate plane, by means of the formula,

$$x = \frac{\mathrm{I}p + \mathrm{I}'p' + \mathrm{I}''p'' + \&c.}{\mathrm{I} + \mathrm{I}' + \mathrm{I}'' + \&c.},$$

in which I, I', I'', &c. denote the intensities at the respective stations; p, p', p'', &c., the perpendicular distances of the corresponding stations, from the co-ordinate plane, to which the common centre of force is referred;* and x the unknown

* The letters α, β, &c., A, B, &c. a, b, &c. in the horizontal co-ordinate plane,

distance of the centre of force from the same co-ordinate plane. These numerical elements being respectively applied to the above formula, will determine the distance of the centre from each co-ordinate plane; and from thence, its absolute situation in each position of the vessel.

The following table contains the results of the computations, for each co-ordinate plane, in the three positions of the vessel. In the first column is entered the direction of the ship's head; in the second the distance of the centre of force from the horizontal co-ordinate plane, correspouding to the three positions of the ship; and in the third and fourth, the distances of the same point, from the longitudinal and transverse planes. These numerical results evidently determine the position of the centre of force, for each system of intensities.

Direction of the Ship's Head.	Distance of the Centre of Force, from the Horizontal Co-ordinate Plane.	Distance of the Centre of Force, from the Longitudinal Co-ordinate Plane.	Distance of the Centre of Force, from the Transverse Co-ordinate Plane.
North.	7.58	15.98	49.23
East.	7.77	16.13	50.84
North-west.	7.64	15.89	49.84

From the preceding Table it appears, that the position of the centre of force, is not constant. This indeed, might have

figs. 1, 2, 3, Plate XVI; and N′, O′, &c., O″, P″, &c. P‴, Q‴, &c., in the longitudinal plane, figs. 1, 2, 3, Plate XV., were employed in the computations relative to the situation of the centre of force, to denote the perpendiculars here alluded to. They are retained in the diagrams, for the purpose of any farther reference.

been anticipated, from the change which the whole system of local attractions was found to undergo, in the different positions of the vessel. It may be interesting, however, to trace the course of its variation.

When the head of the ship was north, the centre of force was found at the point O, fig. 2, Plate XV., at the distance of 0.02 feet from the middle section, on the larboard side of the vessel. As the ship however moved eastward, it crossed the middle section, and was finally found at Q, on the starboard side, distant from that section 0.13 feet. When the vessel passed from north to north-west, the centre receded from O to P, on the larboard side, distant from the middle section 0.11 feet. The distance of the centre of force therefore from the middle section was a minimum when the vessel's head was north; and a maximum when east.

With reference to the transverse plane, the same point varied its position considerably, being found, when the ship's head was north, at O, fig. 2, Plate XV., or fig. 1, Plate XVI., distant 49.23 feet from it. A change of position in the vessel also, to the east or the west, caused the centre of force to advance towards the bow. When, for instance, the head bore north-west, the distance of this point from the transverse plane was 49.84 feet, as at P; and when east, 50.84 feet, as at Q;—the former position producing an increase of its distance 0.61 feet from the plane, and the latter 1.61 feet. The centre of force is therefore situated at its minimum distance from the bow, when the vessel's head is east, and attains its maximum, when due north.

Nor is the distance of the same point from the horizontal co-ordinate plane of the same constant magnitude; for when her head was north, it was found to be 7.58 feet below it; when east, 7.77 feet, and when north-west, 7.64 feet. The depression of the centre of force below this plane is therefore the least when the ship's head is north, and the greatest when due east; the distance in the north-west position being nearly a mean between the two.

Hence it appears that the motion of the centre of force, is in that species of line which geometers denominate a *curve of double curvature.*

For the sake of practical reference it may be added, that the position of the centre of force when the ship's head is north, is nearly in the middle section, at the foremost part of the main hatch-way, and about ten inches and a half below the upper surface of the upper deck.

Of the Helicon.

The next vessel selected was the Helicon brig, mounting ten guns, and in a complete state of equipment for sea. On applying to Captain DAWKINS, her commander, he immediately caused her to be moored with her principal section in the direction of the magnetic meridian.

The first line of stations assumed was in the middle section of the ship, in which however only six points, α, β, γ, δ, ε, ζ, fig. 2, Plate XIX., could be obtained, on account of the midship part of the deck, from the main hatch-way, forward, being occupied by an anchor, boat, ship's gear, &c. On the starboard and larboard sides, at the distance of five feet from the middle section, two other sections were assumed, in which fourteen stations, A, B, C, &c.; *a*, *b*, *c*, &c. were obtained, as nearly equidistant from each other, as circumstances would allow.

The station ⊙ denotes the position of the binnacle, and on each side of it were the centres $\triangle$, $\triangle'$ of the two compasses at the distance of ten inches. From the point ⊙ as a centre, two concentric circles were described on the deck, the exterior having a radius of six feet, and the interior of three feet. Each circumference was divided into twelve equal parts at the points, 1, 1′, 2, 2′, 3, 3′, 4, 4′, &c.; and at these stations, as well as at those before referred to, in the middle, starboard, and larboard sections, the mean intensity, by six sets of experiments, was determined by the same instrument and with the same precautions as described for the Scylla.

In the middle line of stations an increase of intensity was perceptible from α to δ, at the former station it being 102.19, and at the latter 121.87; but from the last mentioned station to ε, the intensity declined, after which it increased to ζ, where it became 125.18. In the starboard and larboard sections, the intensities at the stations A, *a*, were found to be much greater than that at the station α in the middle section, on account of the proximity of those stations to the bulk heads formed in the quarters of the ship. At B and *b*, the decline of intensity was found to be considerable; but at the stations C, *c*, D, *d*, it was again augmented by the action of the carronades at the two after ports. At E, *e*, F, *f*, a still greater increase was observed, produced in part by the carronades at the ports opposite the last mentioned stations. The carronades were trained parallel to the side of the ship, and in no case nearer than four feet to the instrument. Those opposite the stations F, *f*, were at a greater distance; and hence it may be inferred, that the observed augmentation of intensity was to be partly attributed to the increased attraction of the ship. At G, *g*, a farther increase in the intensity was observed, particularly at the former station, occasioned by the proximity of the flukes of the sheet anchor, which lay across the main hatch way, and bore east and west of the instrument. After passing the last mentioned stations, however, a remarkable decrease in the intensity was perceived. At H, which was but little farther distant from the flukes of the anchor than the station at F, the intensity was only 98.87; whereas at the latter station, it was 118.26. At the stations K, L, M, there was an increase of intensity, occasioned by approaching the galley; but after passing it at M, the intensity suddenly declined at N, but encreased a little at O, produced by the proximity of the station to the iron of the foremast and the anchor suspended from the starboard bow.

From the stations A, *a*, to F, *f*, the distribution of the iron, on each side of the middle section, appeared as far as a general observation could be made, to be very nearly similar; and hence the intensities at the corresponding stations of the starboard and larboard sections, approached more nearly to equality than the intensities at the stations from G, *g*, to O, *o*, on account of the chain cable, which proceeded from *g* to the larboard bow, paralled to the line of stations.

If the means of the intensities of the three sections, as far as the transverse line of stations F ζ *f*, just abaft the mainmast be taken, they will present a remarkable approximation to equality; being for the

Starboard section	-	111.92
Middle section	-	111.78
Larboard section	-	111.08;

but if the means of the intensities of the former and latter sections be determined from the stations G, *g*, before the main-mast, to the stations O, *o*, abreast of the fore-mast, this equality will be no longer preserved; the mean being for the

Starboard section 105.23,

and for the Larboard section 95.67.

Those parts of the sections therefore which are *abaft* the main-mast, have their intensities very nearly equal; but in those *before* the main-mast, the intensity of the starboard section exceeded that of the larboard in nearly the ratio of 11 to 10.

It may also be remarked, that the intensity in the after part of the ship is much more considerable than in the forewart part. For if the mean results of the stations from A to G, and *a* to *g* be taken and contrasted with the means of an equal number of stations from H to O and *h* to *o*, the former will be found to exceed the latter considerably. The following table contains the results.

