XVIII. *On the Changes which take place in the Deviations of the Standard Compass in the Iron Armour-plated, Iron, and Composite-built Ships of the Royal Navy, on a considerable change of Magnetic Latitude.*

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The period comprised between the years 1855–68 was one of active research into the magnetic character of the armour-plated and other ships of the Royal Navy and the iron ships of the Mercantile Navy.

It will be remembered that the Transactions of the Royal Society are rich in contributions to this important and interesting subject; important in a practical sense to the navigator, and of great interest as a subject of intelligent inquiry.

Among these contributions was a paper read before the Royal Society in March, 1865, "On the Magnetic Character of the Armour-plated ships of the Royal Navy, and on the effect on the compass of particular arrangements of Iron in a ship," by Frederick John Evans, Esq., Staff Commander, R.N., F.R.S., and Archibald Smith, Esq., M.A., F.R.S. This paper contained the earliest published results of the system of observation and analysis of the deviations of the compass in the ships of the Royal Navy, which, established in 1861, has been carried out to the present day.

These results showed the magnetic character of the several ships named, from the time of launching until fully equipped and at sea, and also an analysis of the semi-circular deviation of those ships which had made short voyages abroad. But the change of magnetic latitude through which the ships passed was so small, and the alternative of heeling the ships in one latitude so difficult, that the authors of the paper were unable to ascertain any but approximate values of the proportions of hard and soft iron affecting their compasses.

The authors write: "The determination of the proportion of the semicircular deviation, or rather of B, which arises from vertical induction in soft iron, and that which arises from the permanent or sub-permanent magnetism of hard iron, is a matter of great interest. Theoretically it may be determined in two modes, either by observing the deviation in two different magnetic latitudes, or by observing the

deviation with the ship upright and heeled over.   Unfortunately there is a great want of observations under these circumstances."

During the last fifteen years long voyages into high southern magnetic inclination or dip, have been made in every class of ship in the Royal Navy, except Turret-ships, and according to the established system of the Admiralty Compass Department, the observed deviations of their compasses made in all latitudes have been analysed to obtain the values of their coefficients as shown in Table III. of this paper.   From these coefficients, the constants of the hard and soft iron producing semicircular deviation at the Standard Compass positions have been computed.

A knowledge of these Constants not only provides a means of predicting for the particular ship examined the probable changes which will take place in her deviation in all parts of the navigable world, but also the power of doing the same for other ships of the same class.

Such being the case, it is thought that the Royal Society will be interested in receiving a paper treating of these subjects, commencing from the time the ships are fully equipped and ready for sea.   The earlier magnetic history of the ships might have been included, but the changes which take place in their fitting, and the numerous iron bodies introduced after launching, render a comparison of the deviations observed at different stages of equipment unsatisfactory.

It is proposed to consider six classes of ships, each of which has been selected for the long range of magnetic latitude over which the ships have sailed :—

1. Iron, armour-plated.
2. Iron cased with wood.
3. Iron troop-ships.
4. Steel* and iron cased with wood.
5. Composite built.
6. Wooden ships with iron beams and vertical bulkheads.

These ships have nearly all been launched upwards of a year previous to the observations about to be discussed, and subjected to the vibration caused by steaming at high rates of speed with powerful engines.   They may therefore be considered to have attained a state of magnetic stability.†

At the close of this paper will be found in Table III. a short description of the ships, the direction in which they were built, and the coefficients for each Standard Compass.

It is not intended to repeat the several mathematical formulæ by means of which

* The vessels have iron frames, and are plated with mild steel, containing ·2 per cent. of carbon.
† See Phil. Trans., 1865, Part I., pp. 279–280.

these coefficients have been computed, as they, together with the methods of making the original observations, were so fully described in the paper on "The Magnetic Character of the Armour-plated ships of the Royal Navy," &c., 1865, to which allusion has already been made.

On comparing the results, however, in that paper with those now brought forward for discussion, a remarkable difference will be observed. In the paper for 1865, the coefficients of the semicircular deviation are those of compasses to which no mechanical correction by permanent magnets had been applied. The corresponding coefficients in the accompanying Table III. have, with the exception of the original values in England, been computed from the deviation of compasses for which a permanent bar magnet, or magnets, has been employed to annul or correct the semicircular deviation.

This correcting magnet has in every case been permanently fixed horizontally in the compass pillar, in the resultant of the magnetic forces producing semicircular deviation, and at a distance found tentatively below the card, after the several horizontal and vertical forces affecting the compass had been ascertained.

It may be asked, whether this application of correcting bar magnets of possible variable magnetic moment does not in itself introduce an element of change in the deviation in addition to those of the ship? It may be answered, with the reasonable confidence induced by fifteen years' trial, that the permanency of the magnetic moment of the magnets employed is considered to be assured.

Thus, in the ships named in the tables, the correction by magnets may be considered as the introduction into them of a permanent magnetic force acting independently on their compasses, and in opposition to the permanent magnetic forces of the ships.

It is now proposed to pass on to the chief object of this paper, which is to show the amount and direction of the changes which take place in the deviations of the standard compasses in six different classes of modern vessels in the Royal Navy, on change of magnetic latitude.

Taking the exact coefficients in Table III. in the order in which they stand we have first :—

The constant deviation.

𝔄.

Some rather large values of this coefficient are found in the tables, but it has been proved that for standard compasses placed in the central fore and aft line of the vessel where the iron is symmetrically placed with respect to that position, little or no real value from magnetic causes has been observed. An error in the bearing of the distant object used for swinging the ship, swinging her too fast, or prism error in the azimuth circle, gives fictitious values of this coefficient, which those in the table are considered to be.

Semicircular deviation.

Coefficient $\mathfrak{B} = \dfrac{1}{\lambda}\left(c \tan \theta + \dfrac{\mathrm{P}}{\mathrm{H}}\right)$ (approximate value in degrees $=$B) is the maximum

of semicircular deviation from fore and aft forces ;

$\dfrac{c}{\lambda} \tan \theta$ arises from soft iron ;

$\dfrac{\mathrm{P}}{\lambda \mathrm{H}}$ from hard iron.

Coefficient $\mathfrak{C} = \dfrac{1}{\lambda}\left(f \tan \theta + \dfrac{\mathrm{Q}}{\mathrm{H}}\right)$ (approximate value in degrees $=$C) is the maximum

of semicircular deviation from transverse forces ;

$\dfrac{f}{\lambda} \tan \theta$ arises from soft iron, and is zero if the iron is symmetrically

arranged ;

$\dfrac{\mathrm{Q}}{\lambda \mathrm{H}}$ from hard iron.

For determining P and c separately, when $\mathfrak{B}$ has been determined in two different magnetic latitudes, the foregoing equations are put under the form,

$$\frac{\mathrm{P}}{\lambda} + \frac{c}{\lambda}\mathrm{H} \tan \theta = \mathfrak{B}\mathrm{H}$$

$$\frac{\mathrm{P}}{\lambda} + \frac{c}{\lambda}\mathrm{H}' \tan \theta' = \mathfrak{B}'\mathrm{H}'$$

and similarly for Q and f when $\mathfrak{C}$ has been determined in two different latitudes.

From the values of $\mathfrak{B}$ and $\mathfrak{C}$ in the table, the constants P and c, Q and f, have been calculated by the above formulæ, and the results are given in Table I., which for convenience has been placed at the end of this paper.

The explanation of this table is as follows :—

The quantities found in the columns headed " Original P " and " Original Q " are the constants P and Q, arising from the hard iron of the ship before correction by magnets, and which are mainly dependent for their values and sign upon the direction in which the ship's head lay during building. This direction is given under each ship's name.

In the columns headed " Corrected P " and " Corrected Q " are shown the constants P and Q as altered by the correcting magnets.

The quantities $\dfrac{c}{\lambda} \tan \theta$ and $\dfrac{f}{\lambda} \tan \theta$ (with their equivalents expressed in degrees) are the changing parts of the coefficients $\mathfrak{B}$ and $\mathfrak{C}$ respectively, for the South of England, which can only be corrected for all latitudes by vertical soft iron bars.

From the constants c and f in the remaining columns, the changing part of the

coefficients $\mathfrak{B}$ and $\mathfrak{C}$, arising from vertical induction in soft iron, may be computed whenever the magnetic inclination or dip is known, or can be taken from charts of that element.

Before further investigating the effects of a change of magnetic latitude on the coefficients, the question of how far time affects the constants P and Q requires consideration.

On looking over the values of P and Q, it will be remarked that in some ships a change takes place immediately after leaving England, which appears to be neither due to time nor change of latitude, but to another cause which will hereafter be referred to. Taking the values obtained subsequently at different times in the same geographical position it will be found—

		P.	Change.	Q.	Change.
Bellerophon.—Quebec	1874 1876	−·002 −·020	·018	−·003 −·008	·005
Iron Duke.—Hong-Kong	1880 1881	−·208 −·193	·015	−·002 −·037	·035
Northampton.—Halifax, N.S.	vi. 1880 x. 1880	+·024 +·032	·008	−·037 −·057	·020
Active.—Simon's Bay, C. G. Hope . .	x. 1874 x. 1876	−·120 −·096	·024	−·019 −·006	·013
Raleigh.—Spithead	ix. 1874 vi. 1876	+·043 +·057	·014	+·026 +·001	·025
Inconstant—Spithead	viii. 1869 xi. 1871	−·023 −·044	·021	+·016 +·017	·001
Himalaya.— Plymouth	vii. 1872 vii. 1874	−·030 −·021	·009	−·061 −·058	·003
Simon's Bay, C. G. Hope	viii. 1872 i. 1875	−·030 −·021	·009	−·042 −·081	·039
Albatross.—Sheerness and Plymouth .	iii. 1874 x. 1874	−·066 −·064	·002	+·015 +·022	·007
Boxer.—Esquimault, V. I.	x. 1869 x. 1874	−·008 −·004	·004	−·049 −·030	·019
Encounter.—Simon's Bay, C. G. Hope .	iv. 1874 i. 1876	+·002 −·048	·050	+·022 −·001	·023

Thus, in the worst case amongst the armour-plated, iron, and composite vessels, P takes a year to alter ·015, and generally two or three years for about half that amount. A change of ·015 in P would make about a degree change in the deviation. This evidently slow change of P by time is important, as should P alter during the ship's sailing over a long range of magnetic latitude, the values of c, as found by the above formulæ, are correspondingly untrustworthy.

With regard to the constant Q, although more subject to change by time than P, it is comparatively of less importance, as, with few exceptions, the value of the constant f, which depends on the constancy of Q, is, if not zero, so small as to be neglected.

Having accepted as the result of fifteen years' trial that the correcting bar magnets

are of constant magnetic moment, it would be reasonable to expect that the constants P and Q should remain unchanged in value, except the small decrease due to time. This is nearly the case, yet there are small fluctuations in them which demand notice.

