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.*

By Staff Commander E. W. CREAK, *R.N., of the Admiralty Compass Department.*

Communicated by Sir FREDERICK J. O. EVANS, *K.C.B., Hydrographer of the Admiralty.*

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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 semicircular 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.

$\mathfrak{A}$.

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 $\mathfrak{B}=\frac{1}{\lambda}\left(c \tan \theta+\frac{P}{H}\right)$ (approximate value in degrees $=$B) is the maximum of semicircular deviation from fore and aft forces;

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

$\frac{P}{\lambda H}$ from hard iron.

Coefficient $\mathfrak{C}=\frac{1}{\lambda}\left(f \tan \theta+\frac{Q}{H}\right)$ (approximate value in degrees $=$C) is the maximum of semicircular deviation from transverse forces;

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

$\frac{Q}{\lambda H}$ 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,

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

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

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

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:—

	θ.	
Triumph	−44°	Range of θ 82°.
	−34	
	− 3	
	+38	

	θ.	
Swiftsure	+67°	Range of θ 119°.
	+17	
	−11	
	−29	
	−52	

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.	$-\cdot005$	$-\cdot012=0°\ 42'$
Triumph.	$-\cdot013$	$-\cdot038=2°\ 10'$
Swiftsure	$+\cdot004$	$+\cdot010=0°\ 35'$
Active	$+\cdot004$	$+\cdot010=0°\ 35'$
Himalaya	$+\cdot006$	$+\cdot015=0°\ 52'$
Comus	$-\cdot004$	$-\cdot010=0°\ 35'$

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

Coefficient $\mathfrak{E}=\frac{d+b}{2\lambda}$ (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.

$\lambda=1+\frac{a+e}{2}$ 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.

$\mu=1+k+\frac{R}{Z}$, 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.

* By Staff Commander J. C. Richards, R.N.

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.									
Spithead . . .	3 xi. 73	+·024	−·004	0	0	+·215	+·025	−·012 = −0° 42′	−·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.									
Plymouth. . .	20 i. 71	+·407	..	+·158 = +9° 5′	+·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. $133\frac{1}{2}$° E. .	27 vii. 74	..	−·123	..	..	..	+·054		
$12\frac{3}{4}$° 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.									
Spithead . . .	15 v. 78	−·033	−·289	+·304 = +17°40′	+·106	−·020	+·044	−·038 = −2° 10′	−·013
Equator, $24\frac{1}{2}$° W.	20 vi. 78	..	−·222		..	..	−·012		
23° S. 39° W.. .	1 vii. 78	..	−·214	..	..	..	+·009		
$40\frac{1}{2}$° S. $78\frac{3}{4}$° W. .	7 vii. 78	..	−·194	..	..	..	−·001		
Valparaiso. . .	x. 78	..	−·190	..	..	..	−·007		
$9\frac{1}{4}$° S. $80\frac{3}{4}$° 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.									
Plymouth. . .	8 v. 82	−·057	−·233	+·304 = +17°40′	+·110	+·010	−·016	+·010 = 0° 35′	+·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).

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 (continued).					
NORTHAMPTON.—Built S. 6° E. Distance of standard from stern 83 feet, from iron mast 22 feet.									
Sheerness . . .	1 xi. 79	+·345	..	−·060	−·021	−·008	−·002		
Spithead . . .	18 xii. 79	..	+·050	= −3° 25′	..	..	−·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.									
Sheerness . . .	28 vii. 81	+·281	..	−·043	−·014	−·060	..		
Plymouth . . .	28 ix. 81	..	+·032	= −2° 30′	..	..	+·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.									
Portsmouth . .	13 x. 73	−·541	−·120	+·039	+·015	+·024	..	+·010	+·004
,, . .	15 x. 73	..	−·120	= +2° 15′	..	..	−·019	= +0° 35′	
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.									
Spithead . . .	8 vii. 76	+·003	..	−·012	−·005	+·173	..		
,, . . .	4 x. 76	..	+·009	= −0° 42′	..	..	+·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.									
Sheerness . . .	6 vi. 74	+·195	..	−·017	−·006	+·203	..		
,, . . .	8 vi. 74	..	+·029	= −1° 0′	..	..	+·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.