Station from	Mean Intensity.
A to G	115.43
a to *g*	111.67
H to O	100.77
h to *o*	92.87

Hence it appears that if the vessel were divided into two parts, tranversely, between the stations G H, *g h*, the mean of the intensities of the seven stations in the after part will be 113.55, and of an equal number in the forward part 96.82; the former exceeding the latter in the ratio of 11.7 to 10.

To avoid the influence of local attraction as much as possible, copper fastenings are commonly employed for a considerable space round the binnacle. This space however is, in most instances, much too confined in its dimensions; nor is sufficient care always displayed by the practical shipwright to avoid the mixture of iron and copper.* And to this circumstance may be attributed many of the irregularities I have noticed, when ascertaining the intensity in the neighbourhood of the binnacle, on board different ships.†

To ascertain the influence actually existing in the space surrounding the binnacle, was the object of employing the concentric circles before alluded to, and of ascertaining the intensities at the different stations assumed in their circumferences. From these it was found, that at nine of the stations in the exterior circle, the intensities were greater than those at the corresponding stations of the interior circle; but at the other three stations, viz. 2, 6, and 11, they were less.

* It may not be improper to remark, that although copper fastenings are commonly employed in fixing the planks of the deck, yet the beams which support it, being generally composed of two or three pieces, have their scharps secured by large *iron* bolts, at very short distances from each other, and several of which are in the vicinity of the binnacle. One cause at least of irregularity in the compass might be avoided, by the *general* employment of copper in the stations round the binnacle. The stanchions also in that part of the vessel should be formed of the same metal.

† HUMBOLDT, in his Voyage across the Atlantic, had much difficulty in discocovering a proper situation for suspending his dipping needle. In his personal Narratives he observes, that he finally ascertained a part of the poop to be the best place, because it appeared *nearly* free from iron, and the *small portions that existed*, were very *equally distributed*

This anomaly is no doubt to be attributed to the partial employment of iron in the inner circumference.

The mean of all the intensities of the stations in the lesser circumference was 102.03, and of the greater 104.40. The starboard semi-circle also of the former gave a mean intensity of 101.37, and the larboard 101.69; — approaching nearly to equality with each other. The mean intensity of the starboard semi-circle of the exterior circumference, was 105.46, and of the larboard 102.09. This excess of the intensity of the former semicircle above the latter, accords with the conclusions before deduced, relatively to the sections of the same name.

On removing the binnacle, and determining the intensity at the centre of the concentric circles, on the horizontal roof of the sky light on which the binnacle rested, the intensity was found to be 100.29, differing but little from the assumed terrestrial intensity; and hence it may be inferred, by comparing the last mentioned result, with the mean intensities of the stations in the two circumferences, that the intensity increases nearly in proportion to the radius, in a circular space surrounding the binnacle, and of which ⊙ is the centre.

At twelve inches above the surface of the compass card, the intensity at Δ was found to be 96.01, and at Δ' 93.59. At ⊙ also, immediately over the centre of the concentric circles, and at an elevation three inches greater than that last alluded to, it was 96.85. The difference between the intensities at Δ, Δ' arose from the compasses; that on the starboard side being heavy, and employed in cases when the ship is much disturbed by the sea; and that on the larboard, being of a more delicate construction, and used in moderate weather.

It was intended to have ascertained the intensities in another circle, exterior to the greater of those before mentioned; and also to have determined the same, at a series of other points, so situated above and below the deck, as to fall in the surfaces of three concentric spheres surrounding the binnacle, and of which ⊙ should be the common centre; but the wind having suddenly become fair, the ship was obliged to sail; a circumstance much to be regretted, as her gallant commander took a great interest in the inquiry, and was most anxious to afford every facility for prosecuting the subject.

Before closing these remarks relative to the Helicon, it may not be uninteresting to point out some analogies which have been traced, between the magnetic intensities observed on board her, and certain anomalies in the variation observed in Captain BUCHAN'S Voyage of Discovery.

It was remarked on board the Trent,* that when WALKER'S compass was placed on the starboard gangway, the variation was found to be 33° 52′ W.; whereas at the binnacle it was 25° 52′ W. By bringing the compass on the gangway nearer to the binnacle, the difference between those results was observed to decrease, and when it was placed on the companion, between the binnacle compasses, it exactly coincided with them.

A somewhat analogous change in the magnetic intensity, was observed on the deck of the Helicon. At the station G, on the starboard gangway, the intensity was found to be

* Journal of Science, Vol. IX.

136.50; and at ⊙, on the horizontal roof of the sky-light, and on which the binnacle rested, it was 100.29. At the station F also, the intensity was 118.26; so that a station might have been found between the points F and G, at which the intensity would have been about 131; a fourth proportional to the two variations above alluded to, and the intensity at ⊙. The observation also, that the magnitude of the difference between the two variations, gradually diminished, as the compass on the gangway was brought nearer the binnacle, affords a very striking coincidence with the intensities successively determined at the stations F, E, D, and C; they being respectively 118.26, 117.14, 110.35, and 105.20; and this analogy was farther confirmed at the station 9, in the circumference of the interior circle, nearly midway between the stations ⊙ and C, the intensity at that point being 102.87, and at ⊙, as before mentioned, 100.29.

The cause of the anomaly in the variation, was considered by the officers of the Trent to arise from "the quantity of "iron stowed round the main-mast, consisting of shot, chain "cable, spare rudder with an iron bolt, and the iron fen- "ders;" and in the present case, the increased intensity is to be attributed to the action of the sheet anchor, which was laid across the main hatchway.

A similar decrease of intensity was also traced from *g* on the larboard gangway to the centre of the binnacle, in a manner still more perfect. It may be proper to observe, however, that the direction of the Trent's head at the time the observations were made was NE $\frac{1}{2}$ N, whereas the Helicon was moored N $\frac{1}{2}$ E.

A case agreeing more exactly as to the position of the

Trent, and which exhibits in a striking manner the difference between the observations at the starboard gangway, and at the binnacle, was observed on another occasion, when her head being in the same direction as the Helicon's, the variation at the former part of the vessel was 39° 41′ W, and at the latter 21° 41′ W. The variations and intensities are not however proportional.

On another occasion, on board the Trent, the variation as determined on the starboard gangway, was found to agree with that determined at the binnacle. This observation, which would seem at first opposed to the remark before made, relative to a proportionality between the intensities at the binnacle and starboard gangway, and the variations determined at the same stations, may nevertheless be accounted for, from the sudden decline of the intensity, after passing the stations G or *g*; since it is not improbable, but between the stations G, H, *g′*, *h′*, points might have been found, at which the same intensity would have existed, as at the station ⊙.

It was also remarked, that "when Captain KATER'S compass (No. 1.) was placed nearly a midships, and at a sufficient distance from the binnacle compasses to prevent attraction, the variation was found to be 31° 9′ W; and by a similar compass (No. 2.) on the ice, 25° 28′ W″."

If now the station of the compass (No. 1.) had been at *δ*, the intensity at that point would have had nearly the same ratio to the intensity at ⊙ (the intensity at the last mentioned point being 100.29, and the assumed terrestrial intensity 100), as the former variation has to the latter.

Of the Ariadne Frigate.

By permission of Captain Moorsom, who commanded the Ariadne, a frigate of 28 guns, the intensity was determined at a great number of stations on her different decks. At the time the experiments were performed, the vessel lay in a complete state of equipment in Hamoaze, having all her guns, shot, and other stores on board, preparatory to her departure for a long voyage. From her being under sailing orders, it was impossible to have her moored in a permanent position; and therefore from the changes which her situation necessarily underwent, in consequence of the current, one great cause of irregularity, which it is at all times desirous to avoid, in an inquiry of this kind, necessarily exercised an influence. Some useful information was however obtained from the different positions assumed by the ship, in consequence of the instantaneous and rapid change the magnetic intensity underwent at every station.