It is known that if an iron vessel be placed in dock for any length of time in one direction with respect to the magnetic meridian, the values of P, and especially Q, undergo small changes dependent upon that relation. If, in addition, the vessel be subjected at the same time to concussion, from whatever cause, the change is greater. On the return of the vessel to her anchorage, or on proceeding to sea when the direction of her head varies frequently, P and Q return slowly to their original value.

It may therefore be inferred, that although P and Q as shown in the tables are for the most part due to permanent magnetism in the hard iron of the ship, there is a small part which is sub-permanent and subject to alterations from concussion, or the vibratory motion caused in the ship by powerful steam-engines when proceeding in a given direction for several days. On the removal of the cause inducing the change in P and Q they gradually return to their original values.

In the turret ships of the Royal Navy, where the standard compass is necessarily placed on a thin iron superstructure, this temporary dislocation of parts of P and Q, caused by the concussion of firing heavy guns and subsequent gradual recovery, is well known and provided for on board by constant observation for deviation of the compass.

Before considering the constants c and f, which represent the chief part of the changes which take place in the deviation of the compass on change of magnetic latitude, a few preliminary remarks appear to be necessary.

In " Contributions to Terrestrial Magnetism," No. IX.,* Sir EDWARD SABINE records the result of his investigations as to the effects of a change of magnetic latitude on the deviation of the Standard Compass of some wooden sailing ships of forty years ago. He concluded that their deviations were caused by vertical induction in soft iron, that they did not change directly in proportion to the dip, but there was a lagging behind proceeding from a slowness in the soft iron to part with its induced magnetism. For example, a ship passing quickly from 40° N. to 20° N., dip, would find the deviation due to vertical induction in 20° N., dip, to be that of 30° or 32° N.

In considering how far this theory applies to modern armour-plated and iron vessels, it may help to clear the question to note the rapidity with which horizontal soft iron, when magnetised by the earth's horizontal force, takes up and parts with its induced magnetism, as exemplified in swinging a ship for deviation of the compass.

In this operation—during which the direction of the ship's head passes through a complete circle—the deviation caused by horizontal induction in soft iron attains two maxima in an easterly and two in a westerly direction within an hour and a half.

* See Phil. Trans., 1849.

Looking to this result, it hardly seems probable that vertical induction in soft iron should be slower in its action, and require perhaps days for full development.

Among the iron armour-plated ships of the tables we have, in the case of the "Triumph" and "Swiftsure" (two sister ships), experimental evidence that there is no sign of "lagging" in the changing part of their deviation, but that it alters directly as the tangent of the dip for any given position of the ship.

Both vessels, from requirements of the service, have their standard compasses placed unusually far from the stern, in a position 13 feet from the top of an armour-plated transverse bulkhead 5 inches thick. These ships were swung in the course of a few successive months, the observed deviations in each case but one corresponding with the dip at the locality, the values of which were as follows:—

$$\theta.$$

$$\text{Triumph} \quad \left\{\begin{array}{r} -44^\circ \\ -34 \\ -3 \\ +38 \end{array}\right\} \text{Range of } \theta \ 82^\circ.$$

$$\theta.$$

$$\text{Swiftsure} \quad \left\{\begin{array}{r} +67^\circ \\ +17 \\ -11 \\ -29 \\ -52 \end{array}\right\} \text{Range of } \theta \ 119^\circ.$$

To proceed with the constants c and f.

The values of c are very valuable, not only as a means of predicting the probable change of deviation for the particular ships in which they are known, but also for ships of similar construction. As an illustration of the similarity of this constant in certain ships, the following examples are given where sister ships are bracketed:—

	$c.$
{ Triumph	+·106
Swiftsure	+·110
{ Northampton	−·021
Nelson	−·014
Shah	−·005
Raleigh	−·006
{ Comus	+·034
Cleopatra	+·032
Carysfort*	+·044
{ Boxer	+·023
Pert	+·026
Firefly	+·005
Wrangler	+·002

* The "Carysfort" is a sister ship to "Comus" in every respect, with the exception that the former has no vertical iron shaft through which the screw is raised. In the "Comus" and "Cleopatra" this shaft is 30 feet from the compass.

From the position of the standard compass in the "Northampton" and "Nelson," 83 feet from the stern, a positive value of c might have been expected; but there is a transverse armoured bulkhead, 8 inches thick, the top of which is 30 feet nearer the stern than the compass in each vessel, which is the probable cause of the minus sign for c.

It is a subject for further inquiry as to what extent iron masts contribute to the values of c when the Standard Compass is placed near them. A series of experiments was made near Athens, where the magnetic dip is approximately 53° N., and at Singapore, in 13° S. dip, on board the "Ruby."* The Standard Compass of this ship is placed at 6 feet 9 inches from the iron mizenmast. The results showed that at three different parts of the mast (on a level with the compass, and a few feet above, and below that level) the effects of transient induction were very small, and that the mast acted almost entirely as a permanent magnet.

The remaining constant of the semicircular deviation, f, is one which has hitherto been accepted as zero, from the iron in the transverse section of the ships of the Royal Navy—except turret ships—being considered as placed symmetrically with respect to the Standard Compass.

In the Table I., however, there are five ships for which values of f have been discovered, and one, the "Triumph," in which it reaches an amount which could not be disregarded in a forecast of that vessel's deviation for any given geographical position. From Table I. the following values of f have been collected:—

	f.	$\frac{f}{\lambda} \tan \theta$ in England.
Bellerophon.	−·005	−·012=0° 42'
Triumph.	−·013	−·038=2° 10'
Swiftsure	+·004	+·010=0° 35'
Active	+·004	+·010=0° 35'
Himalaya	+·006	+·015=0° 52'
Comus	−·004	−·010=0° 35'

From the peculiar construction of some of the later types of armour-plated ships the constant f will probably attain higher values than those hitherto experienced.

Quadrantal deviation.

Coefficient $\mathfrak{D} = \dfrac{a-e}{2\lambda}$ (approximate value in degrees $=$D) is the maximum of quadrantal deviation from soft iron symmetrically placed.

Coefficient $\mathfrak{E} = \dfrac{d+b}{2\lambda}$ (approximate value in degrees $=$E) is the maximum of quadrantal deviation from soft iron unsymmetrically placed.

* These experiments were made by Navigating Lieutenant HENDERSON, R.N., of the "Ruby."

On again referring to the paper " On the Magnetic Character of the Armour-plated Ships, &c.," of 1865, we read at page 275, " D and E do not change with a change of geographical position."

As regards $\mathfrak{D}$ this is fully confirmed by the results in the tables. Time alone appears to cause a gradual change in this coefficient during the first two or three years after launching, after which it remains remarkably permanent.

Coefficient $\mathfrak{E}$ has no real value in the ships under discussion.

Coefficient λ.

$\lambda = 1 + \dfrac{a+e}{2}$ is a factor generally less than 1, giving the northern component of the mean directive force of the needle, or " mean force to north."

λ, as might be expected from its close connexion with $\mathfrak{D}$, appears to be affected solely by lapse of time similarly to $\mathfrak{D}$; for example, in the " Malabar" (a sister ship to the " Euphrates" of the tables), a valuable series of observations was made between England and Bombay,* the results of which are here recorded.

		λ.
Malabar.—Spithead,	17 vi. 67	·861
Aden,	10 i. 70	·861
Bombay,	$\frac{11}{13}$ ii. 70	·906
Suez,	xi. 70	·907
Spithead,	5 ix. 71	·932
Spithead,	28 x. 78	·930

Each of the above values of λ is the mean of several observations conducted under favourable circumstances, and the observations, as far as they go, confirm the conclusions drawn from other ships in England. The ship's visit to the heat of the tropics seems to have accelerated the change in λ.

Coefficient μ.

$\mu = 1 + k + \dfrac{\mathrm{R}}{\mathrm{Z}}$, in which k represents the vertical force caused by vertical induction in the soft iron of the ship; R the vertical force from the hard iron.

The values of μ contribute largely in many ships to the heeling error. For the purpose of eliminating the values of k from R observations in widely different magnetic latitudes are still required.

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In order to show the relative proportions of hard to soft iron affecting the standard compasses of the ships named in the tables—which are cruisers liable to be sent on long voyages—the values of $\sqrt{P^2+Q^2}$ and $\sqrt{c^2+f^2}$ have been placed together here—

	$\sqrt{P^2+Q^2}$	$\sqrt{c^2+f^2}$
Iron armour-plated ships—		
Bellerophon	·216	·005
Iron Duke	·416	·060
Triumph	·039	·106
Swiftsure	·058	·110
Northampton	·345	·021
Nelson	·287	·024
Iron vessels cased with wood—		
Active	·541	·016
Shah	·173	·005
Raleigh	·282	·006
Inconstant	·238	·039
Iron troop-ships—		
Euphrates	·359	·027
Himalaya	·281	·009
Orontes	·219	·029
Steel and iron ships cased with wood—		
Comus	·238	·034
Carysfort	·263	·044
Cleopatra	·076	·032
Composite vessels—		
Ruby	·500	·027
Gannet	·185	·024
Albatross	·232	·029
Boxer	·196	·023
Pert	·244	·026
Firefly	·332	·005
Wrangler	·375	·002
Wooden ships with iron beams, &c.—		
Encounter	·234	·018
Sapphire	·233	·045

On looking through the above values of $\sqrt{P^2+Q^2}$, it will be noticed that large differences occur in ships of similar construction.

It will be remembered that all iron and composite vessels are large magnets,

generally of widely different forms.   The values of $\sqrt{P^2+Q^2}$ are, therefore, chiefly dependent upon the position which the standard compass occupies on board these ships, considered as magnets.

Again, each iron body introduced during equipment into that great magnet, the ship, tends to modify in one direction or another its action upon the compass.

Consequently, if the compass be moved from the stern along the central longitudinal line of a ship towards her bow, it will be subjected to the influence of forces varying from those of repulsion or attraction, to zero, and then to those of attraction or repulsion.

For example, the " Iron Duke " and the " Triumph "—although not sister ships— are alike in many points, and built nearly in the same direction.

	$\sqrt{P^2+Q^2}.$	Distance of standard compass from stern.
Iron Duke . . .	·416	81 feet.
Triumph . . .	·033	105 ,,

It might at first sight be inferred from these results, that the position of the compass in " Triumph " is better than in the " Iron Duke." Keeping in view the object—always much desired—of so placing the compass as to have, when corrected, small changes of deviation on change of magnetic latitude, it will be seen this is not the case.

A reference to the values of $\sqrt{c^2+f^2}$, representing the changing part of the deviation, shows that in the " Iron Duke " the value is $+·060$; in the " Triumph " it is $+·106$.   Thus, the " Triumph's " compass would be improved as regards deviation by moving it further towards the stern and away from the armour-plated bulkhead causing the large value of c, and opposing the increased value of P which would ensue, by a bar magnet.

These considerations tend to show the importance of the long-established regulations with regard to the placing of the standard compass in ships of the Royal Navy, which provide, that the best possible position with regard to surrounding iron shall be selected for it, subject to the interests of the ship as an engine of war.

General Conclusions.

The following general conclusions have especial reference to the Standard Compass positions in those vessels mentioned in the tables, and to all others of similar types.