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 $7\frac{3}{4}$ feet.									
Sheerness . . .	14 xi. 79	+·246	..	+·089 =	+·034	—·029	..	—·010 =	—·004
" . . .	18 xii. 79	+·234	+·009	+5° 7′	..	+·041	+·022	—0° 35′	
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 =	+·044	—·014	..		
" . . .	6 x. 80	..	—·099	+6° 23′	..	..	—·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 $49\frac{1}{2}$ feet, from iron mast $6\frac{3}{4}$ feet.									
Plymouth . . .	15 ix. 80	+·057	..	+·082 =	+·032	+·050	..		
" . . .	17 ix. 80	..	—·033	+4° 43′	..	..	+·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 $6\frac{3}{4}$ feet.									
Sheerness . . .	30 vi. 77	—·486	..	+·077	+·027	—·109	..		
" . . .	3 vii. 77	..	—·086	+4° 25′	..	..	—·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 =	+·024	+·139	..		
" . . .	30 iv. 79	..	—·012	+3° 45′	..	..	+·010		
Coquimbo . . .	x. 79	..	—·059	..	..	..	—·032		
Esquimault, Vancouver Island .	vii. 81	..	—·059	..	..	..	—·014		
ALBATROSS.*—Built S. 50° E. Distance of standard from stern $37\frac{1}{2}$ feet.									
Sheerness . . .	17 xii. 73	+·209	..	+·073 =	+0·29	+·100	..		
" . . .	20 iii. 74	..	—·066	+4° 12′	..	..	+·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 $30\frac{1}{2}$ feet.									
Greenhithe . .	30 xi. 68	+·124	−·004	+·062 = +3° 35′	+·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 $29\frac{3}{4}$ feet.									
Devonport . .	3 ii. 70	+·170	..	+·070 = +4° 0′	+·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 $15\frac{3}{4}$ feet.									
Plymouth . . .	24 vi. 79	−·332	+·004	+·012 = +0° 42′	+·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 $15\frac{3}{4}$ feet.									
Plymouth . .	26 v. 81	−·183	−·017	+·006 = +0° 20′	+·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.									
ENCOUNTER.—Built S. 76° E. Distance of standard from stern 48 feet. Masts wooden.									
Sheerness . . .	2 ix. 73	+·182	..	+·046 = +2° 40′	+·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 $47\frac{3}{4}$ feet, from iron mast $5\frac{1}{2}$ feet.									
Plymouth . . .	21 viii. 75	+·202	..	+·117 = +6° 45′	+·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.