The point Δ in each of the figures contained in Plates XVII. and XVIII., was regarded as the common origin of the three co-ordinate planes. The horizontal plane passing through ΠΔΣ, was assumed at the height of 16 feet 9 inches above the plane of the water section QR; the draught of water forward being 13 feet, and abaft 13 feet 9 inches, both dimensions being independent of the false keel. The longitudinal plane passing through ΠΔΥ, was supposed to be 16 feet from the middle section, and the tranverse plane ΣΔΥ, 59 feet abaft the centre of the main-mast, on the upper deck.

The figures denoted by 1, 2, and 3, Plate XVII., represent plans of the upper, middle, and lower decks. The lines $\alpha\, o'$, $A'\, P'$, $a'\, p'$, in fig. 1, are the intersections of the three longitudinal vertical planes with the surface of the upper deck. The first of these planes passes through the principal section of the ship; and the other two are at the equal distances of 6 feet from it, on the starboard and larboard sides of the vessel. This distance was selected, because after a careful examination of the situations of the principal attractive masses on the different decks, it seemed equally removed on the one hand from the action of the iron employed in constructing the sides of the vessel, and the guns (which on the middle deck were trained nearly parallel to the ports); and on the other, from the shot arranged round the several hatchways, the iron staunchions, and the other masses of iron existing in the middle parts of the ship.

The form of the vessel would not however admit of the extension of those planes, through the whole range of the lower deck; but at the stations F''', f''', were supposed to pass 5 feet on each side of the middle section, as far as the line of stations $H'''\, x'''\, h'''$; and from the points $E'''\, e'''$, to the line of stations $F'''\, \eta'''\, f'''$, at the distance of 2 feet and a half. The vertical plane therefore which passed through the line $\alpha'\, o'$, produced the section fig. 1, Plate XVIII. intersecting the middle deck in the line $\alpha''\, x''$; the lower deck in the line $\gamma'''\, \xi'''$; the iron ballast in $\pi\, \zeta$; the shot locker in $x'''\, \zeta\, \sigma$; and the middle course of iron tanks in $\tau\, \sigma\, \nu\, \phi$. The starboard and larboard vertical planes which passed through $A'\, P'$, $a'\, p'$, likewise intersected the middle deck in $A''\, N''$, $a''\, n''$; the lower deck in $H'''\, N'''$, $h'''\, n'''$; the iron ballast in $\omega'\, \zeta'$; and the side course of iron tanks in $\tau' \sigma' \nu' \phi'$. These planes produced the sections, fig. 2 and 3, Plate XVIII.; the stations $E''' e'''$, F''', f''' being orthographically projected on them.

The station ξ' in the middle section was assumed midway between the binnacle compasses. In this section, no stations could be obtained on the upper deck between the points ι' and ξ', on account of the stowage of the boats, the ships gear, &c.; nor could any station be assumed on the middle deck farther forward than x'', on account of the pens for the sheep, fowls, &c., and the galley. The station θ''' was taken in the lower deck, so as to be nearly over the middle of the mass of ballast; and the station x''', just above the after bulkhead of the shot locker. The point λ''' was also assumed over the hatchway of the iron tanks; and the station λ'''', immediately below the former point, and about two feet above the surface. The station ν''' was taken as nearly as possible to the foremost extremity of the tanks.

The diagram denoted by fig. 1, Plate XIX., is a horizontal section of the ship, passing through the upper surface of the middle tier of tanks. The tanks are denoted by the letters $\sigma\ t\ u\ \nu\ u'\ t'$, and the ballast by $s\ r\ q\ q'\ r'\ s'$; the iron pigs composing the mass being represented by the small rectangular parallelograms. The single dot in the middle of some of the rectangular spaces, implies, that the ballast in that part is one pig deep; two dots, two pigs deep; three dots, three deep, and so on. The rectangular space $v\ w\ v'\ w'$, is a horizontal section of the well which contains the main mast, chain pumps, &c.; and the parallelogram $w\ x\ w'\ x'$, that of the shot locker. The dotted lines passing through $E''' e'''$, $F''' f'''$, and $N''' n'''$, may be regarded as continuations of the longitudinal sections alluded to, in fig. 3, Plate XVII., and are introduced into the diagram, to exhibit the relative situations of the stations on the lower deck, with respect to the ballast and tanks.

On the after part of the upper deck, as shown in fig. 1, Plate XVII., the stations in the starboard and larboard sections, were less numerous than in the middle section, on account of the difficulty of finding points, as far removed as possible from the influence of the carronades, and which in this part of the ship were at right angles to its sides. In the after part of the middle deck, or in the Captain's cabins, the stations were more numerous; fifteen having been selected for the purpose of particularly discovering what varieties of intensity existed in this part of the ship, in order to form an estimate how far the magnetic changes were likely to affect a chronometer when placed in the cabin. With the same view the stations in the after part of the lower deck, fig. 3, Plate XVII., were assumed; because in this part of the vessel are the births of the lieutenants and master, and in which chronometers are sometimes deposited.

In the middle section, on the upper deck, it was found that the intensity attained its maximum at η', at the distance of 4 feet 5 inches before ε', the position of the binnacle. After passing the point of greatest intensity, a sudden declension of its power was observed at ι', and which was farther continued to ξ', where it became a minimum, after which it received an augmentation at σ'. At ε', the station between the binnacle compasses, a great uniformity was observed in the results of the oscillations; and it was farther remarked, that the intensity at the station ε', was an exact mean between the intensities at the stations ε', and η'. The intensities at and abaft the point η', possessed intensities greater than the assumed terrestrial intensity; and from that station to the forecastle, the magnetic influence was found to be less.

In the same section on the main deck, the intensity increased from 97.90 to 108.47, in the short interval from α'' to β'', in consequence of the iron tiller, which was below the deck, and immediately in the plane of the section. At the station γ'' the intensity underwent a small declension, and at δ'' a still farther decrease, the south pole of the oscillating bar dipping towards the extremity of the tiller, the station being over it. At ε'' the intensity again increased, after which it declined progressively to x'', the last point in the section it was possible to examine.

On the lower deck, and in the same vertical plane, it was remarked that the intensity at γ''' was very nearly the same as at the corresponding station on the main deck. At the points ε''' and η''' the attractive influence increased, but diminished at the stations θ''' and x'''. At this point also the north pole of the oscillating cylinder was drawn five degrees below its horizontal direction; an effect produced by the proximity of the station to the after part of the shot-locker. At the station λ''', over the central tank, the intensity increased to 118.97; but at λ'''', immediately below the last mentioned station, and only twenty inches above the surface alluded to, the intensity was less by the quantity 16.33. At μ''' the attraction again declined; but at γ''', nearly over the foremost extremity of the tanks, attained to 128.15, its maximum.

In the starboard section, on the upper deck, the least intensity was found at F', in the same transverse vertical plane as the maximum intensity of the middle section on the same deck. The greatest intensity also was found at L′, situated, as will hereafter appear, in the same transverse vertical plane as the maximum intensity of the larboard section of the main deck, and the greatest intensities of the middle and starboard sections of the lower deck. The former effect was produced by a carronade, which was stowed away amidships; and in the latter case, from the oscillating bar being between two carronades. The transverse plane also, in which the point F′ of minimum intensity was found, was observed to be at nearly the same distance from the extreme point of the stem, as a similar plane passing through the point L′ of maximum intensity was from the extreme part of the stern.

In the corresponding section on the main deck the greatest intensity was found at B″, in the same transverse vertical plane as the maximum intensity of the middle section, and the minimum intensity of the larboard section on the same deck. The minimum intensity was also discovered at I″, in the same transverse plane as the minimum intensity of the larboard section on the lower deck. The intensities of the stations in this section very much exceed those of any other line of stations, their mean being 115.79. At the points A″, B″, C″, D″, E″, the attractive power was very great, the mean of the intensities at those stations being 134.92; whereas the mean of the five succeeding stations was only 95.40, and that of the remaining points L″, M″, N″, 117.88. The magnetic changes in this section were very considerable; and it was farther remarked, that in the five positions first alluded to, no guns were near the line of stations; and that therefore the great degree of intensity found in this part of the vessel arose from the iron tiller, and the knees and braces employed in securing the stern. The increased intensity of the three last mentioned stations, above the five which preceded them, may be attributed to the chain cable, which commenced at L'', and to the galley, which was opposite to M''.

