A

DESCRIPTION

OF THE

CHANGEABLE MAGNETIC PROPERTIES

POSSESSED BY ALL

IRON BODIES,

AND THE

DIFFERENT EFFECTS PRODUCED BY THE SAME

ON

Ship's Compasses,

FROM THE POSITION OF THE SHIP'S HEAD BEING ALTERED.

WITH ENGRAVINGS.

BY P. LECOUNT,
MIDSHIPMAN IN THE ROYAL NAVY.

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1820.

TO

CAPTAIN WILLIAM SHEPHEARD, R.N.

THIS WORK

Is Inscribed,

IN GRATEFUL REMEMBRANCE

OF THE

MANY ACTS OF FRIENDSHIP

WHICH THE AUTHOR HAS RECEIVED FROM HIM.

DESCRIPTION

OF THE

Variable Magnetic Properties of Iron.

AMONG the numerous researches, in the depths of which the wisest philosophers have been compelled to acknowledge themselves lost, those in the science of Magnetism, seem to stand foremost. It appears to me that hardly any attempts have been made to lay down properly its first laws; as in the way they are now given in the best writings on this subject, they are in some cases directly contrary to truth in one half the world, nor will they in the other half, account for many of the effects of its attraction and its astonishing variations.

One of the most interesting departments of this science is, that which relates to the mariner's compass; and, notwithstanding its importance, on which it is needless to dwell, yet it is often left in a most embarrassing state. A good navigator will find but little use in his dead reckoning in crossing the ocean, except in working it up from his last correct observations, when near land, &c., or till he obtains correct ones again: for with chronometers, lunars, and the eclipses of Jupiter's satellites, his longitude ought never to be materially out; and, if he has a proper knowledge of the stars, he may generally, in very cloudy weather, get a glimpse of some one for a few seconds, and obtain his latitude; but, notwithstanding this, every method of im-

proving and correctly keeping a dead reckoning, ought to be attended to; and its paramount importance in situations close to the land in foggy weather, and in making short runs from one point or headland to another, at night, &c. can only be appreciated by those who have felt the horrors of a lee shore. In situations like these, the compass is the only reliance; and for a seaman to find that after every care in the steerage of his vessel, in a course properly deduced from the differences of latitude and longitude of the two places, and after making every allowance which his experience could suggest or directions supply, that he is embayed amongst rocks and shoals, and unable to determine his true situation, is indeed a disappointment which he must severely feel.

It has been long known that ship's compasses will point differently, the instant after the ship has been tacked; that they will often agree in some positions of her head, and materially disagree in others; and that, placed in different parts of the ship, they will point differently. Two late writers, Capt. Flinders, and Mr. Bain, have traced these attractions with considerable labour; and Capt. Flinders gives a rule for correcting this difference; but after trying that rule, as I did, from England to 16° South latitude, I was obliged to give it up. Mr. Bain, in his Work, which, in my opinion, no seaman ought to be without, shews it to be incorrect in many cases, and gives examples, for which I refer the reader to his Work, which is worthy a most attentive perusal.

There did not remain a doubt in my mind, but that these variations in the compass were the causes of those numerous errors into which ship's reckonings have been brought, and which, as Mr. Bain remarks, are too often charged to currents, &c.

It is a fact, that ship's compasses are often placed too near each other, when two are used on deck; and they thus disturb one another's motions, as may easily be found on experiment, by which it will be seen, that when compasses are placed abreast of each other, as they generally are in the binnacles, the mutual attractions of them will disturb one another least at N. S. E. W., and most at N E. N W. S E. S W., and proportionally between these points, which arises from the attractive and repulsive powers of the North and South Poles acting on each other with different degrees of force in these directions; and it will, when the compasses are two feet apart, sometimes cause a difference of nearly a quarter of a point. See the following figures;

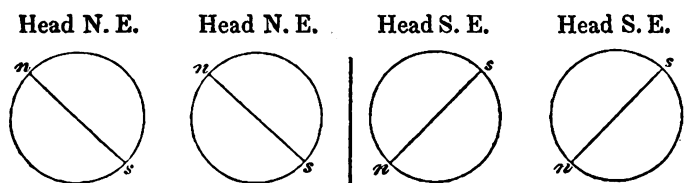
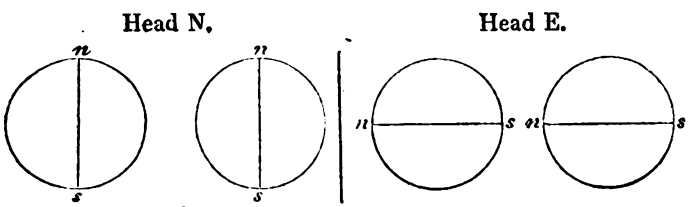


Fig. 1. Fig. 2.