Place.	Date.	Approximate coefficients. A.	B.	C.	D.	E.	Exact coefficients. 𝔄.	𝔅.	ℭ.	𝔇.	𝔈.	Maximum of semi-circular deviation. $\sqrt{B^2+C^2}$	Mean horizontal force of ship. $\sqrt{𝔅^2+ℭ^2}$ Amount.	Direction.	Mean force to north. λ.	$\frac{1}{\lambda}$.	Coefficients of horizontal induction. Headward. *a*.	To starboard. *e*.	Part of 𝔇 from Fore and aft induction.	Transverse induction.	Mean vertical force. μ.	Heeling coefficient to *windward*.	Heeling coefficient for Vertical induction in transverse iron.	Vertical force and induction in vertical iron.	Variable part of vertical force. $\frac{g}{\tan\theta}$.	*g*.
		° ′	° ′	° ′	° ′	° ′						°		°					° ′	° ′		° ′	° ′	° ′		
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.																										
Spithead	3 xi. 73	...	From	quad	rant.	...	...	+·028	+·233	+·098	...	13½	·235	83												
,,	4 xi. 73	+ 1 11	− *0 16*	+ *1 3*	+ 5 12	− 0 32	+·020	−*·005*	+*·017*	+·090	−·009	*1¼*	*·018*	*109*	·878	1·139	−·043	−·201	− 1 22	+ 6 4	1·056	+ 0 42	+ 0 33	+ 0 9	+·016	+·040
Halifax, N.S.	5 viii. 74	− 0 8	+ *2 20*	− *0 50*	+ 6 9	...	−·002	+*·041*	−*·014*	+·107	...	*2¾*	*·044*	*344*												
Quebec	16 ix. 74	− 0 38	− *0 11*	− *2 26*	+ 5 16	+ 1 30	−·011	−*·003*	−*·042*	+·092	+·026	*2½*	*·041*	*265*												
Trinidad	1 iii. 76	+ 0 1	− *0 45*	− *0 21*	+ 5 39	+ 0 26	+·001	−*·013*	−*·006*	+·098	+·008	*0½*	*·015*	*199*												
Halifax, N.S.	21 vi. 76	− 0 28	− *1 30*	− *1 35*	+ 6 11	− 0 37	−·008	−*·026*	−*·028*	+·108	−·011	*2¼*	*·037*	*224*												
Quebec	24 viii. 76	− 0 13	− *1 40*	− *1 25*	+ 4 30	+ 0 39	−·004	−*·029*	−*·025*	+·078	+·011	*2*	*·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.																										
Plymouth	20 i. 71	+ 0 55	+34 18	−11 24	+ 5 45	+ 0 46	+·016	+·598	−·180	+·100	+·013	36	·624	343												
,,	16 ix. 71	+ 1 9	+ *7 31*	+ *3 11*	+ 6 23	− 0 2	+·020	+*·137*	+*·052*	+·112	−·001	*8¼*	*·147*	*21*	·925	1·081	+·028	−·178	+ 0 54	+ 5 29	·826	+ 0 1	+ 0 29	− 0 28		
Gibraltar	x. 71	+ 0 13	+ *3 32*	− *0 23*	+ 6 0	− 0 5	+·004	+*·065*	−*·007*	+·104	−·001	*3½*	*·066*	*354*												
6° N., 96° E.	10 xii. 71	+ 0 33	− *1 37*	+ *2 57*	+ 5 40	+ 0 39	+·009	−*·029*	+*·048*	+·099	+·011	*3½*	*·066*	*121*												
38° N., 136° E.	22 viii. 72	− 0 59	+ *0 35*	+ *0 27*	+ 5 17	+ 0 22	−·017	+*·010*	+*·007*	+·092	+·006	*0¾*	*·012*	*35*												
49° N., 140° E.	viii. 73	+ 0 53	+ *2 12*	+ *1 27*	+ 4 48	− 0 10	+·015	+*·040*	+*·024*	+·084	−·003	*2½*	*·047*	*31*												
34° N., 133½° E	27 vii. 74	+ 0 30	− *0 26*	+ *2 0*	+ 4 45	+ 0 25	+·009	−*·007*	+*·033*	+·083	+·007	*2*	*·034*	*102*												