In the same section also, on the lower deck, the maximum intensity was observed at L''', in the same transverse section as the maximum intensity of the middle section on the same deck, the corresponding intensity of the larboard section on the main deck, and a similar intensity of the starboard section on the upper deck. The least intensity likewise was found at H''', in the prolongation of the after part of the shot-locker, and in the same vertical transverse plane as the minimum intensity of the middle section, and the greatest intensity of the larboard section on the same deck.

At the stations *m'*, *n'*, in the larboard section on the upper deck, a close approximation to equality was perceptible in the observed intensities; and at the corresponding stations M', N', in the other lateral section, a perfect equality was found. At the remaining stations in those sections, however, no analogy could be traced among the results. The maximum intensity was found at *a'*, in the same transverse plane as the least intensity of the middle section on the main deck; and the minimum intensity at O', in the same plane as the least intensity of the middle section on the upper deck.

In the same section, on the main deck, the intensities were no less remarkable, when contrasted with the results of the starboard section on the same deck. The greatest intensity was found at *l''*, in the same vertical plane as the maximum intensity of the starboard section on the upper and lower decks, and the corresponding intensity of the middle section on the latter deck. The minimum intensity was at b'', in the same plane as the greatest intensities of the middle and starboard sections on the main deck.

On the lower deck, and in the same longitudinal plane, the most striking difference in the intensities of the starboard and larboard sections was found at the stations H''', h''', the former being 69.96, and the latter 135.63; the difference between the bearings of the ship's head at the two observations being only a point and a quarter. The last mentioned intensity was also found to be the greatest in the whole section; and was situated in the same transverse plane as the minimum intensities of the middle and starboard sections on the same deck. The line of stations H''' x''' h''' was immediately over the after part of the shot-locker. The least intensity was discovered at e''', in the same vertical plane as the minimum intensity of the starboard section on the main deck.

The following table exhibits the maximum, minimum, and mean intensities of the stations assumed in the three longitudinal planes, arranged according to the sections in which they are found.

Intensities according to the Sections.

Name of the Deck.	Station.	Maximum Intensity.	Direction of the Ship's Head.	Station.	Minimum Intensity.	Direction of the Ship's Head.	Mean Intensity.
Starboard Section.							
Upper Deck,	L′	107.98	NNE	F′	89.64	SSE	100.69
Main Deck,	B″	154.36	SE by E½E	I′	92.50	W½S	115.79
Lower Deck,	L‴	115.49	SW½W	H‴	69.96	W by S½S	96.58
Middle Section.							
Upper Deck,	*η*′	119.54	NE by N½E	*ξ*′	80.29	N by E¾E	100.98
Main Deck,	*β*″	108.47	SE by E½E	*α*″	97.90	E by N½N	103.78
Lower Deck,	*γ*‴	128.15	SW¾S	*x*‴	74.83	W	104.04
Larboard Section.							
Upper Deck,	*a*′	118.68	SSW¼W	*o*′	s2.80	N by E½E	96.58
Main Deck,	*l*″	121.28	SW by S	*b*″	71.07	E½N	98.70
Lower Deck,	*h*‴	135.63	W¼S	*i*″	95.71	W½N	114.27

It also appears from the preceding table, that the mean intensity of the stations assumed in the middle section increases from the upper to the lower deck; the intensity augmenting however in a greater ratio from the upper to the main deck, than from the main to the lower deck. The mean intensity likewise in the starboard section increases considerably from the upper to the main deck; but from the last mentioned deck to the lower it diminishes in a still greater ratio. In the larboard section, however, there is a small increase of the intensity from the upper to the lower deck, amounting to nearly the same quantity as in the middle section; but from the main to the lower deck, the rapidity of increase is very considerable.

The intensities also in the line of stations assumed in the middle section on the main deck, approached much nearer a state of uniformity than those of any other; the difference between the greatest and least intensities being only 10.57; whereas the difference on the same deck, in the starboard section, amounted to 61.86, and in the larboard section 50.21. In these sections also the greatest uniformity was perceptible on the upper deck.

It is worthy of remark, moreover, that the mean intensities of the stations in the middle section on the different decks, accord very nearly with the means of the greatest and least intensities in the same section on the same decks;—a principle not to traced in the other sections.

By considering the different results according to the order of the sections on the same deck it will be perceived, that the mean intensity on the upper deck increases in a small degree from the starboard to the middle section, from which it undergoes a more considerable decline to the plane on the larboard side; but on the main deck, the average intensity decreases rapidly from the starboard to the middle section, and from thence, by a less rapid diminution, to the larboard plane. On the lower deck, however, the case is the reverse; the mean intensity being the least in the starboard section, from which it increases to the middle section, and finally attains its maximum in the larboard section.

The diversities however which exist in the intensities at the corresponding stations of the three sections abaft the mizen mast, merits a particular examination, on account of the effects which such varied and uncertain influences must have on the rates of chronometers. To afford some idea of the diversified nature of these intensities, the following results have been selected from many others, and which sufficiently prove that the action of induced magnetism in this part of the vessel is subject to the most singular and remarkable variations.

Experiments in the Captain's Cabin.								
Larboard Section.			Middle Section.			Starboard Section.		
Station.	Intensities.	Direction of the Ship's Head.	Stations.	Intensities.	Direction of the Ship's Head.	Stations.	Intensities.	Direction of the Ship's Head.
a''	92.31	ENE	α''	97.90	E by ½ N	A″	137.38	E by N ½ N
b''	71.07	E ½ N	β''	108.47	SE by E ½ E	B″	154.36	SE by E ½ E
c''	79.35	NE by E	γ''	107.36	NE by E	C″	128.15	ENE
d''	89.83	NE by E	δ''	98.87	NE by E	D″	127.84	NE ½ E
e''	80.45	E by N	ϵ''	108.22	E by N ¼ N	E″	126.89	E ½ S
Mean	82.60		Mean	104.16		Mean	134.92	

At the time the above experiments were performed, the iron tiller was exactly amidships; and the iron knees and braces round the stern and sides of the ship appeared to be so equally distributed, that it seems difficult to account for the different intensities recorded in the table, on any other principle than as arising from the constant fluctuations of the ship's head. That this at least is one of the primary causes of the observed anomalies, will be rendered exceedingly probable, from some observations which will be speedily advanced. Of the starboard section it may be remarked, that all the results very much exceed the assumed terrestrial intensity; but in the middle section, at two of the stations only, were the measures of the magnetic influence found below that of the earth; and in the larboard stations, the whole of the results were found much below. If the mean of the five intensities in the latter section be denoted by 10, that of the corresponding stations in the middle section will be 12.6, and of the starboard 16.3*

The magnetism arising from position is, it is well known, of a very variable kind; developing its intensity in some situations of an iron mass, with singular energy and force, and in others exhibiting only an action of the feeblest kind. Those changes also, manifesting their influence in an instan-

* The following observations made by Captain MOORSOM, on board the Ariadne, in Simon's Bay, at the Cape of Good Hope, will exhibit the anomalous results of a dipping needle when employed on ship board.

Experiments performed in the After Cabin.			
	Larboard Side.	Amidships.	Starboard Side.
Station,	b''	β''	B''
Dip,	51° 55′	52° 10′	51° 5′

In the fore cabin, at the station δ'' amidships, the dip was found to be 47° 47′.

On the quarter-deck, at the station ξ', between the binnacle compass, and on the stand for the azimuth compass, it was found to be 48° 15′.

In the after cabin at the station β'' amidships, the dipping needle showed 59° 25′, when placed in a plane inclined 45° to the magnetic meridian; but in the fore cabin at δ'', the instrument with the same azimuth gave only a result of 56° 15′.

In the stern sheets of the barge, on the booms, the dip was found to be 50° 22½′.

The dip determined in a house in Simon's Town, distant thtee quarters of a mile from the ship, was 48° 23′½, agreeing within 8′½ of that determincd between the binnacles.