1. A large proportion of the semicircular deviation is due to permanent magnetism in hard iron.

2. A large proportion of the semicircular deviation may be reduced to zero, or corrected for all magnetic latitudes, by fixing a hard steel bar magnet or magnets in the compass pillar in opposition to and of equal force to the forces producing that deviation.

3. A very small proportion of the semicircular deviation is due to sub-permanent magnetism, which diminishes slowly by lapse of time.

4. The sub-permanent magnetism produces deviation in the same direction as the permanent magnetism in hard iron, except when temporarily disturbed, (1) by the ship's remaining in a constant position with respect to the magnetic meridian for several days, (2) by concussion, (3) or by both combined, when the disturbance is intensified.

5. To ascertain the full value of changes in the sub-permanent magnetism, observations should be taken immediately on removal of the inducing cause.

6. In the usual place of the standard compass the deviation caused by transient vertical induction in soft iron is small, and of the same value (nearly) for ships of similar construction.

7. The preceding conclusions point to the conditions which should govern the selection of a suitable position for the standard compass with regard to surrounding iron in the ship.

TABLE I.—Values of the Constant Parameters P and c, Q and f, at Standard Compass Positions in Her Majesty's Ships.

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	c.	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	f.

Armour-plated ships.

BELLEROPHON.—Built S. 51° E. Distance of standard from stern 61 feet, from iron mast 15 feet.

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	c.	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	f.
Spithead . . .	3 xi. 73	+·024	−·004	0·	0	+·215	+·025	$\left.\begin{array}{c}-·012\\ =\\ -0°\,42'\end{array}\right\}$	−·005
Halifax, N.S. .	5 viii. 74	..	+·031	..	..	..	−·002		
Quebec . . .	16 ix. 74	..	−·002	..	..	..	−·003		
Trinidad . . .	1 iii. 76	..	−·020	..	..	..	−·003		
Halifax, N.S. .	21 vi. 76	..	−·020	..	..	..	−·010		
Quebec . . .	24 viii. 76	..	−·020	..	..	..	−·008		

IRON DUKE.—Built S. 39° W. Distance of standard from stern 81 feet, from iron mast $17\frac{1}{2}$ feet.

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	c.	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	f.
Plymouth . . .	20 i. 71	+·407	..	$\left.\begin{array}{c}+·158\\ =\\ +9°\,5'\end{array}\right\}$	+·060	−·166	..		
,, . . .	16 ix. 71	..	−·019		..	..	+·048		
Gibraltar . . .	x. 71	..	−·047	..	..	..	−·008		
6° N. 96° E. . .	10 xii. 71	..	−·047	..	..	..	+·097		
38° N. 136° E. .	22 viii. 72	..	−·110	..	..	..	+·010		
49° N. 140° E. .	viii. 73	..	−·099	..	..	..	+·028		
30° N. 133½° E. .	27 vii. 74	..	−·123	..	..	..	+·054		
12¾° N. 46° E. .	11 iii. 75	..	−·126	..	..	..	−·016		
Plymouth . . .	27 vii. 75	..	−·136	..	..	..	+·042		
Belfast . . .	5 ix. 76	..	−·138	..	..	..	+·034		
Plymouth . . .	18 vii. 78*	+·402*	−·122†	..	..	−·108	−·022†		
Singapore . . .	xi. 78	..	−·193	..	..	..	+·031		
Yokohama . .	vii. 79	..	−·193	..	..	..	−·021		
Hong Kong . .	28 xii. 80	..	−·208	..	..	..	−·002		
,, . .	31 xii. 81	..	−·193	..	..	..	−·037		

TRIUMPH.—Built S. 45° W. Distance of standard from stern 105 feet, from iron mast $27\frac{1}{2}$ feet.

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	c.	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	f.
Spithead . . .	15 v. 78	−·033	−·289	$\left.\begin{array}{c}+·304\\ =\\ +17°\,40'\end{array}\right\}$	+·106	−·020	+·044	$\left.\begin{array}{c}-·038\\ =\\ -2°\,10'\end{array}\right\}$	−·013
Equator, 24½° W.	20 vi. 78	..	−·222		..	..	−·012		
23° S. 39° W. . .	1 vii. 78	..	−·214	..	..	..	+·009		
40½° S. 78¾° W. .	7 vii. 78	..	−·194	..	..	..	−·001		
Valparaiso . .	x. 78	..	−·190	..	..	..	−·007		
9¼° S. 80¾° W. .	7 ii. 79	..	−·209	..	..	..	−·001		
20° N. 157° W. .	4 iv. 79	..	−·195	..	..	..	−·003		

SWIFTSURE.—Built S. 56° W. Distance of standard from stern 107 feet, from iron mast $28\frac{3}{4}$ feet.

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	c.	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	f.
Plymouth . . .	8 v. 82	−·057	−·233	$\left.\begin{array}{c}+·304\\ =\\ +17°\,40'\end{array}\right\}$	+·110	+·010	−·016	$\left.\begin{array}{c}+·010\\ =\\ 0°\,35'\end{array}\right\}$	+·004
1° S. 26° W. . .	22 vi. 82	..	−·182		..	..	−·007		
23° S. 43° W. .	5 vii. 82	..	−·227	..	..	..	−·086		
Monte Video . .	23 vii. 82	..	−·236	..	..	..	−·031		
Sandy Point, Magellan Straits .	4 viii. 82	..	−·239	..	..	..	−·016		

* Previous to this date the ship had been under repair at Birkenhead.

† After re-correction by a permanent magnet.

TABLE I.—Values of the Constant Parameters P and c, Q and f, at Standard Compass Positions in Her Majesty's Ships (continued).

Armour-plated ships (continued).

NORTHAMPTON.—Built S. 6° E. Distance of standard from stern 83 feet, from iron mast 22 feet.

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	c.	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	f.
Sheerness . . .	1 xi. 79	+·345	..	−·060 ⎫ ± ⎬ −3° 25′ ⎭	−·021	−·008	−·002		
Spithead . . .	18 xii. 79	..	+·050		..	..	−·002		
27½° N. 62¾° W. .	23 i. 80	..	+·060	..	..	..	−·053		
St. Lucia . . .	20 ii. 80	..	+·041	..	..	..	−·073		
Bermuda . . .	8 v. 80	..	+·082	..	..	..	−·090		
Halifax, N.S. .	27 vi. 80	..	+·024	..	..	..	−·037		
Rimouski, River St. Lawrence .	21 viii. 80	..	+·046	..	..	..	−·046		
Halifax, N.S. .	1 x. 80	..	+·032	..	..	..	−·057		
Dominica . . .	22 i. 81	..	+·046	..	..	..	−·004		

NELSON.—Built S. 21° E. Distance of standard from stern 83 feet, from iron mast 23 feet.

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	c.	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	f.
Sheerness . . .	28 vii. 81	+·281	..	−·043 ⎫ = ⎬ −2° 30′ ⎭	−·014	−·060	..		
Plymouth . . .	28 ix. 81	..	+·032		..	..	+·027		
Madeira . . .	11 x. 81	..	+·048	..	..	..	+·016		
Simon's Bay, C. G. Hope . . .	14 xi. 81	..	+·048	..	..	..	+·040		

Iron ships cased with wood.

ACTIVE.—Built N. 33° E. Distance of standard from stern 69 feet, from iron mast 16½ feet.

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	c.	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	f.
Portsmouth . .	13 x. 73	−·541	−·120	+·039 ⎫ = ⎬ +2° 15′ ⎭	+·015	+·024	..	+·010 ⎫ = ⎬ +0° 35′ ⎭	+·004
,, .	15 x. 73	..	−·120		..	..	−·019		
Simon's Bay, C. Good Hope . .	x. 74	..	−·120	..	..	..	−·019		
,, .	x. 75	..	−·094	..	..	..	−·023		
,, . . .	xi. 76	..	−·096	..	..	..	−·006		

SHAH.—Built S. 70° E. Distance of standard from stern 70 feet, from iron mast 17½ feet.

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	c.	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	f.
Spithead . . .	8 vii. 76	+·003	..	−·012 ⎫ = ⎬ −0° 42′ ⎭	−·005	+·173	..		
,, .	4 x. 76	..	+·009		..	..	+·083		
Esquimault, Vancouver's Island.	x. 77	..	−·017	..	..	..	−·067		
Coquimbo . . .	8 iii. 78	..	−·017	..	..	..	−·002		
Panama . . .	11 v. 78	..	−·010	..	..	..	+·002		

RALEIGH.—Built S. 51° E. Distance of standard from stern 65½ feet, from iron mast 8¾ feet.

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	c.	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	f.
Sheerness . . .	6 vi. 74	+·195	..	−·017 ⎫ = ⎬ −1° 0′ ⎭	−·006	+·203	..		
,, .	8 vi. 74	..	+·029		..	..	+·054		
Spithead . . .	18 ix. 74	..	+·043	..	..	..	+·003		
Simon's Bay, C. Good Hope . .	iii. 75	..	+·043	..	..	..	+·026		
Bombay . . .	29 x. 75	..	−·006	..	..	..	−·010		
Spithead . . .	14 vi. 76	..	+·057	..	..	..	+·001		

TABLE I.—Values of the Constant Parameters P and c, Q and f, at Standard Compass Positions in Her Majesty's Ships (continued).

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	c.	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	f.
Iron ships cased with wood (continued).									
INCONSTANT.—Built S. 38° W. Distance of standard from stern 79 feet, from iron mast 13 feet.									
Spithead . . .	19 viii. 69	+·297	..	$+·107$ = $+6°\,10'$	+·039	−·124	..		
,, . .	20 viii. 69	..	−·023		..	..	+·016	
Plymouth . . .	21 viii. 70	..	−·071	..	..	..	+·020	
Spithead . . .	18 xi. 71	..	−·044	..	..	..	+·017	
Rio de Janeiro .	9 i. 72	..	−·044	..	..	..	−·015	
Spithead . . .	12 x. 80	+·238	..	..	..	+·010	..	
,, . .	14 x. 80	..	−·094*	..	..	..	−·005*	
Melbourne . .	vii. 81	..	−·150	..	..	..	+·031	
Simonoseki . .	15 xi. 81	..	−·150	..	..	..	−·041	
Simon's Bay, C. Good Hope . .	v. 82	..	−·131	..	..	..	−·020	
Iron troopships.									
EUPHRATES.—Built N. 67° W. Distance of standard from stern 96 feet, from iron mast 33¾ feet.									
Birkenhead . .	16 v. 67	−·239	..	$+·079$ = $4°\,30'$	+·027	−·267	..		
,, . .	18 v. 67	..	−·226		..	..	+·019	
Spithead . . .	18 vi. 67	..	−·172	..	..	..	+·004	
Simon's Bay, C. Good Hope . .	31 vii. 67	..	−·159	..	..	..	+·092	
Suez . . .	10 i. 68	..	−·156	..	..	..	+·097	
Spithead . . .	11 x. 71	−·245	..	..	..	−·089	..	
HIMALAYA.—Built . . . . . . Distance of standard from stern 64 feet.									
Spithead . . .	8 iii. 67	−·077	..	$+·017$ = $+1°\,0'$	+·007	+·270	..	$+·015$ = $+0°\,52'$	+·006
,, . .	15 iii. 67	..	−·048		..	..	+·035	
Plymouth . . .	2 vii. 72	..	−·030	..	..	..	−·061	
Simon's Bay, C. Good Hope . .	viii. 72	..	−·030	..	..	..	−·042	
Plymouth . . .	9 xi. 74	..	−·021	$+·015$ = $+0°\,52'$	+·006	..	−·058	
Simon's Bay, C. Good Hope . .	18 i. 75	..	−·021		..	..	−·081	
Plymouth . . .	18 vi. 75	..	−·031	..	..	..	−·081	
ORONTES.—Built N. 68° W. Distance of standard from stern 66 feet, from iron mast 9 feet.									
Birkenhead . .	26 i. 76	−·084	..	$+·074$ = $+4°\,15'$	+·029	−·202	..		
Spithead . . .	2 iii. 76	..	−·042		..	..	+·018	
,, . . .	5 ix. 79	..	−·058	..	..	..	+·084	
Simon's Bay, C. Good Hope . .	x. 79	..	−·058	..	..	..	+·034	
Mauritius . . .	xi. 79	..	−·044	..	..	..	+·094	

* After re-correction by a permanent magnet.