12¾° N., 46° E.	11 iii. 75	− 2 25	− *3 23*	− *0 36*	+ 5 3	+ 0 34	−·042	−*·062*	−*·009*	+·088	+·010	*3½*	*·063*	*189*												
Plymouth	27 vii. 75	− 0 12	+ *0 38*	+ *2 45*	+ 4 47	+ 0 13	−·003	+*·011*	+*·046*	+·083	+·004	*3*	*·047*	*76*												
Belfast Lough	5 ix. 76	− 0 27	+ *1 0*	+ *2 15*	+ 4 16	+ 0 7	−·007	+*·018*	+*·038*	+·074	+·002	*2¼*	*·042*	*64*												
Plymouth*	18 vii. 78	From	four	cardinal	points.		...	+·593	−·117	...	...	36	·605	349												
,,	,,	+ 0 8	+ *1 26*	− *1 25*	+ 4 57	+ 0 21	+·002	+*·026*	−*·024*	+·086	+·006	*2*	*·035*	*317*												
Singapore	xi. 78	+ 0 1	− *6 17*	+ *1 1*	+ 4 56	+ 0 14	+·001	−*·114*	+*·016*	+·086	+·004	*6½*	*·115*	*172*												
Yokohama	vii. 79	− 1 40	− *3 0*	− *0 52*	+ 5 3	+ 0 31	−·029	−*·054*	−*·014*	+·088	+·009	*3*	*·056*	*194*												
Hong Kong	28 xii. 80	− 0 46	− *3 57*	− *0 2*	+ 4 52	+ 0 34	−·013	−*·072*	−*·001*	+·085	+·010	*4*	*·072*	*181*												
,,	31 xii. 81	− 1 8	− *3 35*	− *1 12*	+ 4 23	+ 0 49	−·020	−*·064*	−*·020*	+·079	+·014	*3¾*	*·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.																										
Plymouth	18 iii. 73	− 1 9	+20 53	−10 0	+ 6 45	− 0 5	−·020	+·377	−·161	+·117	−·001	23¼	·410	337												
,,	,,	+ 0 18	+ *1 40*	− *0 23*	+ 7 12	+ 0 33	+·005	+*·031*	−*·007*	+·125	+·009	*1¾*	*·032*	*347*	·839	1·192	−·056	−·266	− 1 56	+ 9 7	·881	+ 0 26	+ 0 47	− 0 21	+·067	+·167
Spithead†	15 v. 78	...	From S.	W. qua	drant.	...	...	+·266	−·063	...	...	15	·273	347												
,,	,,	− 1 23	− *2 7*	+ *0 51*	+ 5 51	− 0 53	−·024	−*·039*	+*·014*	+·102	−·015	*2¼*	*·041*	*160*												
Equator, long. 24½° W.	20 vi. 78	− 2 29	− *7 0*	− *0 56*	+ 7 6	− 0 58	−·043	−*·129*	−*·015*	+·124	−·017	*7*	*·130*	*187*												
23° S., 39° W.	1 vii. 78	− 3 31	−*11 13*	+ *0 38*	+ 6 41	− 0 44	−·061	−*·205*	+*·010*	+·116	−·013	*11¼*	*·205*	*177*												
40½° S., 78¾° W.	7 viii. 78	+ 0 49	−*14 51*	+ *0 55*	+ 6 39	− 1 19	+·014	−*·271*	+*·015*	+·116	−·023	*15*	*·272*	*177*												
Valparaiso	ix. x. 78	− 0 29	−*12 14*	+ *0 14*	+ 6 30	− 0 20	−·008	−*·224*	+*·004*	+·113	−·006	*12¼*	*·224*	*179*												
9½° S., 80½° W.	7 ii. 79	+ 1 31	− *7 28*	− *0 11*	+ 6 55	+ 0 18	+·026	−*·138*	−*·003*	+·120	+·005	*7½*	*·138*	*181*												
20° N., 157° W.	4 iv. 79	− 1 51	− *2 2*	− *0 51*	+ 6 28	− 0 42	−·032	−*·037*	−*·014*	+·112	−·012	*2½*	*·040*	*201*												
Esquimault	v. 79	...	From S.	W. qua	drant.	...	...	+*·103*	+*·015*	...	...	*5½*	*·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).