The latitude of the ship was 34° 11′ 38″ S., and longitude 18° 28′ 35″ E. Variation 28° W.

taneous and rapid manner, may be supposed to have unfolded some anomalies in the course of the present experiments, from the numerous alterations which took place in the bearings of the ship's head, and the consequent change of intensity of every mass of iron.

In a preceding page, a table was introduced for the purpose of exhibiting the remarkable anomalies existing at different stations of the longitudinal sections abaft the mizen mast; but the succeeding observations relate to the changes which the intensity of the *same* station underwent in consequence of alterations in the bearings of the ship's head. At the starboard station B″, for example, the intensity was found to be 154.36, when the direction of the ship's head was SE by E$\frac{1}{2}$E, but declined to 52.85, when it bore W$\frac{1}{2}$N. At the larboard station *b*″, likewise, the intensity was found to be 71.07, when the head was directed E$\frac{1}{2}$N, and increased to 147.64, when it turned to W$\frac{1}{2}$N. At the latter station also, when the vessel's head was NW by N$\frac{1}{4}$W, it amounted to 112.81. The intensity at the station β'' in the middle section was likewise found to vary, but not in the same degree as the stations in the starboard and larboard sections. When the head, for instance, bore SE by E$\frac{1}{2}$E, the intensity at the last mentioned point amounted to 108.47; and when, by the influence of the tide, the same part of the vessel was directed W by N, it declined to 103.79; and when by the continued change of the ship's position the head became N$\frac{1}{2}$W, a farther declension took place to 99.43. These results however may be more clearly understood by a reference to the following table.

Station.	Intensity.	Direction of the Ship's Head.
	Starboard Section.	
B″	154.36 52.85	SE by E ½ E W ½ N
	Middle Section.	
β″	108.47 103.79 99.43	SE by E ½ E W by N N ½ W
	Larboard Section.	
b″	71.07 147.64 112.81	E ½ N W ½ N NW by N ¼ W

In the succeeding table will be found the different stations, at which the most considerable variations were observed in the magnetic intensity, during the uncertain positions of the vessel; and also the representative numbers for the intensities, corresponding to the respective bearings of her head. The fourth column exhibits the observed variation of intensity at each station; and the last, the simultaneous change of the ship's head in point of the compass.

Stations.	Intensity.	Direction of the Ship's Head.	Changes of Intensity.	Change of Ship's Head in Points.
		Starboard Section.		
C''	129.92 126.42	NE by E E by N	— 3.50	2
H''	95.71 94.79 92.70	WSW ½ W W by S W by S ½ W	— 0.92 — 2.09	½ ½
L''	119.68 116.31 113.07 110.48	WSW ½ W W by S W by S ½ W W by S ¾ W	— 3.37 — 3.24 — 2.59	½ ½ ¼
E'''	101.73 100.50 99.30 94.49	SSW ½ W SW by S SW ½ W SW by W ¼ W	— 1.23 — 1.20 — 4.81	½ 1½ ¾
		Middle Section.		
ε''	104.96 111.39	E ½ S ENE	+ 6.43	2½
η'''	115.62 113.74 113.07 111.77 110.10	S S by W ½ W SSW SSW ¼ W SSW ½ W	— 1.88 — 0.67 — 1.30 — 1.67	1½ ½ ¼ ¼
ν'''	125.34 131.07	SW SW by S ½ S	+ 5.73	1½
		Larboard Section.		
a''	90.68 96.33 89.74	ENE ENE ½ N E by N ½ N	— 5.65 — 6.59	½ 1
b''	65.68 70.29 77.53	E by S E ½ N ENE ½ E	+ 4.61 + 7.24	1½ 2
k''	118.12 120.99	SW by W ½ W SW	+ 2.87	1½

Some analogy may be traced between the magnetic changes recorded in the above table, and those which an iron mass undergoes when its situation is altered with respect to the magnetic meridian. If, for example, a number of points be assumed in an iron mass in the direction of the magnetic meridian, it is well known that the intensity of each point will diminish, as the stations are brought into a position at right angles with the first; and on the contrary, an increase of intensity will be observed when they are removed from the latter situation to the former. Changes of a similar kind may be distinctly traced in all the preceding observations. At either stations, ε'' and b'', for example, an increase of intensity was perceived as the ship moved from the position when her head was easterly, to that when it bore due north; and a similar change was observed at ν''' and k''', as her bow passed from a westerly direction to one exactly south. So also at the station H''', an augmentation of intensity was remarked as her head moved from a westerly to a southerly position; and on the contrary, a diminution of intensity as the direction of her bow was changed from south to west.

In like manner at the station a'', an increase of the magnetic power was discovered as the vessel passed from east to north; but a diminution of intensity as she moved from north to east. At the stations η''', H'', L'', E''', and K''', a decrease of intensity was likewise apparent as her head was carried by the current from south to west; and a change of a similar kind as it varied from north to east.

From these considerations it appears, that the changes in the magnetic intensity, at any station in the vessel, are regulated by laws analogous to those which influence simple masses of iron.

The variations of intensity however at the several stations were of a very unequal kind. In some parts of the ship, the alteration of a quarter of a point in the direction of her head was productive of a greater change than the variation of an entire point at some other stations. Nor does the change of intensity at the *same* point, appear to be proportional to the alteration in the direction of the ship's head. Such inequalities must however be considered as necessary consequences of the irregular distribution of the iron, and of its inequality of action.

The position of the common centre of force of all the determined intensities may be referred to the three rectangular co-ordinate planes, by the same method as that employed for the Scylla; and the application of the different numerical elements to the proper formula, furnishes the following results:

Value of S″ V″, being the Distance of the Centre of Force from the Horizontal co-ordinate plane.	Value of S″ W″, being the Distance of the Centre of Force from the Longitudinal co-ordinate plane.	Value of S″ T″, being the Distance of the Centre of Force from the Transverse co-ordinate plane.
9.45	16.08	59.81

By comparing these results with the actual dimensions of the ship, it appears that the common centre of force of all the intensities is at the point S″, 59.81 feet from the transverse co-ordinate plane near the fore part of the main-mast, and 4.71 feet abaft the prolongation of the after part of the shot-locker. From the horizontal co-ordinate plane the same point appears to be 9.45 feet distant, and hence 1.25 feet above the plane of the main deck. Its distance also from the longitudinal co-ordinate plane is .08 feet on the starboard side; and practically considered, may be regarded as in the middle section of the ship.

Of the Impregnable of 104 *guns.*

Many interesting results were obtained on the different decks of this fine ship. Three longitudinal planes, similar to those adopted in the Ariadne and Scylla, were supposed to intersect her different decks from the poop and forecastle, down to the hold and kelson; and stations were assumed in each, at which the intensities were determined. Figure 3, Plate XIX., denotes the section formed by the plane passing through the principal axis; and the letters A, B, C, D, E, F, G, H, I, the stations assumed in it on the poop, quarter deck, and forecastle. The dotted lines proceeding from each of these stations, intersecting the successive decks, &c. of the vessel, represent the positions of the points at which the intensities of the other parts of the section were determined. In the following table, the numerical results of the intensies are recorded; those of the other sections having been suppressed, on account of the length to which the enquiry has extended.