4 M

TABLE I.—Values of the Constant Parameters P and c, Q and f, at Standard Compass Positions in Her Majesty's Ships (continued).

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	$c.$	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	$f.$

Steel and iron ships cased with wood.

COMUS.—Built S. 11° W.   Distance of standard from stern 50 feet, from iron mast 7¾ feet.

Sheerness . . .	14 xi. 79	+·246	..	+·089 ⎫ = +5° 7′ ⎬	+·034	−·029	..	−·010 ⎫ = −0° 35′ ⎬	−·004
,, . . .	18 xii. 79	+·234	+·009		..	+·041	+·022		
Simon's Bay, C. Good Hope . .	20 iii. 80	..	−·042		..	..	+·038		
Hong Kong . .	12 vii. 80	..	−·042		..	..	+·038		
Singapore. . .	13 xii. 81	..	−·017		..	..	+·035		

CARYSFORT.—Built S. 11° W.   Distance of standard from stern 50 feet, from iron mast 7·9 feet.

Sheerness . . .	5 x. 80	+·262	..	+·111 ⎫ = +6° 23′ ⎬	+·044	−·014			
,, . . .	6 x. 80	..	−·099		..	..	−·024		
Simon's Bay, C. Good Hope . .	1 iv. 81	..	−·133		..	..	+·030		
Kobé, Japan . .	10 xi. 81	..	−·133		..	..	+·007		

CLEOPATRA.—Built S. 11° W.   Distance of standard from stern 49½ feet, from iron mast 6¾ feet.

Plymouth . . .	15 ix. 80	+·057	..	+·082 ⎫ = +4° 43′ ⎬	+·032	+·050	..		
,, . . .	17 ix. 80	..	−·033		..	..	+·031		
Monte Video . .	31 xii. 80	..	−·074		..	..	−·028		
Hong Kong . .	20 xii. 81	..	−·074		..	..	+·039		

Composite vessels.

RUBY.—Built N. 3° W.   Distance of standard from stern 50 feet, from iron mast 6¾ feet.

Sheerness . . .	30 vi. 77	−·486	..	+·077 ⎫ +4° 25′ ⎬	+·027	−·109	..		
,, . . .	3 vii. 77	..	−·086		..	..	−·009		
Gulf of Xeros .	iii. 78	..	−·083		..	..	+·003		
Singapore. . .	vi. 78	..	−·083		..	..	+·018		
Rangoon . . .	x. 79	..	−·101		..	..	−·028		
Zanzibar . . .	12 iii. 80	..	−·076		..	..	−·009		

GANNET.*—Built S. 76° E.   Distance of standard from stern 38 feet.

Sheerness . . .	29 iv. 79	+·122	..	+·065 ⎫ = +3° 45′ ⎬	+·024	+·139	..		
,, . . .	30 iv. 79	..	−·012		..	..	+·010		
Coquimbo. . .	x. 79	..	−·059		..	..	−·032		
Esquimault, Vancouver Island .	vii. 81	..	−·059		..	..	−·014		

ALBATROSS.*—Built S. 50° E.   Distance of standard from stern 37½ feet.

Sheerness . . .	17 xii. 73	+·209	..	+·073 ⎫ = +4° 12′ ⎬	+0·29	+·100	..		
,, . . .	20 iii. 74	..	−·066		..	..	+·015		
Rio de Janeiro .	5 vii. 74	..	−·066		..	..	−·017		
Plymouth . . .	10 x. 74	..	−·064		..	..	+·022		
Taboga. . . .	27 x. 75	..	−·091		..	..	−·006		
Pisco	15 xii. 76	..	−·093		..	..	+·002		
Esquimault, Vancouver Island .	29 x. 77	..	−·093		..	..	+·016		

* These vessels have wooden masts.

TABLE I.—Values of the Constant Parameters P and c, Q and f, at Standard Compass Positions in Her Majesty's Ships (continued).

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	c.	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	f.
Composite vessels (continued).									
BOXER.*—Built S. 60° W. Distance of standard from stern 30½ feet.									
Greenhithe . .	30 xi. 68	+·124	−·004	$\left.\begin{array}{c}+·062\\=\\+3°\ 35'\end{array}\right\}$	+·023	−·150		−·022	
Rio de Janeiro .	20 ii. 69	..	−·016		..	..		−·105	
Esquimault, Vancouver's Island	5 x. 69	..	−·008		..	..	..	−·049	
Komax, Vancouver's Island .	24 iv. 71	..	−·029		..	..	..	−·058	
Esquimault . .	30 xii. 74	..	−·004		..	..	..	−·030	
Coquimbo . . .	13 v. 75	..	−·004		..	..	..	−·003	
PERT.*—Built S. 65° W. Distance of standard from stern 29¾ feet.									
Devonport . .	3 ii. 70	+·170	..	$\left.\begin{array}{c}+·070\\=\\+4°\ 0'\end{array}\right\}$	+·026	−·174		..	
,, . .	8 ii. 70	..	−·056		..	..		−·016	
Elephant Bay, W. C. Africa . .	29 xii. 70	..	−·056		..	..	..	−·051	
Rio de Janeiro .	29 xii. 71	..	−·043		..	..	..	−·054	
FIREFLY.*—Built N. 26° E. Distance of standard from stern 15¾ feet.									
Plymouth . . .	24 vi. 79	−·332	+·004	$\left.\begin{array}{c}+·012\\=\\+0°\ 42'\end{array}\right\}$	+·005	..		+·015	
Simon's Bay, C. Good Hope . .	29 v. 80	..	+·004		..	..		+·001	
Gaboon River, W. C. Africa .	30 viii. 80	..	+·032		..	..	..	+·046	
WRANGLER.*—Built N. 45° E. Distance of standard from stern 15¾ feet.									
Plymouth . .	26 v. 81	−·183	−·017	$\left.\begin{array}{c}+·006\\=\\+0°\ 20'\end{array}\right\}$	+·002	+·323	+·004		
Simon's Bay, C. Good Hope . .	31 xii. 81	..	−·017		..	..		+·027	

Wooden corvettes with iron beams and iron vertical bulkheads from keel to lower deck.

Geographical position.	Date of observation.	Original P.	Corrected P.	$\frac{c}{\lambda}\tan\theta$ in England.	c.	Original Q.	Corrected Q.	$\frac{f}{\lambda}\tan\theta$ in England.	f.
ENCOUNTER.—Built S. 76° E. Distance of standard from stern 48 feet. Masts wooden.									
Sheerness . . .	2 ix. 73	+·182	..	$\left.\begin{array}{c}+·046\\=\\+2°\ 40'\end{array}\right\}$	+·018	+·148		..	
,, . . .	9 ix. 73	..	+·016		..	..		+·034	
Simon's Bay, C. Good Hope . .	11 iv. 74	..	+·002		..	..	..	+·022	
,, . .	15 x. 74	..	−·002		..	..	..	+·007	
,, . .	20 i. 76	..	−·048		..	..	..	−·001	
Grenada . . .	30 x. 76	..	−·048		..	..	..	−·014	
SAPPHIRE.—Built East. Distance of standard from stern 47¾ feet, from iron mast 5½ feet.									
Plymouth . . .	21 viii. 75	+·202	..	$\left.\begin{array}{c}+·117\\=\\+6°\ 45'\end{array}\right\}$	+·045	+·115		..	
,, . . .	24 viii. 75	..	−·093		..	..		+·012	
Simon's Bay, C. Good Hope . .	30 xi. 75	..	−·093		..	..	..	+·013	
Wellington, N.Z.	xii. 76	..	−·107		..	..	..	+·001	
Sydney, N.S.W.	viii. 77	..	−·152		..	..	..	−·033	

* These vessels have wooden masts.

TABLE II.—Table of Terrestrial Magnetic Elements for the Year 1880,
used in the computations.

Geographical position.	Inclination θ.	Approximate annual change.	Absolute horizontal force in British units.	Approximate annual change.
Greenwich	+67 36	− 1·7	3·915	+·005
Gibraltar	+55 43	− 4·5	5·259	+·007
Maderia	+56 0	− 5·0	5·282	+·006
Gaboon River	−15 0	−12·0	6·50	−·012
Elephant Bay	−39 12	..	5·40	..
Simon's Bay, C. Good Hope	−56 28	− 5·0	4·270	−·007
Quebec	+77 0	..	2·97	..
Rimouski	+77 52	..	2·85	..
Halifax, N.S.	+74 48	− 1·8	3·388	+·002
Bermuda	+65 0	..	5·115	+·002
St. Lucia	+43 50	..	6·75	..
Dominica	+45 48	..	6·67	..
Grenada	+41 20	..	6·85	..
Trinidad	+39 40	..	6·89	..
Rio de Janeiro	−10 46	+ 3·0	5·66	−·016
Monte Video	−29 10	+ 8·5	5·745	−·017
Sandy Point, Magellan Straits	−52 20	+11·0	6·056	−·004
27½° N., 62¾° W.	+60 0	..	5·70	..
Equator, and 24½° W.	+15 7	− 9·0	6·40	−·007
23° S., 39° W.	−11 52	+ 2·0	5·51	−·016
40½° S., 78¾° W.	−44 8	..	6·20	..
1° S., 26° W.	+16 42	− 9·0	6·40	−·007
Valparaiso	−33 39	+ 5·0	6·078	−·018
Coquimbo	−29 12	+ 4·0	6·14	−·017
Pisco	− 7 44	..	6·69	−·013
Panama	+31 57	..	7·560	−·004
Esquimault, Vancouver Island	+71 54	..	4·21	..
9¼ S., 80¾° W.	− 3 15	..	7·0	..
20 N., 157° W.	+37 58	..	6·64	..
Komax, Vancouver Island	+71 37	..	4·27	..
Gulf of Xeros	+55 23	..	5·49	..
Suez	+40 47	− 1·0	6·50	..
Zanzibar	−36 0	..	6·205	..
Mauritius	−56 23	− 1·0	5·158	−·002
Bombay	+19 29	+ 1·2	8·10	+·003
Rangoon	+17 44	..	8·15	..
6° N., 96° E.	− 5 10	..	8·30	..
Singapore	−13 11	− 0·2	8·251	+·004
Hong Kong	+32 40	+ 4·2	7·794	+·006
Yokohama	+49 12	+ 3·4	6·417	..
Kobé, Japan	+48 48	+ 3·5	6·56	..
Simonoseki	+48 40	+ 4·0	6·64	..
49° N., 149° E.	+62 30	..	5·00	..
38° N., 136° E.	+53 5	..	6·19	..
34° N., 133½° E.	+46 8	..	6·60	..
12¾° N., 46° E.	+ 5 52	..	7·50	..
Melbourne	−67 5	Stationary	5·117	−·002
Sydney, N.S.W.	−62 44	Stationary	5·754	−·003
Wellington, N.Z.	−65 12	− 1·0	5·266	..