Place.	Date.	Approximate coefficients. A.	B.	C.	D.	E.	Exact coefficients. 𝔄.	𝔅.	ℭ.	𝔇.	𝔈.	Maximum of semicircular deviation. $\sqrt{B^2+C^2}$ Amount.	Mean horizontal force of ship. $\sqrt{𝔅^2+ℭ^2}$	Direction.	Mean force to north. λ.	$\frac{1}{\lambda}$.	Coefficients of horizontal induction. Headward. *a*.	To starboard. *e*.	Part of 𝔇 from Fore and aft induction.	Transverse induction.	Mean vertical force. μ.	Heeling coefficient to *windward*.	Heeling coefficient for Vertical induction in transverse iron.	Vertical force and induction in vertical iron.	Variable part of vertical force. $\frac{g}{\tan\theta}$.	*g*.
		° ′	° ′	° ′	° ′	° ′						°		°					° ′	° ′		° ′	° ′	° ′		
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.																										
Plymouth	17 vi. 72	From s	outhern	and we	st semi	circles.	...	+·386	−·186	+·122	...	25¼	·430	337	·834	1·199	−·064	−·268	− 2 11	+ 9 13	1·184	+ 1 21	+ 0 48	+ 0 33	+·062	+·155
,,	8 v. 82	...	From	N.E. qu	adrant.	...	...	+·239	...	+·108	ass.	12½	·239	...												
,,	,,	+ 0 33	+ *2 5*	− *0 22*	+ 6 12	+ 0 22	+·009	+*·038*	−*·006*	+·108	+·006	*2*	*·038*	*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 5	− *5 0*	− *0 13*	+ 6 19	+ 0 46	+·019	−*·092*	−*·004*	+·110	+·013	*5*	*·092*	*183*							*·872*			− *0 21*		
23° S., 43° W.	5 vii. 82	− 4 1	−*11 8*	− *4 10*	+ 5 44	+ 0 17	−·070	−*·202*	−*·068*	+·100	+·005	*12*	*·213*	*199*												
Monte Video	23 vii. 82	− 3 31	−*14 6*	− *1 40*	+ 4 49	− 0 9	−·061	−*·255*	−*·027*	+·084	−·002	*14¼*	·255	*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*												
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.																										
Sheerness	1 xi. 79	− 0 44	+20 1	− 0 37	+ 3 38	− 0 6	−·013	+·354	−·010	+·063	−·002	20	·354	359	·834	1·189	−·114	−·218	− 3 54	+ 7 32	·903	+ 0 21	+ 0 37	− 0 16	+·055	+·132
Spithead	18 xii. 79	+ 0 37	+ *0 1*	− *0 6*	+ 4 3	− 0 1	+·011	+*·001*	−*·002*	+·070	−·001	*0¼*	*·002*	*260*												
27½° N., 62¾° W.	23 i. 80	+ 1 13	+ *0 21*	− *2 39*	+ 3 44	− 0 16	+·021	+*·006*	−*·044*	+·065	−·004	*2¾*	*·044*	*278*												
St. Lucia, S.W. Point	20 ii. 80	+ 0 58	+ *0 17*	− *3 4*	+ 3 30	+ 0 22	+·017	+*·005*	−*·051*	+·061	+·006	*3¼*	*·051*	*276*												
Bermuda	8 v. 80	− 1 53	+ *1 12*	− *4 58*	+ 5 3	− 0 40	−·034	+*·022*	−*·082*	+·088	−·012	*5*	*·085*	*285*												
Halifax, N.S.	27 vi. 80	+ 0 36	− *3 10*	− *3 2*	+ 3 40	− 1 32	+·010	−*·057*	−*·051*	+·064	−·027	*4¼*	*·077*	*222*												
Rimouski River, St. Lawrence	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	+ *0 23*	− *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.																										
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		
Plymouth	28 ix 81	− 0 23	− *0 13*	+ *1 57*	+ 4 7	− 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.																										
Portsmouth	28 ii. 70	From	deviation and	force on	one point		...	−·540	−·064	+·085	ass.	32	·544	187												
,,	7 iii. 70	− 0 10	− *2 35*	+ *0 42*	+ 4 0	− 0 8	−·003	−*·046*	+*·012*	+·070	−·002	*3*	*·048*	*165½*	·904	1·106	−·033	−·159	−1 4	+5 4	1·096	+0 44	+0 26	+0 18	...	ass.
																					·854	+*0 2*	+0 26	−*0 24*	...	
,,	13 x. 73	...	From	quad	rant	...	...	−·537	−·016	+·059	...	32½	·537	182	·941	1·063	−·004	−·114	−0 7	+3 34	1·052	+0 26	+0 18	+0 8	...	
,,	15 x. 73	+ 0 24	− *4 59*	− *0 34*	+ 3 17	− 0 5	+·007	−*·089*	−*·010*	+·057	−·001	*5*	*·090*	*186*							*·949*	+*0 1*	+*0 18*	−*0 17*	...	
Simon's Bay	x. 74	− 1 27	− *7 51*	− *1 31*	+ 2 41	+ 0 59	−·025	−*·140*	−*·025*	+·047	+·017	*8*	*·142*	*190*												
,,	x. 75	− 1 16	− *6 33*	− *1 33*	+ 2 14	− 0 18	−·022	−*·115*	−*·028*	+·039	−·005	*6¾*	*·118*	*194*												
,,	xi. 76	− 2 12	− *6 33*	− *0 42*	+ 2 44	− 0 18	−·038	−*·117*	−*·012*	+·048	−·005	*6½*	*·118*	*186*												

TABLE III.—Coefficients (continued).