	STATIONS.									
Names of the Decks.	A.	B.	C.	D.	E.	F.	G.	H.	I.	Mean of the Intensites.
Poop, - -	100.00	100.66	104.19	—	—	—	—	—	—	101.62
Quarter Deck and Forecastle,	98.69	91.29	104.54	98.91	94.94	98.27	100.44	109.14	96.58	99.20
Main Deck,	96.58	89.96	102.91	100.33	98.70	93.93	92.64	118.03	100.00	99.23
Middle Deck,	88.76	94.83	80.73	100.88	102.69	100.22	94.43	94.63	96.06	94.80
Lower Deck,	—	102.34	108.88	108.27	95.04	101.22	88.67	90.72	100.00	99.39
Orlop Deck,	—	—	—	91.67	95.75	75.08	93.23	101.89	97.42	92.51
Hold, - -	—	—	—	96.37	83.00	78.47	87.67	121.77	87.22	92.42
On the Kelson in the Pump Well,	—	—	—	—	—	107.05	—	—	—	107.05
Mean of the Intensities,	96.01	95.82	100.25	99.40	95.02	93.46	92.85	106.03	96.21	—

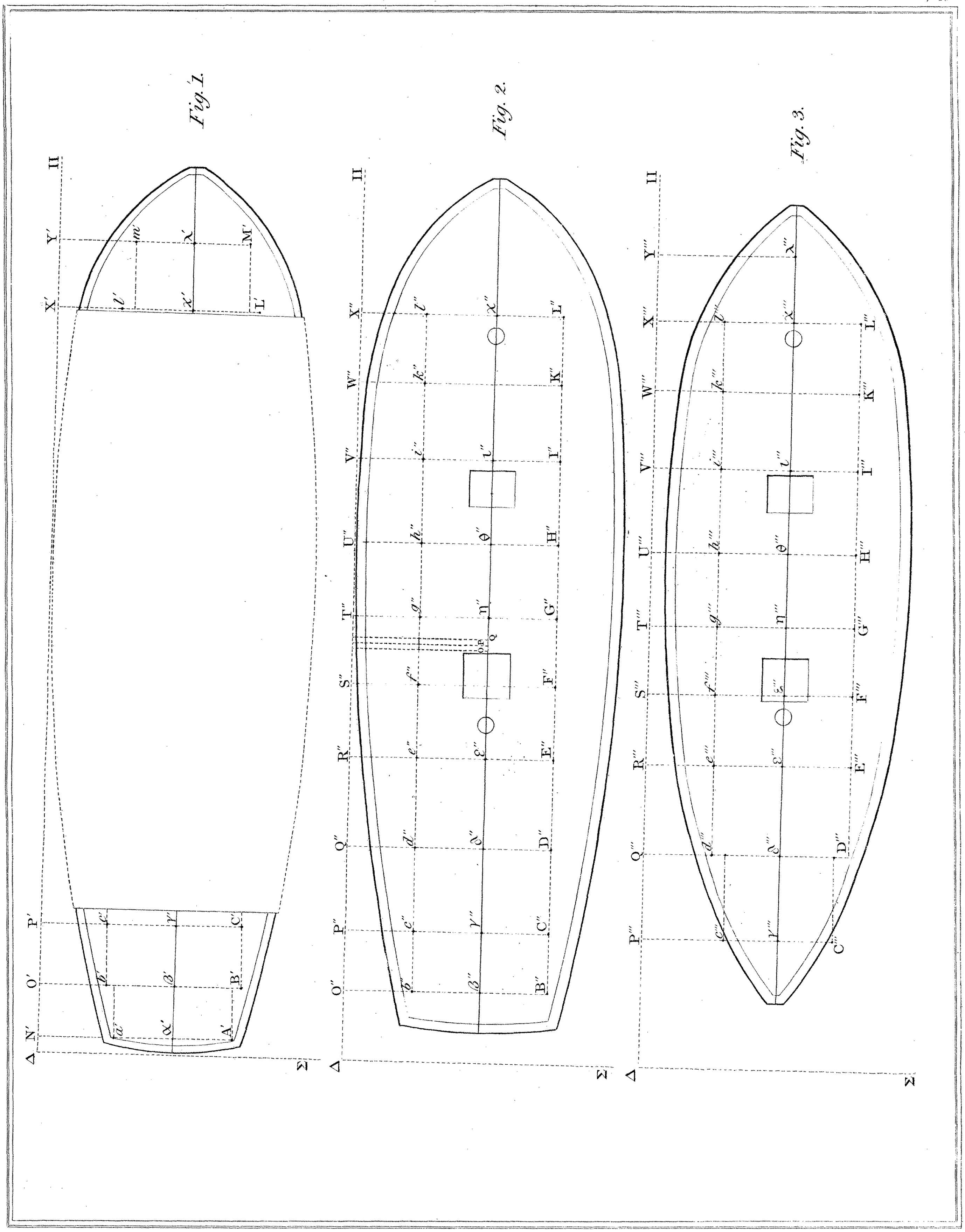
From an inspection of the preceding results it appears, that in passing from the mean intensity of the poop, to that of the quarter deck and forecastle, there is a decrease amounting to 2.42; from the deck last mentioned to the main deck, a feeble increase of 0.03; from the main to the middle deck, a diminution of 4.43; from the middle to the lower deck, an increase of 4.59; from that to the orlop deck, a decrement of 6.88; from the orlop deck to the hold, another decrement of 0.09; and from the mean intensity of the hold to the single intensity determined on the kelson, an increment of 14.63. Hence it appears, that the greatest mean intensities are found at the extremes of the series; that the mean results of the quarter deck and forecastle, and main and lower decks, are very nearly the same; as are also those of the orlop deck and hold. The mean intensity of the middle deck is also very nearly a mean, between the mean of the intensities of the three first mentioned decks, and of the two latter. The mean of the deck from the poop to the middle deck inclusive, is 98.71; and of the lower and orlop decks, hold and kelson 97.84. The mean of all the decks is 98.28, being 1.72 less than the assumed terrestrial intensity.

In taking the means of the lines of stations vertically, it will be perceived, that the maximum intensity is attained at the line of stations denoted by H, and the minimum at the adjacent stations G. If also the mean of the middle column of intensities E be adopted, the result will be very nearly the same as the mean of the intensities of the middle deck; and likewise, that the mean of the results of the columns A, B, C, D, abaft the column E, is very nearly equal to that of the columns F, G, H, I, on its other side; the former being 97.89, and the latter 97.13. It is proper to add, that this vessel had not her lower deck guns on board.*

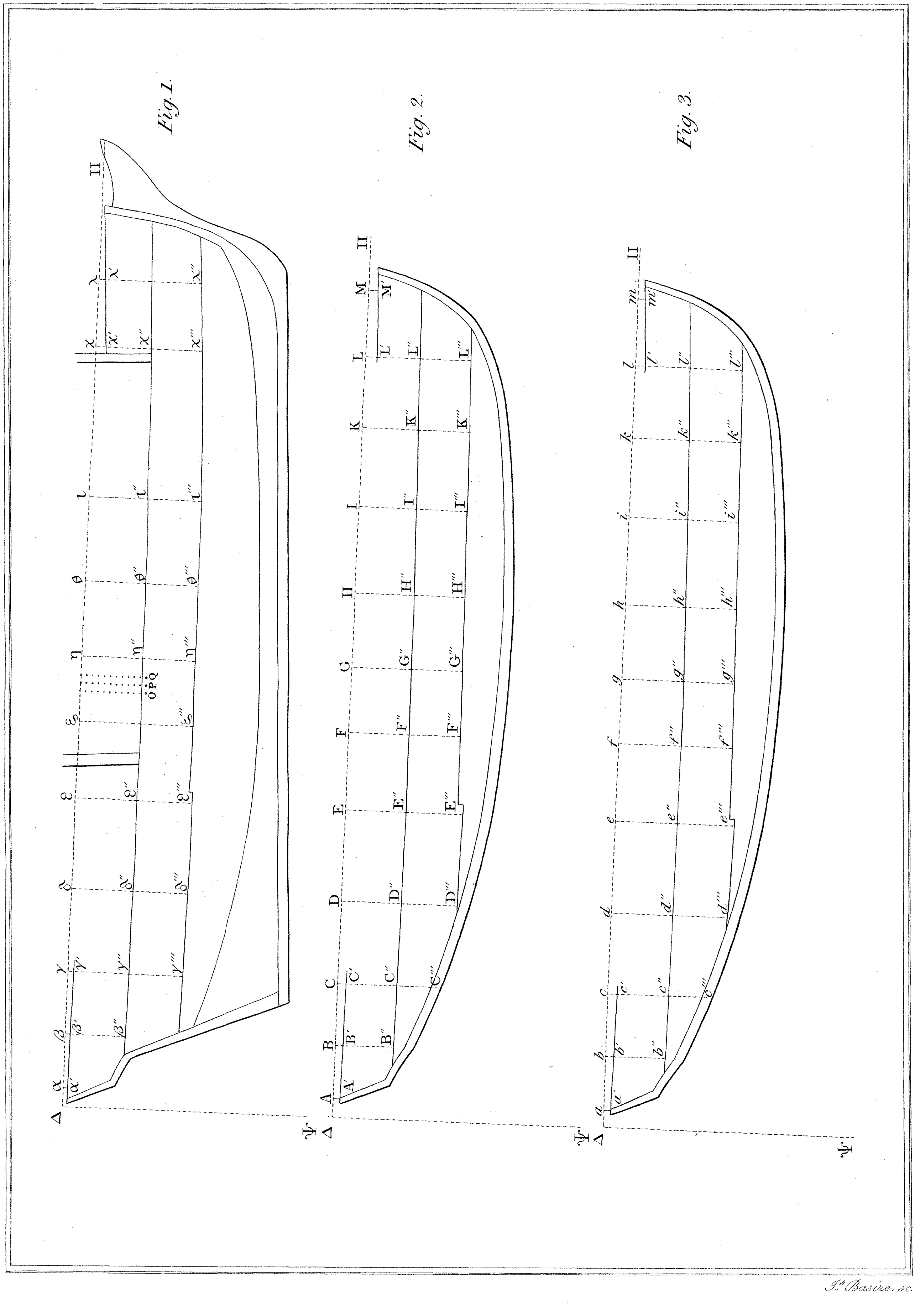
As examples of the diversities of intensity existing in different ships at stations similarly chosen, and determined by the same instrument, the following are selected. The primary position assumed in each vessel was that of the binnacle, as A, Plate XIX., fig. 4. The right line MN, which passes through this point, is supposed to denote the principal axis of the ship, M being the after part. The lines CD, EB, which likewise pass through A, and form angles of 45° with the axis, are each 16 feet in length. At the extremities of those lines, and also at the station A, the intensities were determined by a mean of six experiments, and the results are recorded in the following table. The oscillating bar was elevated in each case at the constant height of 20 inches above the deck.