The + sign indicates north inclination or dip, the − sign that of south dip. The correction for annual change of the inclination or dip is to be applied algebraically.

TABLE III.—Coefficients.

Iron armour-plated ships.

BELLEROPHON.—Iron screw ship, armour-plated; 7550 tons; 6520 H.P.; 13 guns. Built, Chatham; head S., 51° E.; launched, 3 iii. 66.—Standard Compass.

Place	Date	A. (approx.)	B.	C.	D.	E.	𝕬. (exact)	𝕭.	ℭ.	𝕯.	𝕰.	Max. semicirc. dev. — Amount	Direction	λ	1/λ	a.	e.	Fore and aft induc.	Transverse induc.	μ.	Heeling windward	Vert. induc. in trans. iron	Vert. force and induc. in vert. iron	g/tan θ	g.
Spithead	3 xi.73	From quadrant.					+·020	+·028	+·233	+·098	...	·235	83	·878	1·139	−·043	−·201	+1 22	+6 4	1·056	+0 42	+0 33	+0 9	+·016	+·040
Halifax, N.S.	4 xi.73	+1 11	−0 16	+1 3	+5 12	−0 32	−·002	−·005	+·017	+·090	−·009	·018	109												
Quebec	5 viii.74	+0 8	+2 20	+0 9	+5 6	...	−·011	+·041	−·014	−·107	...	·044	344												
Trinidad	16 ix.74	−0 38	+0 11	−2 26	+5 16	+1 30	+·001	−·003	−·049	+·092	+·026	·041	265												
Halifax, N.S.	1 iii.76	−0 1	−0 45	+0 21	+5 39	+0 26	−·013	−·013	−·006	+·098	+·008	·015	199												
Quebec	21 vi.76	−0 28	−1 30	−1 35	+6 11	+0 37	−·008	−·026	−·028	+·108	−·011	·037	224												
	24 viii.76	−0 13	−1 40	−1 25	+4 30	+0 39	−·004	−·029	−·025	+·078	+·011	·032	286												

IRON DUKE.—Iron double screw ship, armour-plated; 6010 tons; 4270 H.P.; 14 guns. Built at Pembroke; head S., 39° W.; launched, 1 iii. 70.—Standard Compass.

Place	Date	A.	B.	C.	D.	E.	𝕬.	𝕭.	ℭ.	𝕯.	𝕰.	Amount	Direction	λ	1/λ	a.	e.	Fore & aft	Transv.	μ.	windward	Vert. trans.	Vert. vert.	g/tan θ	g.
Plymouth	20 i.71	+0 55	+34 18	−11 24	+5 45	+0 46	+·016	+·598	−·180	+·100	+·013	·624	343	·925	1·081	+·028	−·178	+0 54	+5 29	·826	+0 1	+0 29	−0 28		
Gibraltar	16 ix.71	+1 9	+7 31	+3 11	+6 23	−0 2	+·020	+·137	+·052	+·112	−·001	·147	21												
6° N., 96° E.	10 x.71	+0 13	−1 37	+3 32	+5 40	−0 5	+·004	+·065	−·007	+·104	−·001	·066	354												
38° N., 136° E.	22 viii.72	+0 33	−1 37	+2 57	+5 40	+0 39	+·009	−·029	+·048	+·099	+·011	·065	121												
49° N., 140° E.	viii.73	+0 59	+0 35	+1 17	+5 17	+0 22	−·017	+·010	+·007	+·092	+·006	·012	35												
34° N., 133½° E.	27 vii.74	+0 53	+2 12	+1 27	+4 48	−0 10	+·015	+·040	+·024	+·084	−·003	·034	31												
123° N., 46⅝° E.	11 iii.75	+0 30	−0 26	+2 0	+4 45	+0 25	+·009	−·007	+·033	+·083	+·007	·034	102												
Plymouth	27 vii.75	+2 25	−3 23	+3 3	+4 5	−0 34	−·042	−·062	−·009	+·088	+·010	·063	189												
Belfast Lough	5 ix.76	+0 12	+0 38	+2 45	+4 47	+0 13	−·003	+·011	+·046	+·083	+·004	·047	76												
Plymouth*	18 vii.78	+0 27	+1 0	+2 15	+4 16	+0 7	−·007	+·018	+·038	+·074	+·002	·042	64												
		From four cardinal points.					...	+·593	−·117	...	...	·605	349												
Singapore	,,	+0 8	+1 26	−1 25	+4 57	+0 21	+·002	−·026	−·024	+·086	+·006	·085	317												
Yokohama	xii.78	+0 1	+6 17	+1 1	+4 56	+0 14	+·001	−·114	+·016	+·086	+·004	·115	172												
Hong Kong	vii.79	+1 40	−3 0	+0 62	+4 5	+0 31	−·029	−·054	−·014	+·088	+·009	·056	194												
	28 xii.80	+0 46	−3 57	+0 2	+4 52	+0 34	−·013	−·072	−·001	+·085	+·010	·072	181												
	31 xii.81	−1	−3 35	+1 12	+4 23	+0 49	−·020	−·064	−·080	+·079	+·014	·067	197												

TRIUMPH.—Iron screw ship, armour-plated; 6640 tons; 5110 H.P.; 14 guns. Built on River Tyne; head S., 45° W.; launched, 29 ix. 70.—Standard Compass.

Place	Date	A.	B.	C.	D.	E.	𝕬.	𝕭.	ℭ.	𝕯.	𝕰.	Amount	Direction	λ	1/λ	a.	e.	Fore & aft	Transv.	μ.	windward	Vert. trans.	Vert. vert.	g/tan θ	g.
Plymouth	18 iii.73	−1 9	+20 53	−10 0	+0 45	−0 5	−·020	+·377	−·161	+·117	−·001	·410	337	·839	1·192	−·056	−·266	−1 56	+9 7	·881	+0 26	+0 47	−0 21	+·067	+·167
Spithead†	15 v.78	+0 18	+1 40	−0 23	+7 12	+0 33	+·005	+·031	−·007	+·125	+·009	·032	347												
	,,	From S.W. quadrant.																							
Equator, long.		−1 23	−2 7	+0 51	+5 51	−0 53	−·024	+·266	−·063	+·102	−·015	·273	347												
24½° W.	20 vi.78	−2 29	−7 0	+0 56	+7 6	−0 58	−·043	−·129	−·015	+·124	−·017	·130	187												
23° S., 39° W.	1 vii.78	−3 31	−11 13	+0 38	+6 41	−0 44	−·061	−·205	+·00	+·116	−·013	·205	177												
40½° S., 78¾° W.	7 viii.78	−0 49	−14 51	+0 55	+6 39	−1 19	+·014	−·271	+·015	+·116	−·023	·272	177												
Valparaiso.	ix. x.78	−0 29	−12 14	+0 14	+6 30	−0 20	−·008	−·224	+·004	+·113	−·006	·224	179												
9½° S., 80½° W.	7 ii.79	−1 31	−7 28	−0 11	+6 55	+0 18	+·026	−·138	−·003	+·120	+·005	·138	181												
20° N., 157° W.	4 iv.79	−1 51	−2 2	−0 51	+6 28	+0 42	−·032	−·087	−·014	+·112	−·012	·040	201												
Esquimault.	v.79	From S.W. quadrant.					...	+·103	+·015	...	...	·104	8												

* After repair at Birkenhead.　Compass re-corrected at Plymouth.　　† Compass re-corrected on this day.

NOTE.—The values of B. and C., &c., printed in italics have been computed from the tables of deviation observed after the compass had been corrected by magnets.

Table III.—Coefficients (continued).

Iron armour-plated ships (continued).

SWIFTSURE.—Iron, screw ship, armour plated; 6910 tons; 4910 H.P.; 18 guns. Built on River Tyne; head S., 56° W; launched, 15 vi. 70.—Standard Compass.

Place.	Date.	A.	B.	C.	D.	E.	𝕬.	𝕭.	𝕮.	𝕯.	𝕳.	Max √B²+C² Amount.	√𝕭²+𝕮² Amount.	√𝕭²+𝕮² Direction.	Mean force to north. λ.	1/λ	a. (Head-ward)	e. (To star-board)	Fore and aft induction.	Transverse induction.	Mean vertical force. μ.	Heeling coeff. to windward.	Vertical induction in transverse iron.	Vertical force and induction in vertical iron.	g/tan θ	g.
Plymouth	17 vi. 72	+0 33	+2 5	−0 22	+6 12	... 22	...	+·386	−·186	+·122	....	25¼ / 12½	·430	337	·834	1·199	−·064	−·268	−2 11	+ 9 13	1·184	+1 21	+0 48	+0 33	+·062	+·155
,,	8 v. 82	+1 5	−5 0	−0 13	+6 19	+0 46	+·009	+·239	...	+·108	ass.	12½	·239	351	·876	1·141	−·030	−·218	−0 56	+ 7 8	1·103	+0 52	+0 36	+0 15	+·066	+·158
1° S., 26° W.	22 vi. 82	+1 4	−1 11	...	+5 44	+0 17	+·019	+·038	−·006	+·108	+·006	5	·038	183							·872			−0 21		
23° S., 43° W .	5 vii. 82	...	...	...	+4 10	... 9	+·019	−·092	−·004	+·110	+·013	5	·092	199												
Monte Video	23 vii. 82	−3 31	−14 6	−1 40	+4 49	−0 9	−·061	−·202	−·070	+·100	+·005	12	·202	185												
Sandy Point, Magellan Straits	4 viii. 92	−1 54	−18 32	−1 7	+6 3	−1 34	−·033	−·337	−·018	+·105	−·027	18½	·337	183												

(Plymouth, 17 vi. 72: From southern and west semicircles; From N.E. quadrant.)