Place.	Date.	Approximate coefficients.					Exact coefficients.					Maximum of semicircular deviation. $\sqrt{B^2+C^2}$ / Mean horizontal force of ship. $\sqrt{\mathfrak{B}^2+\mathfrak{C}^2}$		Mean force to north.	$\frac{1}{\lambda}$.	Coefficients of horizontal induction.		Part of 𝔇 from		Mean vertical force.	Heeling coefficient to *windward.*	Heeling coefficient for		Variable part of vertical force.	
		A.	B.	C.	D.	E.	𝔄.	𝔅.	ℭ.	𝔇.	𝔈.	Amount.	Direction.	λ.		Head-ward. *a.*	To star-board. *e.*	Fore and aft induction.	Transverse induction.	μ.		Vertical induction in transverse iron.	Vertical force and induction in vertical iron.	$\frac{g}{\tan\theta}$.	*g.*
		° ′	° ′	° ′	° ′	°						°	°					° ′	° ′		° ′	° ′	° ′		
***Iron ships cased with wood* (continued).**																									
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 15	+·002	−·009	+·188	+·100	+·004	11½	·188	93											
,, . . .	4 x. 76	− 1 29	− 0 8	+ 5 25	+ 5 5	+ 0 33	−·026	−·002	+·090	+·089	+·009	5½	·090	91	·923	1·083	+·005	−·159	+0 12	+4 54	·988	−0 24	+0 26	−0 2	+·011	+·027
Esquimault . .	x. 77	+ 0 8	− 1 49	− 4 6	+ 5 15	+ 0 20	+·002	−·033	−·068	+·091	+·006	4½	·076	244											
Coquimbo . . .	8 iii. 78	...	− 0 31	− 0 2	+ 5 37	+ 0 30	...	−·009	−·001	+·095	+·009	0½	·009	186											
Panama. . . .	11 v. 78	− 0 2	− 0 31	+ 0 5	+ 5 15	+ 0 38	−·001	−·009	+·001	+·091	+·011	0½	·009	174											
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	20	·326	48											
,, . . .	8 vi. 74	+ 0 39	+ 1 1	+ 3 59	+ 6 33	+ 0 35	+·011	+·018	+·065	+·114	+·010	4¼	·067	74	·833	1·200	−·072	−·262	− 2 29	+ 9 2	·930	+ 0 33	+ 0 47	−0 14	−·017	−·042
Spithead . . .	18 ix. 74	− 0 6	+ 2 1	+ 0 14	+ 6 55	− 0 36	−·002	+·035	+·004	+·120	−·010	2¼	·037	6							·772	+ 0 6		−0 41		
Simon's Bay . .	iii. 75	− 1 14	+ 3 17	+ 1 44	+ 6 35	− 0 55	−·021	+·059	+·028	+·116	−·016	3¾	·066	26											
Bombay. . . .	29 x. 75	+ 1 14	− 0 16	− 0 27	+ 5 59	+ 0 18	+·021	−·006	−·006	+·105	+·005	0½	·008	225											
Spithead . . .	14 vi. 76	+ 0 58	+ 2 53	+ 0 3	+ 5 19	+ 1 4	+·017	+·052	+·001	+·094	+·019	3	·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	26½	·463	342	·890	1·123	−·035	−·185	−1 6	+ 6 2	·827	+ 0 2	+ 0 31	− 0 29	+·042	+·105
,, . . .	20 viii. 69	+ 0 13	− 4 38	+ 1 6	+ 4 52	+ 0 15	+·004	+·083	+·018	+·085	+ 004	5	·085	12											
Plymouth . . .	21 viii. 70	+ 0 48	+ 1 30	+ 1 23	+ 4 48	+ 0 3	+·014	+·027	+·023	+·084	+·001	2	·035	40											
Spithead. . . .	18 xi. 71	+ 0 7	+ 3 8	+ 1 8	+ 4 13	− 0 4	+·002	+·057	+·019	+·074	−·001	3¼	·060	19											
Rio de Janeiro .	9 i. 72	+ 0 42	− 2 23	− 0 40	+ 4 22	+ 0 24	+·012	−·042	−·011	+·076	+·007	2¼	·044	195											
Spithead . . .	12 x. 80	...	From N	.W. qua	drant.	...	...	+·374	+·011	+·068	...	22	·375	1											
,, * . . .	14 x. 80	+ 0 55	+ 0 5	− 0 24	+ 3 54	+ 0 16	+·016	+·001	−·006	+·068	+·005	0½	·006	280							·860	+ 0 3	+ 0 25	− 0 22		
Melbourne . . .	6 vii. 81	+ 0 18	−13 5	+ 1 37	+ 3 40	− 0 17	+·005	−·234	+·027	+·064	−·005	13	·236	173											
Simonoseki. . .	15 xi. 81	+ 0 55	− 2 50	− 1 37	+ 3 55	...	+·016	−·050	−·027	+·068	...	3¼	·058	208											
Simon's Bay . .	4 v. 82	− 0 26	−11 22	− 1 18	+ 2 47	+ 0 35	−·008	−·202	−·021	+·048	+·010	11½	·203	186											
Iron troopships.																									
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	semi	circle.	...	...	−·201	−·314	+·098	...	21¾	·370	237											
,, . .	18 v. 67	+ 1 40	− 8 4	+ 1 21	+ 5 39	+ 0 43	+·029	−·147	+·022	+·098	+·013	8¼	·149	171½	·851	1·175	−·066	−·232	− 2 11	+ 7 50	1·197	+ 1 22	+ 0 44	+ 0 38		
Spithead . . .	18 vi. 67	− 0 9	− 6 43	+ 0 16	+ 5 45	− 0 9	−·003	−·123	+·005	+·100	−·003	6¾	·123	177½											
Simon's Bay . .	31 vii. 67	− 3 17	− 9 4	+ 5 44	+ 5 24	− 1 5	−·057	−·165	+·095	+·094	−·010	10¾	·141	150											
Suez	10 i. 68	+ 0 9	− 4 33	+ 3 59	+ 3 40	− 0 21	+·002	−·081	+·067	+·064	−·006	6	·105	140											
Spithead . . .	11 x. 71	...	From	quad	rant.	...	...	−·166	−·105	+·067	...	11¼	·196	212											