Head S. Head W.

Fig. 3. Fig. 4

where it will be seen, that when the ship's head is N E. S E. N W. S W., the opposite Poles are so placed as to have the greatest power of disturbing each other, by Fig. 1 & 2, and by Fig. 3 & 4, it will be seen, that when the ship's head is N. or S., the attractive and repulsive powers neutralize one another; and when E. or W., their effect will be to make the compasses vibrate; and when settled, to render them very inert: and, from this cause, the compasses, where two are used, should never be less than four feet from each other. But this will not account for the many and diversified variations to be found in compasses; nor will the rules and observations of Capt. Flinders and Mr. Bain, account for them: they have considered and traced effects without looking to their causes; and thus their examination has been rendered laborious, inaccurate, and on such a subject as this, almost endless.

In the laws of Magnetism, as at present laid down in the best treatises, it is given, that vertical bars which have remained long in that position, acquire a magnetic property, the upper end being a South pole, and the lower end a North one; and here the matter is generally rested. But I shall prove, that it requires no time whatever for iron to acquire this property—its communication is instantaneous. It may indeed require time to occasion it to retain this property. Nor is the fact of its polarity correct, excepting in the Northern magnetic hemisphere: in the Southern it is perfectly contrary; the upper end is a North Pole, and the lower a South.

It always struck me that nothing could possibly produce the alteration observed in ship's compasses, but the effects of local attraction in the ship alone.

I tried to refer it to the effects of that power which produces the dip; if that power is different from the one which occasions the needle to point North and South, which I can never allow to be the case. But in referring it to the effects of the dip, I could find nothing whatever to justify the idea that that was the cause; for this plain reason, that whatever the dip might be, yet the dipping-needle pointed North and South as well as the needles did which were balanced horizontally.

Local attraction, therefore, was the idea which I pursued as the hidden cause of this change; and iron appeared from its numerous magnetic properties, to demand sole attention. The result of my experiments have perfectly satisfied me, and have opened to me a field of consequences, into which I shall perhaps never be able fully to enter; but with respect to the matter in hand, the following facts are the ground-work of what will follow in this work.

Iron of all descriptions, and of all sorts, bars, circles, guns, bolts, hoops, staunchions, &c. and, whether placed horizontal, vertical, or in any inclination or position whatever, are acted upon in the strongest manner by the magnetic effluvia, and that most instantaneously; and this action is varied

in a moment by the slightest change in the direction of the iron. Each and every of these pieces of iron have two poles, which have each their respective powers of attraction and repulsion; and these poles, which are communicated by the magnetic effluvia, are instantaneously altered and reversed, &c. by the slightest change in the position of the iron; so that in a bar of iron eight feet long, laid horizontally, I have, by moving one of its ends one inch altered it from a North pole to a South one; and the changes which are requisite in the position of the iron to produce this effect, are subject to a certain and definable law.

After the fact of ship's compasses differing so widely in different positions of the ship's head, a fact so well known among nautical men, and after so many scientific men have devoted their time to the improvement of other branches of navigation, I have often wondered that this should have been so long neglected; and, that the cause which I now assign for it should not have been laid down before; for nature would seem to point out iron as the thing alone to be studied.

I now lay down the law which governs these changes.

A plane or circle, held East and West (magnetic) and at right angles with the direction of the dipping-needle, will, in any part of the world, divide the North from the South magnetic effluvia, each lying on that side to which the dipping-needle points; and, by referring the position of all iron

bodies to this plane, the line of intersection shall divide the iron into North and South polarity, provided it is of uniform thickness.

If it is not of uniform thickness, the intersection must be drawn, not through the centre of its length, but through its centre of gravity.

This plane will therefore be vertical on the magnetic equator, and horizontal when the dip is either 90° N. or 90° S., and will be inclined proportionally to the dip between these situations.

I have before said, that staunchions, and all upright pieces of iron had, in the Southern magnetic hemisphere, their upper parts North poles, and their lower ones, South poles: this property changed in H. M. S. Conqueror, on her passage home from the Island of St. Helena, in latitude 11° 30′ South, and longitude 9° 29′ W. on the 23rd of July, 1820; and every principal piece of iron in that ship, which I observed both at St. Helena and during the passage home, in whatever situation it was placed, might have had its polarity instantly determined at sight from a consideration of the above law, by knowing the direction of the ship's head and the dip; and it has equally stood the test in other ships, and on shore in England.