NORTHAMPTON.—Iron double screw ship, armour-plated; 7630 tons; 6070 H.P.; 12 guns. Built at Glasgow; head S., 6° E.; launched, 18 xi. 76.—Standard Compass.

Place.	Date.	A.	B.	C.	D.	E.	𝕬.	𝕭.	𝕮.	𝕯.	𝕳.	Max √B²+C² Amount.	√𝕭²+𝕮² Amount.	√𝕭²+𝕮² Direction.	λ.	1/λ	a.	e.	Fore and aft.	Transverse.	μ.	Heel. wind.	Vert. ind. trans.	Vert. iron.	g/tan θ	g.
Sheerness	1 xi. 79	−0 44	+20 1	−0 37	+3 38	−0 6	−·013	+·354	−·010	+·063	−·002	20	·354	359	·834	1·199	−·114	−·218	−3 54	+ 7 32	·903	+0 21	+0 37	−0 16	+·055	+·132
Spithead	18 xii. 79	−0 37	+6 4	−0 6	+4 3	−0 1	+·011	+·001	−·002	+·070	−·001	0¾	·002	260												
27¾° N., 62¾° W., St. Lucia, S.W. Point	23 i. 80	+1 13	+0 21	−2 39	+3 44	−0 16	+·021	+·006	−·044	+·065	−·004	2¾	·044	278												
Bermuda	20 ii. 80	+0 58	+0 17	−3 4	+3 30	+0 22	+·017	+·005	−·051	+·061	+·006	3¼	·051	276												
Halifax, N.S.	8 v. 80	+1 53	+1 12	−4 58	+3 5	+0 40	+·034	+·022	−·082	+·088	−·012	4¾	·085	285												
Rimouski River, St. Lawrence	27 vi. 80	+0 36	−3 10	−3 2	+3 8	−1 32	+·010	−·057	−·051	+·064	−·027		·077	222												
Halifax, N.S.	31 viii. 80	−1 38	−2 17	−4 32	+3 42	−0 31	−·028	−·041	−·076	+·064	−·009	5	·087	241												
Halifax, N.S.	1 x. 80	−1 1	−2 32	−4 50	+3 40	−0 15	−·018	−·045	−·081	+·064	−·004	5¼	·093	241												
Dominica	22 i. 81	−1 37	−6 33	−0 10	+4 1	−0 18	−·028	+·007	−·003	+·070	−·005	0½	·008	336												

NELSON.—Iron, double screw ship, armour-plated; 7630 tons; 6640 H.P.; 12 guns. Built at Glasgow; head S., 21° E; launched 4 xi. 76.—Standard Compass.

Place.	Date.	A.	B.	C.	D.	E.	𝕬.	𝕭.	𝕮.	𝕯.	𝕳.	Max √B²+C² Amount.	√𝕭²+𝕮² Amount.	√𝕭²+𝕮² Direction.	λ.	1/λ	a.	e.	Fore and aft.	Transverse.	μ.	Heel. wind.	Vert. ind. trans.	Vert. iron.	g/tan θ	g.
Sheerness	28 vii. 81	−0 3	+16 36	−4 7	+4 0	+0 7	−·001	+·296	−·072	+·070	+·002	17	·305	347	·830	1·204	−·112	−·228	−3 52	+ 7 52	·952	+0 31	+0 39	−0 8	+·063	
Plymouth	28 ix. 81	−0 23	+0 13	+1 57	+3 47	−0 5	−·007	−·004	+·033	+·071	−·001	2	·033	97												
Madeira	11 x. 81	−0 6	+0 55	+0 51	+3 47	+0 24	−·002	+·016	+·015	+·066	−·007	1¼	·022	43												
Simon's Bay, C. Good Hope	14 xi. 81	−0 44	+4 35	+2 34	+3 37	−0 12	−·013	+·082	+·044	+·063	−·003	5¼	·093	28												

Iron ships cased with wood.

ACTIVE.—Iron cased with wood; 3080 tons; 4130 H.P.; 12 guns. Built at Blackwall; head N., 33° E; launched, 13 ii. 69.—Standard Compass.

Place.	Date.	A.	B.	C.	D.	E.	𝕬.	𝕭.	𝕮.	𝕯.	𝕳.	Max √B²+C² Amount.	√𝕭²+𝕮² Amount.	√𝕭²+𝕮² Direction.	λ.	1/λ	a.	e.	Fore and aft.	Transverse.	μ.	Heel. wind.	Vert. ind. trans.	Vert. iron.	g/tan θ	g.
Portsmouth	28 ii. 70	−0 10	−2 35	+0 42	+4 0	−0 8	...	−·540	−·064	+·085	ass.	32	·544	187	·904	1·106	−·033	−·159	−1 4	+ 5 4	1·096	+0 44	+0 26	+0 18	...	ass.
,,	7 iii. 70						−·003	−·046	+·012	+·070	−·002		·048	165½	·941	1·063	−·004	−·114	−0 7	+ 3 34	·854	+0 2	+0 26	−0 24	...	
,,	13 x. 73	+0 24	−4 59	−0 34	+3 17	... 5	...	−·537	−·016	+·059	...	32½	·537	182							1·052	+0 26	+0 18	+0 8	...	
,,	15 x. 73	+1 27	−7 51	−1 37	+2 41	+0 59	+·007	−·089	−·010	+·057	−·001	5	·090	186							·949	+0 1	+0 18	−0 17	...	
Simon's Bay	x. 74	...	...	...	+2 44	... 18	−·025	−·140	−·025	+·047	+·017	6½	·142	190												
,,	v. 75	−1 16	−6 33	−1 33	+2 14	−0 18	−·022	−·115	−·098	+·039	−·005	6½	·118	194												
,,	xi. 76	−2 12	−6 33	−0 42	+2 44	−0 18	−·038	−·117	−·012	+·048	−·005		·118	186												

(Portsmouth: From deviation and force on one point; From quadrant.)

TABLE III.—Coefficients (continued).

Iron ships cased with wood (continued).

Place.	Date.	A.	B.	C.	D.	E.	𝔄.	𝔅.	ℭ.	𝔇.	𝔈.	√𝔅²+ℭ² Amount.	Direction.	Mean force to north. λ.	1/λ	Headwʳᵈ. a.	To starboard. e.	Fore and aft induction.	Transverse induction.	Mean vertical force. μ.	Heeling coeff. to windward.	Vertical induction in transverse iron.	Vertical force and induction in vertical iron.	g/tanθ.	g.
		° '	° '	° '	° '	° '						°	°					° '	° '		° '	° '	° '		
SHAH.—Iron cased with wood; 6050 tons; 7480 H.P.; 26 guns. Built at Portsmouth; head S. 70° E.; launched, 10 ix. 73. Standard Compass.																								
Spithead	8 vii. 76	+ 0 8	− 0 33	+11 25	+ 5 44	+ 0 15½	+·002	−·009	+·188	+·100	+·004	·188	93	·923	1·083	+·005	−·159	+0 12	+4 54	·988	− 0 24	+ 0 26	− 0 2	+·011	+·027
„ Esquimault	4 x. 76	− 1 29	− 0 8	+ 5 25	+ 5 5	+ 0 33	−·026	−·002	+·090	+·089	+·009	·090	91												
Coquimbo	8 x. 77	+ 0 8	− 1 49	− 4 6	+ 5 15	+ 0 20	+·002	−·033	−·068	+·091	+·006	·076	244												
Panama	11 v. 78	− 0 2	− 0 31	− 0 5½	+ 5 15½	+ 0 38	−·001	−·009	−·001	+·095	+·011	·009	186												
RALEIGH.—Iron cased with wood; 5200 tons; 5640 H.P.; 22 guns. Built at Chatham; head S. 51° E.; launched, 1 iii. 73. Standard Compass.																								
Sheerness	6 vi. 74	+ 0 39	+11 46	+15 15	+ 8 0	− 0 28	+·011	+·217	+·244	+·140	−·008	·326	48	·833	1·200	−·072	−·262	−2 29	+9 2	{ ·930 / ·772 }	+ 0 33 / + 0 6	+ 0 47	− 0 14 / − 0 41	−·017	−·042
„ Spithead	8 vii. 74	+ 0 39	+ 1 4	+ 3 59	+ 6 33	− 0 35	+·011	+·067	+·065	+·114	+·010	·067	74												
Simon's Bay	18 ix. 74	− 0 6	+ 2 1	+ 0 14	+ 6 55	− 0 36	−·002	+·035	+·004	+·120	−·010	·037	6												
Bombay	29 x. 75	− 1 14	+ 3 17	+ 1 44	+ 6 35	− 0 18	+·021	+·059	−·006	+·116	−·016	·066	26												
Spithead	14 vi. 76	+ 0 58	+ 2 53	+ 0 27	+ 5 59	+ 1 4	+·017	+·052	+·001	+·105	+·019	·053	1												
INCONSTANT.—Iron cased with wood; 5780 tons; 7360 H.P.; 16 guns. Built at Pembroke; head S. 38° W.; launched, 12 xi. 68. Standard Compass.																								
Spithead	19 viii. 69	+ 0 56	+24 54	− 8 40	+ 4 55	− 0 22	+·016	+·441	−·140	+·085	−·006	·463	342	·890	1·123	−·035	−·185	−1 6	+6 2	·827	+ 0 2	+ 0 31	− 0 29	+·042	+·105
Plymouth	20 viii. 69	+ 0 13	− 4 38	+ 1 6	+ 4 52	− 0 15	+·004	+·083	+·018	+·085	+·004	·085	12												
Spithead	21 viii. 70	+ 0 48	+ 1 30	+ 1 23	+ 4 48	− 0 0	+·014	+·027	+·023	+·084	+·001	·035	40												
Rio de Janeiro	18 xi. 71	+ 0 7	+ 3 8	+ 1 8	+ 4 13	− 0 4	+·002	+·057	+·019	+·074	−·001	·060	19												
Spithead	9 i. 72	+ 0 42	− 2 23	+ 0 40	+ 4 22	− 0 24	+·012	+·042	−·011	+·076	+·007	·044	195												
Spithead *	12 x. 80	From N.W. quadrant.					...	+·374	+·011	+·068	+·005	·375	1												
Melbourne	14 x. 80	+ 0 55	+ 0 5	− 0 24	+ 3 54	− 0 16	+·016	+·001	−·006	+·068	+·005	·006	280												
„	6 vii. 81	+ 0 18	−13 5	+ 1 37	+ 3 40	− 0 17	+·005	−·234	+·027	+·064	+·005	·236	173												
Simonoseki	15 xi. 81	+ 0 55	− 2 50	+ 1 37	+ 3 55	...	+·016	−·050	−·027	+·068	...	·058	208												
Simon's Bay	4 v. 82	− 0 26	−11 22	− 1 18	+ 2 47	+ 0 35	−·008	−·202	−·021	+·048	+·010	·203	186												

Iron troopships.