	Caledonia, 120 guns.		St. Vincent, 120 guns.		Malta, 84 guns.		Cornwallis, 74 guns.		Nereus, 46 guns.		Melampus, 46 guns.	
Stations.	Intensity.	Direction of the Ship's Head.	Intensity.	Direction of the Ship's Head.	Intensity.	Direction of the Ship's Head.	Intensity.	Direction of the Ship's Head.	Intensity.	Direction of the Ship's Head.	Intensity.	Direction of the Ship's Head.
A	101.74	N by E	104.49	SW by S	94.39	SE	89.74	SSW	96.95	N by W	100.95	S by W
B	108.97	N by E	102.64	S by W½W	102.07	SE by S½E	80.37	SSW	107.98	N by W½W	105.92	S by W½W
C	103.68	N by E	99.08	SSW	90.02	SE by S	97.48	SSW	100.84	NNW	96.64	S½W
D	105.43	N by E	100.62	S by W	106.51	SE by S	99.85	SSW	103.44	NW by N	104.26	S by W
E	103.10	N by E	98.01	S by W	97.29	SE by S½E	96.12	SSW	95.40	NW	104.96	S
Mean	104.58	Mean	100.97	Mean.	98.06	Mean.	92.71	Mean.	100.92	Mean.	102.55	

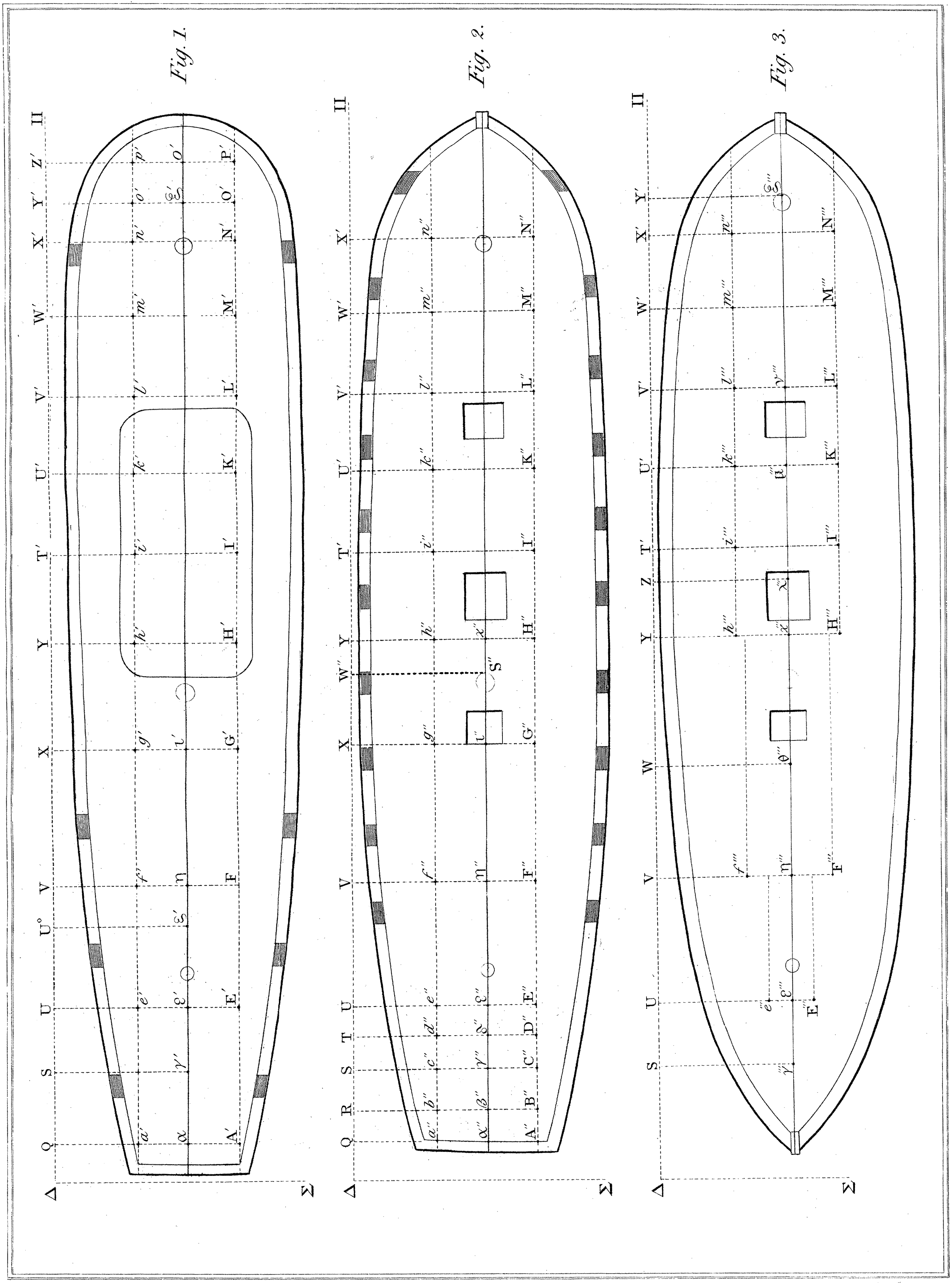
* The assistance I received from the officers of the Impregnable, in enabling me to obtain suitable stations for determining the intensity, demand from me the warmest acknowledgments.