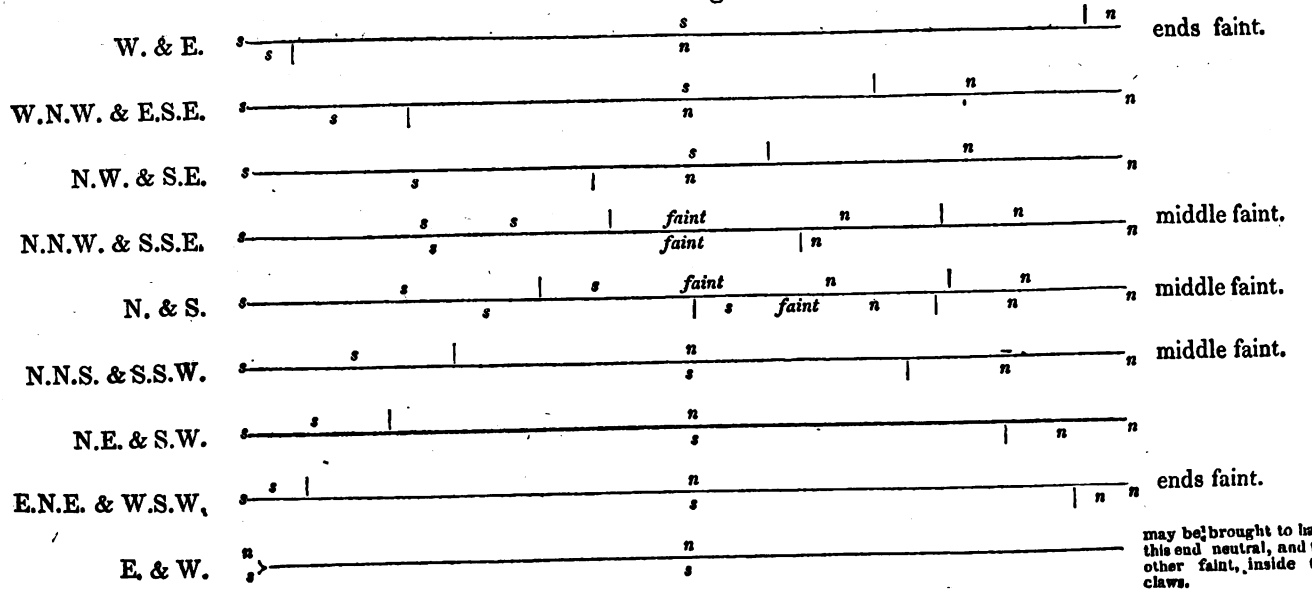
The immense number of pieces of iron, particularly in a ship of war, or merchantman mounting many guns, having each of them this polarity, and that polarity instantaneously and continually shifting, and often reversing with the slightest alteration in the ship's head, thus presents an attractive or repulsive power to the compasses; which power

is continually acting on them in a direction which is regulated by their relative positions, and thus produces this variation in them so often observed.

I shall now give a few of the observations I made, and which any person may repeat, or vary, as he pleases, and for himself ascertain the correctness of the above laws.

Experiments on an iron bar, four feet nine inches long, laid perfectly horizontal, and moved in the following bearings, and a delicate pocket compass presented to its different parts: the letters annexed to the lines, shew which pole of the compass the iron attracted, and the bearings on the left hand, one for the left hand of the bar, and vice versa. This mark ____|____ shews where the change took place, or where the polarity was reversed, the effect being there neutral,

Lat. 16° S. Long. 5. 36. W.

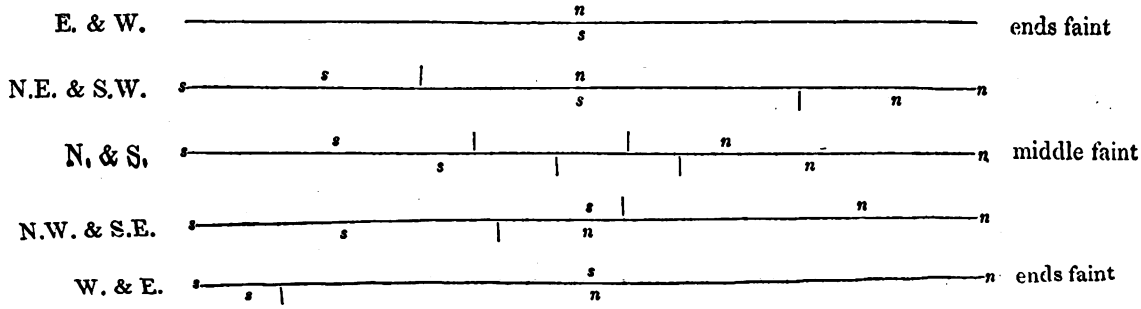


Where this mark is ⎽|⎽ there was always a faintness on each side of it, the bearing in which the ends were neutral, was about E. or W.

OBSERVATIONS.