Place.	Date.	A.	B.	C.	D.	E.	𝔄.	𝔅.	ℭ.	𝔇.	𝔈.	√𝔅²+ℭ² Amount.	Direction.	Mean force to north. λ.	1/λ	Headwʳᵈ. a.	To starboard. e.	Fore and aft induction.	Transverse induction.	Mean vertical force. μ.	Heeling coeff. to windward.	Vertical induction in transverse iron.	Vertical force and induction in vertical iron.	g/tanθ.	g.
EUPHRATES.—Iron screw; 6211 tons; 3900 H.P. Built at Birkenhead; head N. 67° W; launched, 24 xi. 66.—Standard Compass.																								
Birkenhead	16 v. 67	From semicircle.				...	−·201	−·314	...	+·098	...	·370	237	·851	1·175	−·066	−·232	−2 11	+7 50	1·197	+ 1 22	+ 0 44	+ 0 38		
„	18 v. 67	+ 1 4	− 8 4	+ 1 21	+ 5 39	+ 0 43	+·029	−·147	+·022	+·098	+·013	·149	171½												
Spithead	18 vi. 67	+ 0 4	− 6 43	+ 0 16	+ 5 45	+ 0 9	−·003	−·123	+·065	+·100	−·003	·123	177½												
Simon's Bay	31 vii. 67	− 3 17	− 9 4	+ 5 24	+ 5 24	− 1 5	−·057	−·165	+·095	+·094	−·010	·165	150												
Suez	10 i. 68	+ 0 9	− 4 33	+ 3 59	+ 3 40	+ 0 21	+·002	−·081	+·067	+·064	−·006	·105	140												
Spithead	11 x. 71	From quadrant.				...	−·166	−·105	...	+·067	...	·196	212												

* Compass re-corrected on this day.

TABLE III.—Coefficients (continued).

Iron troopships (continued).

HIMALAYA.—Iron screw; 4690 tons; 2500 H.P. Built, 1854, at Blackwall.—Standard Compass.

Place.	Date.	A.	B.	C.	D.	E.	𝔄.	𝔅.	ℭ.	𝔇.	𝔈.	Max. semicirc. Amount.	Direction.	λ	1/λ	a. (Head-ward.)	e. (To star-board.)	Fore and aft induction.	Transverse induction.	Mean vertical force. μ.	Heeling coeff. to windward.	Vert. induction in transverse iron.	Vert. force and induction in vertical iron.	g/tan θ	g.
Spithead	8 iii. 67	+ 0 6	– 3 48	+17 50	+ 3 3	0 29	+·002	–·067	+·299	+·053	+·008	–·307	103												
"	15 iii. 67	+ 1 20	– 2 6	+ 3 2	+ 2 25	0 35	+·023	–·037	+·052	+·042	+·004	–·063	125												
Plymouth	2 vii. 72	+ 1 13	– 0 55	– 2 52	+ 3 0	0 14	+·021	–·016	–·049	+·052	+·004	–·051	252												
Simon's Bay	2 vii. 72	+ 0 50	– 2 31	– 2 53	+ 2 57	0 18	–·014	–·046	–·046	–·051	–·005	–·067	227												
Plymouth	9 xi. 74	+ 0 25	– 0 23	– 2 42	+ 2 49	0 9	–·007	–·018	–·085	–·049	+·003	–·047	260												
Simon's Bay	18 i. 75	– 0 56	– 1 37	– 4 56	+ 2 58	0 2	–·016	–·030	–·069	+·052	–·001	–·091	251	·945	1·058	–·015	–·095	– 28	+ 2 53	1·167	+ 0 41	+ 0 15	+ 0 26	+ ·151	+ ·377
Plymouth	18 vi. 75	+ 0 36	– 0 51	– 4 0	+ 2 46	0 12	+·010	–·016	+·048	+·048	–·004	–·071	257	·950	1·053	...	–·100	...	+ 3 0	1·119	+ 0 34	+ 0 16	+ 0 18	+ ·007	+ ·017

ORONTES.—Iron screw; 5920 tons; 2570 H.P. Built at Birkenhead; head N. 68° W.; launched, 22 xi. 62.—Standard Compass.

Place.	Date.	A.	B.	C.	D.	E.	𝔄.	𝔅.	ℭ.	𝔇.	𝔈.	Amount.	Direction.
Birkenhead	26 i. 76	– 0 18	– 0 54	–12 57	+ 3 5	0 8	–·004	–·016	–·218	+·054	+·002	–·219	266
Spithead	2 iii. 76	+ 1 1	+ 1 41	+ 1 12	+ 3 31	0 18	+·017	+·020	+·061	+·057	+·005	+·040	34
"	5 ix. 79	+ 0 46	+ 5 40	+ 5 24	+ 3 17	0 4	–·013	+·013	+·091	+·062	+·001	–·092	82
Simon's Bay	x. 79	– 3 21	+ 5 40	+ 4 0	+ 3 34	0 2	–·058	–·102	+·034	+·062	–·002	–·108	162
Mauritius	xi. 79	– 0 56	– 4 21	+ 4 28	+ 3 39	0 13	–·016	–·078	+·076	+·064	+·004	+·076	136

Iron and steel ships cased with wood.

COMUS.—Iron and steel screw corvette, cased with wood; 2380 tons; 2450 H.P.; 14 guns. Built, Glasgow; head S. 11° W.; launched, 3 iv. 78.—Standard Compass.

Place.	Date.	A.	B.	C.	D.	E.	𝔄.	𝔅.	ℭ.	𝔇.	𝔈.	Amount.	Direction.	λ	1/λ	a.	e.	Fore and aft.	Transverse.	μ.	Windward.	Vert. transverse.	Vert. vertical.
Sheerness	14 xi. 79	...	From N.W. quadrant. + 0 3	+ 0 49	+ 6 9	0 34	...	–·041	...	+·098	...	–·354	353	·937	1·073	+·033	–·169	+ 1 0	+ 5 9	·998	+ 0 25	+ 0 26	– 0 1
"	15 xi. 79	+ 0 50	– 0 3	...	...	...	+·014	–·001	+·013	+·107	...	–·014	94	·932						·977	+ 0 22	+ 0 26	– 0 4
Simon's Bay	18 xii. 79	...	From n. semicircle. + 5 25	+ 6 9	0 15		+·342	+·099	–·097	+·001	–·001	–·348	5							·796	– 0 5		0 31
* Hong-Kong	20 iii. 80	+ 0 17	– 5 17	+ 2 38	0 19		+·099	+·014	+·044	+·107	–·005	+·100	8										
"	12 vii. 80	+ 0 21	+ 1 6	+ 0 8	0 37		–·097	+·001	+·018	+·107	+·011	–·706	155										
Singapore	13 xii. 81	+ 0 17	+ 1 1	+ 1 18	0 42		–·001	–·001	+·019	+·099	+·012	–·018	87										

CARYSFORT.—Iron and steel screw corvette, cased with wood, 2380 tons; 2400 H.P.; 14 guns. Built, Glasgow; head S. 11° W.; launched, 26 ix. 78.—Standard Compass.

Place.	Date.	A.	B.	C.	D.	E.	𝔄.	𝔅.	ℭ.	𝔇.	𝔈.	Amount.	Direction.	λ	1/λ	a.	e.	Fore and aft.	μ.	Windward.	Vert. transverse.	Vert. vertical.	g/tan θ	g.
Sheerness	5 x. 80	+ 0 25	From southern semicircle. + 0 22	– 1 30	+ 5 23	0 18	–·015	+·387	+·006	+·094	+·005	–·387	358	·950	1·052	+·039	–·139	+ 1 13	·897	+ 0 5	+ 0 21	– 0 26	+ ·040	+ ·096
"	6 x. 80	+ 0 22	– 1 30	+ 1 48	0 8		–·025	+·006	+·029	+·089	–·002	+·026	284					+ 4 10						
Simon's Bay	1 iv. 81	– 0 50	–10 58	+ 5 0	0 8		–·198	–·014	+·004	+·087	–·005	–·200	172											
Kobé, Japan	10 xi. 81	– 0 50	– 1 51	+ 0 14	0 18		–·033	+·004	+·033	+·173		–·033	173											

CLEOPATRA.—Steel and iron screw corvette, cased with wood; 2380 tons; 2610 H.P.; 14 guns. Built, Glasgow; head S. 11° W.; launched, 1 viii. 78.—Standard Compass.

Place.	Date.	A.	B.	C.	D.	E.	𝔄.	𝔅.	ℭ.	𝔇.	𝔈.	Amount.	Direction.	μ.	Windward.	Vert. transverse.	Vert. vertical.
Devonport	15 ix. 80	+ 0 25	From southern semicircle. + 2 5	+ 6 16	0 35		+·143	+·054	+·109	+·109	+·007	+·153	21	·942	+ 0 17	+ 0 27	– 0 10
"	17 ix. 80	+ 2 32	– 4 2	+ 6 26	0 34		+·046	+·034	+·112	+·109	–·010	+·057	37				
Monte Video	23/31 xii. 80	– 0 26	– 1 0	+ 6 19	0 48		–·074	–·021	+·112	+·110	+·010	+·077	196				
Hong-Kong	20 xii. 81	– 0 6	+ 1 15				–·018	+·021		+·014		–·028	190				

* Compass re-corrected on this day.

TABLE III.—Coefficients (continued).

Composite vessels.

RUBY.—Composite screw corvette; 2120 tons; 1380 H.P.; 12 guns. Built, Hull; head N. 3° W.; launched, 10 viii. 76.—Standard Compass.

Place	Date	\ Approximate coefficients \ A	B	C	D	E	\ Exact coefficients \ 𝕬	𝕭	ℭ	𝕯	𝕰	Max. of semicirc. dev. √B²+C²	Mean horiz. force √𝕭²+ℭ² Amount	Direction	Mean force to north λ	1/λ	Headward a	To starboard e	Part of 𝕯 from Fore and aft induction	Transverse induction	Mean vert. force μ	Heeling coeff. to windward	Vertical induction in transverse iron	Vertical force and induction in vertical iron	g/tanθ	g
Sheerness	30 vi. 77	From east semicircle.					…	−409	−128	…	…	25½	·430	197	·853	1·172	−061	−233	− 2 2	+ 7 50	1·444	+ 1 22	+ 0 41	+ 0 41	−·020	−·050
„	3 vii. 77	− 0 56	− 1 19	− 0 45	+ 5 48	− 0 53	−016	−024	−013	+101	−015	1½	·026	205							·941	+ 0 30		− 0 10		
Gulf of Xeros	iii. 78	+ 0 44	− 1 18	+ 0 7	+ 6 9	− 0 6	+013	−024	+002	+107	−002	1¼	·024	176												
Singapore	vi. 78	+ 0 45	− 2 59	+ 0 38	+ 5 50	+ 0 15	+013	−055	+011	+102	+004	3	·056	170												
Rangoon	x. 79	+ 0 33	− 2 32	− 0 58	+ 5 0	+ 0 6	+010	−046	−016	+087	+002	2¾	·049	199												
Zanzibar	12 iii. 80	+ 0 11	− 4 20	− 0 26	+ 4 42	+ 0 5	+003	−079	−008	+082	+001	4¼	·079	185												

GANNET.—Composite screw sloop; 1130 tons; 1110 H.P.; 6 guns. Built, Sheerness; head S. 76° E.; launched, 31 viii. 78.—Standard Compass.