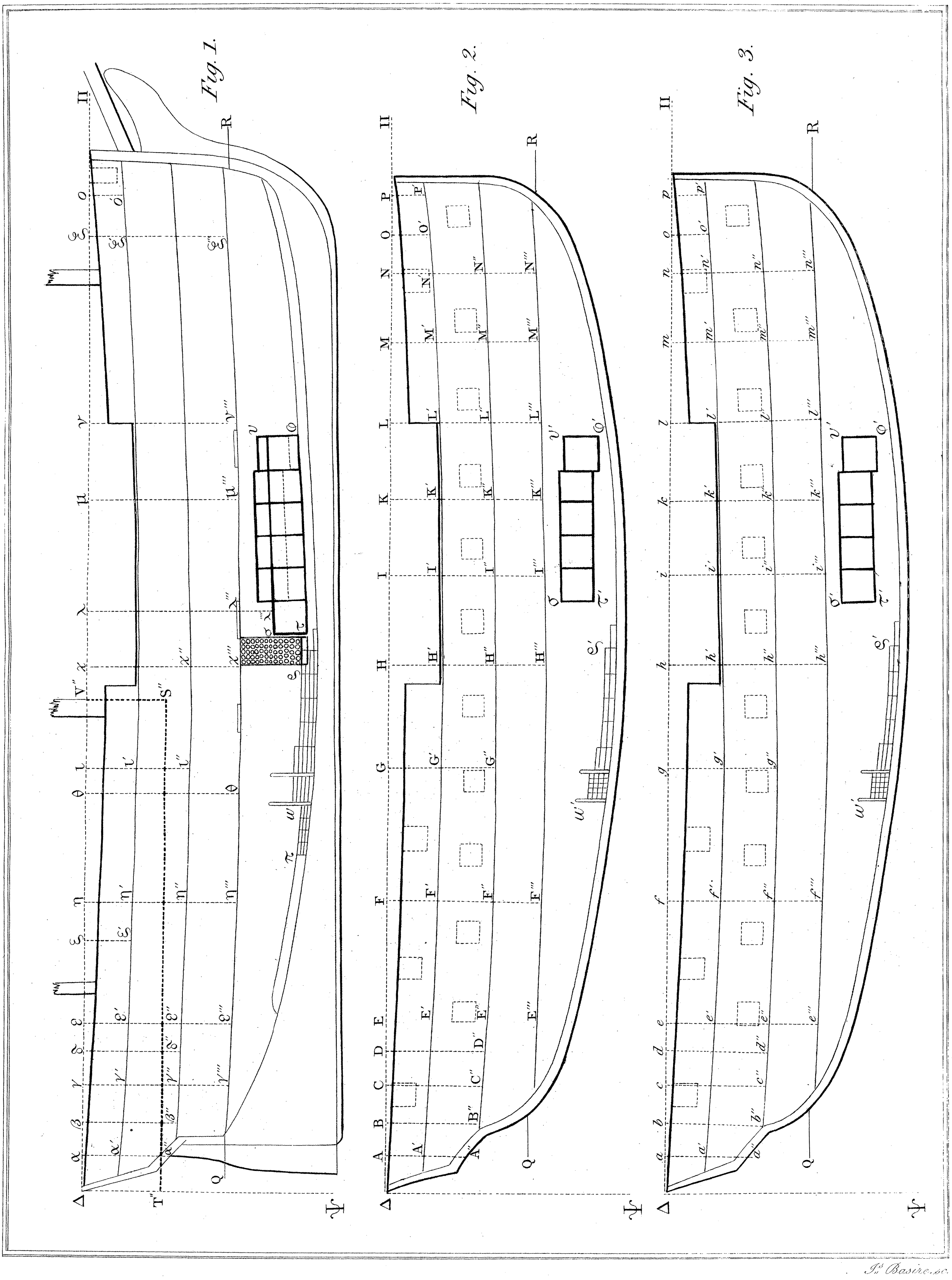
Js. Basire, sc.



J. Basire. sc.



J. Basire, sc.



Js. Basire sc.

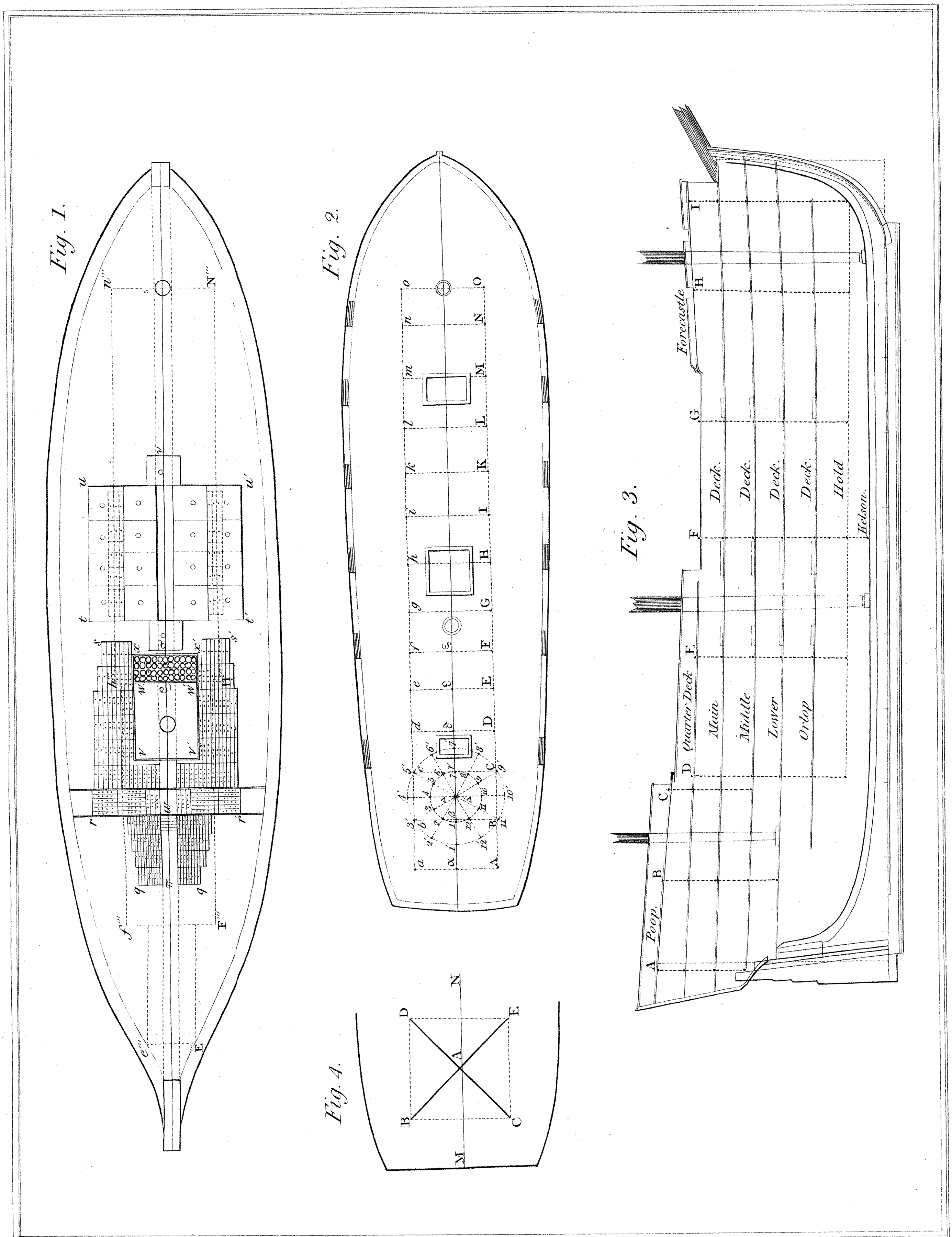


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Forecastle
Quarter Deck
Main Deck
Middle Deck
Lower Deck
Orlop Deck
Hold
Kelson
Poop

J. Basire sc.

The diversities which prevail in the above intensities, must be attributed to the unequal distribution of the iron in the different ships, and to the varied directions of their heads. No definite relation appears to exist between the magnitudes of the ships, and the several results. The example of he Cornwallis deserves notice, as having the intensities of all its stations singularly below the assumed terrestrial intensity. It may be proper to add, that these ships were in a state of ordinary, in Hamoaze, and that the intensities are therefore due to the hull alone.

As a useful practical remark it may be added, since some difference of opinion has existed on the subject, that during the course of these experiments it has appeared, that the changes and diversities of intensity on board small ships of war, are more considerable than those which take place in vessels of a larger class.

The mean latitude of the positions of the ships may be regarded as 50° 22′ 53″ N; and longitude 4° 14′ 44″ W.

Plymouth, May 1, 1823.