* Compass re-corrected on this day.

TABLE III.—Coefficients (continued).

Place.	Date.	Approximate coefficients. A.	B.	C.	D.	E.	Exact coefficients. 𝔄.	𝔅.	ℭ.	𝔇.	𝔈.	Maximum of semicircular deviation. $\sqrt{B^2+C^2}$ Mean horizontal force of ship. $\sqrt{𝔅^2+ℭ^2}$ Amount.	Direction.	Mean force to north. λ	$\frac{1}{\lambda}$.	Coefficients of horizontal induction. Headward. *a*.	To starboard. *e*.	Part of 𝔇 from Fore and aft induction.	Transverse induction.	Mean vertical force. μ.	Heeling coefficient to *windward*.	Heeling coefficient for Vertical induction in transverse iron.	Vertical force and induction in vertical iron.	Variable part of vertical force. $\frac{g}{\tan\theta}$.	*g*.
		° ′	° ′	° ′	° ′	° ′						°	°					° ′	° ′		° ′	° ′	° ′		
Iron troopships (continued).																									
HIMALAYA.—Iron screw; 4690 tons; 2500 H.P. Built, 1854, at Blackwall.—Standard Compass.																									
Spithead	8 iii. 67	+ 0 6	− 3 48	+17 50	+ 3 3	+ 0 29	+·002	−·067	+·299	+·053	+·008	18	·307	103											
,,	15 iii. 67	+ 1 20	− 2 6	+ 3 2	+ 2 25	+ 0 35	+·023	−·037	+·052	+·042	+·010	3½	·063	125	·945	1·058	−·015	−·095	− 0 28	+ 2 53	1·167	+ 0 41	+ 0 15	+ 0 26	+·151	+·377
Plymouth	2 vii. 72	+ 1 13	− 0 55	− 2 52	+ 3 0	+ 0 14	+·021	−·016	−·049	+·052	+·004	3	·051	252	·950	1·053	...	−·100	...	+ 3 0	1·119	+ 0 34	+ 0 16	+ 0 18	+·007	+·017
Simon's Bay	viii. 72	− 0 50	− 2 31	− 2 53	+ 2 57	− 0 18	−·014	−·046	−·049	+·051	−·005	3½	·067	227												
Plymouth	9 xi. 74	+ 0 25	− 0 23	− 2 42	+ 2 49	+ 0 9	+·007	−·018	−·046	+·049	+·003	2¾	·047	260												
Simon's Bay	18 i. 75	− 0 56	− 1 37	− 4 56	+ 2 58	− 0 2	−·016	−·030	−·085	+·052	−·001	5¼	·091	251												
Plymouth	18 vi. 75	+ 0 36	− 0 51	− 4 0	+ 2 46	− 0 12	+·010	−·016	−·069	+·048	−·004	4¼	·071	257												
ORONTES.—Iron screw; 5920 tons; 2570 H.P. Built at Birkenhead; head N. 68° W; launched, 22 xi. 62.—Standard Compass.																									
Birkenhead	26 i. 76	− 0 13	− 0 54	−12 57	+ 3 5	+ 0 8	−·004	−·016	−·218	+·054	+·002	13	·219	266											
Spithead	2 iii. 76	+ 1 1	+ 1 41	+ 1 12	+ 3 31	+ 0 18	+·017	+·030	+·020	+·061	+·005	2	·040	34											
,,	5 ix. 79	− 0 46	+ 0 46	+ 5 24	+ 3 17	+ 0 4	−·013	+·013	+·091	+·057	+·001	5½	·092	82											
Simon's Bay	x. 79	− 3 21	− 5 40	+ 2 1	+ 3 34	− 0 12	−·058	−·102	+·034	+·062	−·002	6	·108	162											
Mauritius	xi. 79	− 0 56	− 4 21	+ 4 28	+ 3 39	+ 0 13	−·016	−·078	+·076	+·064	+·004	6¼	·109	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.																									
Sheerness	14 xi. 79	...	From N.W. quadrant.			...	...	+·354	−·041	+·098	...	20¾	·354	353	·937						·998	+ 0 25	+ 0 26	− 0 1		
,,	15 xi. 79	+ 0 50	− 0 3	+ 0 49	+ 6 9	+ 0 34	+·014	−·001	+·013	+·107	...	0¾	·014	94	·932	1·073	+·033	−·169	+ 1 0	+ 5 9	·977	+ 0 22	+ 0 26	− 0 04		
,,	18 xii. 79	...	From north semicircle.				...	+·342	+·030	+·107	...	20¼	·348	5							·796	− 0 5		− 0 31		
,, *	19 xii. 79	+ 0 17	+ 5 25	+ 0 52	+ 6 9	+ 0 15	+·005	+·099	+·014	+·107	+·004	5½	·100	8												
Simon's Bay	20 iii. 80	+ 0 21	− 5 17	+ 2 38	+ 5 52	− 0 19	+·006	−·097	+·044	+·102	−·005	6	·106	155												
Hong-Kong	12 vii. 80	+ 0 7	+ 0 2	+ 1 6	+ 6 8	+ 0 37	+·002	+·001	+·018	+·107	+·011	1	·018	87												
Singapore	10/13 xii. 81	− 0 17	− 0 1	+ 1 18	+ 5 40	+ 0 42	−·005	−·001	+·019	+·099	+·012	1¼	·019	90												
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.																									
Sheerness	5 x. 80	From southern semicircle.					...	+·387	−·015	...	...	21	·387	358											
,,	6 x. 80	− 0 29	+ 0 22	− 1 30	+ 5 23	+ 0 18	−·008	+·006	−·025	+·094	+·005	1½	·026	284	·950	1·052	+·039	−·139	+ 1 13	+ 4 10	·897	+ 0 5	+ 0 21	− 0 26	+·040	+·096
Simon's Bay	1 iv. 81	− 0 50	−10 58	+ 1 48	+ 5 8	− 0 8	−·014	−·198	+·029	+·089	−·002	11	·200	172												
Kobé, Japan	10 xi. 81	− 0 50	− 1 51	+ 0 14	+ 5 0	− 0 18	−·014	−·033	+·004	+·087	−·005	1¾	·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.																									
Devonport	15 ix. 80	From southern semicircle.					...	+·143	+·054	+·109	...	8¾	·153	21											
,,	17 ix. 80	+ 0 25	+ 2 32	+ 2 5	+ 6 16	− 0 35	+·007	+·046	+·034	+·109	−·010	3¼	·057	37							·942	+ 0 17	+ 0 27	− 0 10		
Monte Video	23/31 xii. 80	− 0 26	− 4 2	− 1 17	+ 6 26	+ 0 34	−·007	−·074	−·021	+·112	+·010	4¼	·077	196												
Hong-Kong	20 xii. 81	− 0 6	− 1 0	+ 1 15	+ 6 19	+ 0 48	−·002	−·018	+·021	+·110	+·014	1½	·028	130												