Place	Date	A	B	C	D	E	𝕬	𝕭	ℭ	𝕯	𝕰	Max. dev.	Amount	Direction	λ	1/λ	a	e	Fore and aft ind.	Transverse ind.	μ	Heel to wind.	Vert. ind. trans. iron	Vert. force vert. iron
Sheerness	29 iv. 79	+ 0 52	+11 20	+ 9 17	+ 3 22	+ 0 11	+015	+201	+155	+059	+003	14¾	·253	38	·895	1·117	−052	+158	− 1 39	+ 5 2	·864	+ 0 3	+ 0 24	− 0 21
„	30 iv. 79	+ 0 43	+ 2 54	+ 0 42	+ 3 47	+ 0 7	+013	+052	+012	+066	+012	3	·053	13										
Coquimbo	x. 79	+ 0 25	− 3 15	− 1 24	+ 3 55	+ 0 36	+007	−058	−023	+068	+010	3½	·063	202										
Esquimault	vii. 81	+ 0 2	+ 1 17	− 0 53	+ 3 26	+ 0 21	+001	+024	−015	+060	−006	1½	·028	328										

ALBATROSS.—Composite screw sloop; 940 tons; 840 H.P.; 4 guns. Built, Chatham; head S. 50° E.; launched, 27 viii. 73.—Standard Compass.

Place	Date	A	B	C	D	E	𝕬	𝕭	ℭ	𝕯	𝕰	Max. dev.	Amount	Direction	λ	1/λ	a	e	Fore and aft ind.	Transverse ind.	μ	Heel to wind.	Vert. ind. trans. iron	Vert. force vert. iron	g/tanθ	g
Sheerness	17 xii. 73	− 0 38	+16 33	+ 6 17	+ 3 59	− 0 24	−011	+295	+105	+070	−007	17¾	·315	20	·951	1·051	+017	−115	+ 0 34	+ 3 25	·820	+ 0 10	+ 0 18	+ 0 28	+·034	+·085
Rio de Janeiro	20 iii. 74	− 1 31	+ 0 19	+ 0 55	+ 4 1	− 0 6	−026	+005	+016	+070	−002	1	·017	72												
Esquimault	5 vii. 74	− 0 39	+ 2 55	+ 0 45	+ 4 14	− 0 6	−011	+054	+012	+074	+002	3	·054	193												
Plymouth	10 x. 74	+ 0 10	+ 1 10	+ 1 23	+ 3 28	+ 0 41	+002	+023	+023	+060	−012	1¼	·023	82												
Taboga	27 x. 74	+ 0 20	+ 1 44	+ 0 12	+ 3 44	0 9	−006	+031	+003	+065	−003	1¾	·031	186												
Pisco	15 xii. 76	+ 0 31	− 3 28	+ 4 55	+ 2 55	+ 0 41	+001	+061	+001	+051	−012	3¾	·061	179												
Esquimault	29 x. 77	+ 0 47	+ 0 16	+ 0 56	+ 3 26	− 0 6	−014	+016	+005	+060	+005	1	·017	72												

BOXER.—Composite double screw gun vessel; 603 tons; 590 H.P.; 4 guns. Built, Deptford; head S. 60° W.; launched, 25 i. 68.—Standard Compass.

Place	Date	A (From N.E. quadrant)	B	C	D	E	𝕬	𝕭	ℭ	𝕯	𝕰	Max. dev.	Amount	Direction
Greenhithe	30 xi. 68	…	+ 3 11	− 1 27	+ 3 39	+ 0 20	…	+195	−161	+072	+006	14¾	·253	320
Rio de Janeiro	20 ii. 69	+ 0 11	+ 0 49	− 4 15	+ 3 50	+ 0 24	+003	+057	−024	+064	−007	3½	·062	337
Esquimault	x. 69	+ 0 6	+ 3 49	− 2 53	+ 2 33	− 0 20	−002	−014	−071	+067	−007	4½	·072	259
Esquimault	+ 0 8						+065	−049	+050	−006	4¼	·082	323
Komax, Vancouver Island	24 iv. 71	+ 1 33	+ 2 52	+ 3 27	+ 2 25	+ 0 19	+027	+051	−059	+042	+005	4½	·078	311
Esquimault	30 xii. 74	+ 2 52	+ 4 4	− 1 46	+ 3 18	+ 0 24	−050	+073	−030	+057	+007	5	·079	338
Coquimbo	13 v. 75	− 1 05	− 0 59	+ 3 20	+ 2 20	− 0 10	+019	+017	−002	+041	−002	1	·017	186

PERT.—Composite double screw gun vessel; 603 tons; 500 H.P.; 4 guns. Built, Glasgow; head S. 65° W.; launched, 22 vi. 68.—Standard Compass.

Place	Date	A (From N.E. quadrant)	B	C	D	E	𝕬	𝕭	ℭ	𝕯	𝕰	Max. dev.	Amount	Direction	λ	1/λ	a	e	Fore and aft ind.	Transverse ind.
Devonport	3 ii. 70	…	+ 0 46	+ 1 04	+ 3 50	− 0 31	…	+251	−186	+065	+017	18	·312	323	·939	1·065	+·002	−·124	+ 0 5	+ 3 45
„	8 ii. 70	+ 1 0					+017	+013	−017	+047	−009	1¼	·021	307						
Elephant Bay, W. Coast of Africa	29 xii. 70	+ 3 9	− 3 30	− 2 15	+ 2 59	…	+055	−062	−038	+052	−028	4½	·073	202						
Rio de Janeiro	29 xii. 71	− 0 7	− 2 0	− 2 13	+ 3 15	− 1 35	−002	−036	−038	+057		3	·052	227						

TABLE III.—Coefficients (continued).

Composite vessels (continued).

FIREFLY.—Composite screw gunboat; 455 tons; 470 H.P.; 4 guns. Built, Glasgow; head N. 26° E.; launched, 28 vi. 77.—Standard Compass.

Place	Date	_Approx. A	B	C	D	E	_Exact A	B	C	D	E	Max. semicirc. dev.	H. force Amount	Direction	λ	1/λ	a	e	Fore & aft ind.	Transv. ind.	μ	Heeling to windward	Vert. ind. transv. iron	Vert. force vert. iron	$g/\tan\theta$	g
Plymouth	24 vi. 79 (From S.W. quadrant)						…	−·330	+·016	+·065	+·005	18	·330	180												
"		…	+0 45	+0 55	+0 57	+3 45 / +0 18		+·016		+·071	+·001	1¼	·023	45												
False Bay, C. of Good Hope	29 vi. 80	−0 23	−0 14	+0 4	+4 6	+0 4	−·006	−·004	+·001	+·071	+·001	0¾	·004	166												
Gaboon R.	30 viii. 80	+0 32	+1 3	+1 42	+3 40	+0 45	+·009	+·019	+·029	+·064	+·013	2	·035	57												

WRANGLER.—Composite screw gun vessel; 465 tons; 480 H.P.; 4 guns. Built, Barrow-in-Furness; head N.E.; launched, 5 x. 80.—Standard Compass.

Place	Date	A	B	C	D	E	A	B	C	D	E	Max. dev.	Amount	Direction	λ	1/λ	a	e	F&A	Transv.	μ	Heel. wind.	Vert. transv.	Vert. iron	$g/\tan\theta$	g
Plymouth	26 v. 81	−0 37	−10 28	+20 28	+3 15	−0 30	−·011	−·183	+·339	+·057	−·009	23	·385	117	·970		assumed.				·943	+0 7	+0 15	−0 15		
"		−0 4	−0 41	+0 15	+4 38	−0 31	−·001	−·012	+·004	+·081	−·009	0¾	·013	162												
Simon's Bay	31 xii. 81	−0 52	−1 5	−1 32	+5 2	+0 9	−·015	−·020	+·026	+·088	+·002	2	·033	232												

Wooden ships with iron beams and vertical bulkheads.

ENCOUNTER.—Wood corvette, iron beams and iron transverse bulkheads from keel to lower deck. Built at Sheerness; head S. 75° E.; launched, 6 xi. 69.—Standard Compass.

Place	Date	A	B	C	D	E	A	B	C	D	E	Max. dev.	Amount	Direction	λ	1/λ	a	e	F&A	Transv.	μ	Heel. wind.	Vert. transv.	Vert. iron	$g/\tan\theta$	g
Sheerness	2 ix. 73	−0 3	+13 24	+9 27	+4 12	+0 20	−·001	+·240	+·157	+·073	+·006	16½	·287	33	·940	1·063	+·008	−·128	+0 20	+3 53	·944	−0 4	+0 20	−0 24	+·002	+·05
"	9 ix. 73	−0 35	+3 32	+2 8	+4 14	+0 11	+·010	+·064	+·036	+·074	−·003	4	·074	29												
Simon's Bay	11 iv. 74	+1 18	−1 26	+1 19	+3 40	+1 0	+·020	−·026	+·022	+·064	+·017	2	·034	140												
"	15 x. 74	−1 36	−1 10	+0 27	+4 43	+0 28	+·010	−·021	+·008	+·082	+·008	1⅝	·022	160												
"	20 i. 76	−1 9	−4 12	−0 12	+2 48	+0 59	−·020	−·075	−·001	+·050	−·017	4½	·076	185												
Grenada	30 x. 76	+0 36	−0 42	−0 37	+3 20	+0 22	+·010	−·014	−·009	+·059	−·006	1	·016	218												

SAPPHIRE.—Wood corvette, iron beams and iron transverse bulkheads from keel to lower deck. Built at Devonport; head E.; launched, 24 ix. 74.—Standard Compass.

Place	Date	A	B	C	D	E	A	B	C	D	E	Max. dev.	Amount	Direction	λ	1/λ	a	e	F&A	Transv.	μ	Heel. wind.	Vert. transv.	Vert. iron	$g/\tan\theta$	g
Devonport	21 viii. 75	−0 22	+18 44	+7 24	+4 7	−0 25	−·006	+·333	+·123	+·072	−·007	20	·352	20	·938	1·066	+·005	−·129	+0 9	+3 58	·831	−0 6	+0 21	−0 27	+·013	+·082
"	24 viii. 75	−0 17	+1 3	+0 45	+4 9	−0 17	−·005	+·018	+·013	+·072	−·005	1⅛	·022	36												
Simon's Bay	30 xii. 75	−0 5	−8 54	+0 49	+3 55	+0 20	−·001	−·160	+·013	+·068	+·006	9	·160	175												
Wellington, N.Z.	xii. 76	−0 49	−10 43	+0 5	+3 0	+0 52	−·014	−·188	+·001	+·052	−·015	11	·189	179												
Sydney, N.S.W.	viii. 77	−0 10	−11 20	−1 25	+3 48	+0 15	−·003	−·203	−·024	+·066	+·004	12	·204	187												