* Compass re-corrected on this day.

TABLE III.—Coefficients (continued).

Place.	Date.	Approximate coefficients. A. ° ′	Approximate coefficients. B. ° ′	Approximate coefficients. C. ° ′	Approximate coefficients. D. ° ′	Approximate coefficients. E. ° ′	Exact coefficients. 𝔄.	Exact coefficients. 𝔅.	Exact coefficients. ℭ.	Exact coefficients. 𝔇.	Exact coefficients. 𝔈.	Maximum of semicircular deviation. $\sqrt{B^2+C^2}$ Mean horizontal force of ship. $\sqrt{𝔅^2+ℭ^2}$ Amount. °	Direction. °	Mean force to north. λ.	$\frac{1}{\lambda}$.	Coefficients of horizontal induction. Headward. a.	Coefficients of horizontal induction. To starboard. e.	Part of 𝔇 from Fore and aft induction. ° ′	Part of 𝔇 from Transverse induction. ° ′	Mean vertical force. μ.	Heeling coefficient to windward. °	Heeling coefficient for Vertical induction in transverse iron. ° ′	Heeling coefficient for Vertical force and induction in vertical iron. ° ′	Variable part of vertical force. $\frac{g}{\tan\theta}$.	Variable part of vertical force. g.
Composite vessels.																									
RUBY.—Composite screw corvette; 2120 tons; 1830 H.P.; 12 guns. Built, Hull; head N. 3° W.; launched, 10 viii. 76.—Standard Compass.																									
Sheerness . . .	30 vi. 77	F	rom ea	st semi	circle.	...	...	−·409	−·128	...	...	25½	·430	197											
,, . . .	3 vii. 77	− 0 56	− 1 19	− 0 45	+ 5 48	− 0 53	−·016	−·024	−·011	+·101	−·015	1½	·026	205	·853	1·172	−·061	−·233	− 2 2	+ 7 50	1·444	+ 1 22	+ 0 41	+0 41	−·020	−·050
Gulf of Xeros . .	iii. 78	− 0 44	− 1 18	+ 0 7	+ 6 9	− 0 6	−·013	−·024	+·002	+·107	−·002	1¼	·024	176							·941	+ 0 30		−0 10		
Singapore . . .	vi. 78	+ 0 45	− 2 59	+ 0 38	+ 5 50	+ 0 15	+·013	−·055	+·010	+·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	−·007	+·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.																									
Sheerness . . .	29 iv. 79	− 0 52	+11 20	+ 9 17	+ 3 22	+ 0 11	−·015	+·201	+·155	+·059	+·003	14½	·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	−·012	+·052	+·012	+·066	+·002	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.																									
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
,, . . .	20 iii. 74	− 1 31	+ 0 19	+ 0 55	+ 4 1	− 0 6	−·026	+·005	+·016	+·070	−·002	1	·017	72												
Rio de Janeiro .	5 vii. 74	− 0 39	− 2 55	− 0 45	+ 4 14	+ 0 6	−·011	−·053	−·012	+·074	+·002	3	·054	193												
Plymouth . . .	10 x. 74	+ 0 10	+ 0 10	+ 1 23	+ 3 28	− 0 41	+·002	+·003	+·023	+·060	−·012	1½	·023	82												
Taboga	27 x. 75	− 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	+ 0 4	+ 2 55	+ 0 41	+·009	−·061	+·001	+·051	+·012	3½	·061	179												
Esquimault . .	29 x. 77	− 0 47	+ 0 16	+ 0 56	+ 3 26	− 0 6	−·014	+·005	+·016	+·060	−·002	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.																									
Greenhithe . .	30 xi. 68	...	From	N.E. qu	adrant	...	...	+·195	−·161	+·072	...	14¾	·253	320											
,, . .	,,	+ 0 11	+ 3 11	− 1 27	+ 3 39	+ 0 20	+·003	+·057	−·024	+·064	+·006	3½	·062	337											
Rio de Janeiro .	20 ii. 69	− 0 6	− 0 49	− 4 15	+ 3 50	− 0 24	−·002	−·014	−·071	+·067	−·007	4¼	·072	259											
Esquimault . .	⅕ x. 69	− 0 8	+ 3 42	− 2 53	+ 2 33	− 0 20	−·002	+·065	−·049	+·050	−·006	4¾	·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	− 0 5	+ 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.																									
Devonport . . .	3 ii. 70	...	From	N.E. qu	adrant	...	...	+·251	−·186	+·065	...	18	·312	323											
,, . . .	8 ii. 70	+ 1 0	+ 0 46	− 1 04	+ 3 50	− 0 31	+·017	+·013	−·017	+·067	−·009	1¼	·021	307	·939	1·065	+·002	−·124	+0 5	+3 45						
Elephant Bay, W. Coast of Africa .	29 xii. 70	+ 3 9	− 3 30	− 2 15	+ 2 59	...	+·055	−·062	−·038	+·052	...	4¼	·073	202												
Rio de Janeiro .	29 xii. 71	− 0 7	− 2 0	− 2 13	+ 3 15	− 1 35	−·002	−·036	−·038	+·057	−·028	3	·052	227												

TABLE III.—Coefficients (continued).

Place.	Date.	Approximate coefficients.					Exact coefficients.					Maximum of semi-circular deviation. $\sqrt{B^2+C^2}$ Mean horizontal force of ship. $\sqrt{\mathfrak{B}^2+\mathfrak{C}^2}$		Mean force to north.	$\frac{1}{\lambda}$.	Coefficients of horizontal induction.		Part of 𝔇 from		Mean vertical force.	Heeling coefficient to *windward*.	Heeling coefficient for		Variable part of vertical force.	
		A.	B.	C.	D.	E.	𝔄.	𝔅.	ℭ.	𝔇.	𝔈.	Amount.	Direction.	λ.		Headward. *a*.	To starboard. *e*.	Fore and aft induction.	Transverse induction.	μ.		Vertical induction in transverse iron.	Vertical force and induction in vertical iron.	$\frac{g}{\tan\theta}$.	*g*.
		° ′	° ′	° ′	° ′	° ′						°	°					° ′	° ′		° ′	° ′	° ′		
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.																									
Plymouth . . .	24 vi. 79	...	From	S.W. qu	adrant	...	...	−·330	...	...	...	18	·330	180											
" . .	"	+0 45	+*0 55*	+*0 57*	+3 45	+0 18	+·013	+*·016*	+*·016*	+·065	+·005	*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	*0¼*	*·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.																									
Plymouth . . .	26 v. 81	−0 37	−10 28	+20 28	+3 15	−0 30	−·011	−·183	+·339	+·057	−·009	23	·385	117	·970	assu	med.			·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.																									
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	·844	−0 4	+0 20	−0 24	+·002	+·005
" . . .	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	+0 36	−*1 10*	+*0 27*	+4 43	+0 28	+·010	−*·021*	+*·008*	+·082	+·008	*1½*	*·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.																									
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	+·032
" . . .	24 viii. 75	−0 17	+*1 3*	+*0 45*	+4 9	−0 17	−·005	+*·018*	+*·013*	+·072	−·005	*1½*	*·022*	*36*												
Simon's Bay . .	30 xi. 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*												