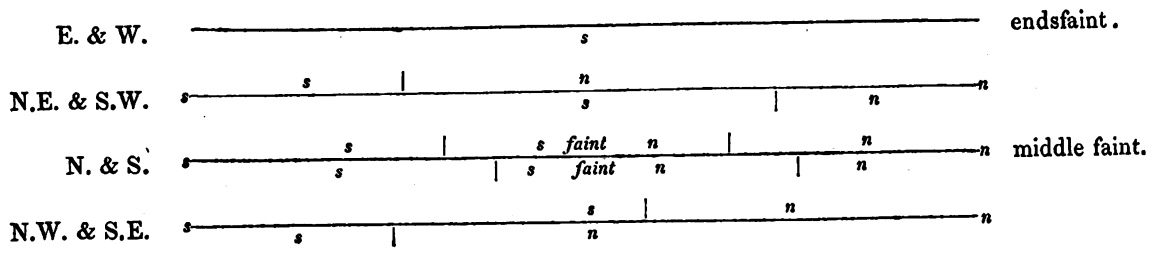
In whatever position the bar lay, by reversing it, its polarities were all instantaneously reversed; and this will invariably be found to be the case in all iron whatever, which has not been rendered permanently magnetical by other means; and the quantity of inclination necessary to reverse its polarity, when in a vertical position, varied with the points of bearing the bar was held in while being reversed, as may be seen by placing a ring as before directed in an E. and W. plane, and at right angles with the dipping-needle.

The same experiments with a 32lb. carronade traversing-bar, latitude and longitude same as before.



Both with this bar and the former when laid E. S. E. its West end attracted the South strongly, and *vice versa*, its East end the North, and when laid E. N. E., its West end attracted the North, and its East end the South.

The same experiments, with another iron bar four feet long, latitude 2° S. and longitude 15° W.



And the ends of the bar were neutral nearly at E. and W. inclining northerly; in these, and all other experiments which I made, the greatest quantity of inclination from the vertical, which was requisite to produce a reversion of polarity, corresponded to the dip of the place I was

then in, and was greatest when the bar lay magnetically N. and S. and decreased as it was made to approach the bearings of E. and W.

I likewise tried every shaped piece of iron which I could procure, particularly guns and large mast hoops, &c. &c. and found the results invariably the same. When the ship has been tacking, I have placed my compass on the north side, for instance, of the line of neutrality, and have followed that line as it shifted, all the time the ship was coming round till it has settled; when she became steady, in quite a different position, and when the polarity of every part of the iron was completely altered, exactly agreeable to the foregoing laws: when the ship was at anchor, I made use of moveable bars, for by placing them in any position and varying them, it of course answered the same purpose as if the whole ship had been moved correspondently.

In 29° north latitude, and 36° west longitude, I repeated the whole of these experiments again very carefully, and the results were exactly the same, only as the dip had increased, it took more inclination to produce the reversion of polarity: thus when the bar lay north and south, by lifting its south end, no reversion took place when it had considerably passed the vertical point, but by lifting its North end about 30 degrees, a reversion instantly took place.

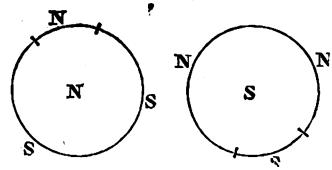
When the bar lay East and West, by lifting its East end eight or ten degrees, its poles were reversed. When the bar lay neutral at the ends, if

its West end was lifted two degrees, its poles were reversed; inclining it more Northerly, it took eight or ten degrees; at N. W. it took 15° &c. to produce the same effect; and the bearing in which the ends were neutral, had to appearance drawn Northward.

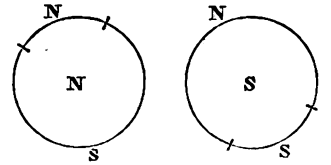
By using a crow bar for these experiments, the fact of the magnetic effluvia attending closely to the position and bearing of the iron will be very clearly seen; for you may lay the bar so that its clawed end shall be neutral, inside the claws, and yet one claw shall have North polarity, and the other South; they being curved on each side from the body of the bar, and thus thrown one into each of the divisions of magnetic effluvia, while the body of the bar, immediately within them, lies between both, and is therefore so neutral, that from the smallness of its size, it would be difficult to point out a line dividing these effects.*

The following experiments were made in latitude 32° N. longitude 38. West, with an iron ring 10,2 inches in diameter, and 5,5, inches thick, with the ring vertical; the letters on the ring shew which pole of the compass was attracted; and the letters in the centre of the ring, shew which plane the compass was placed against.

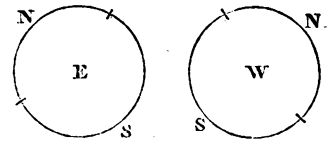
* See the Figures in the first experiment.



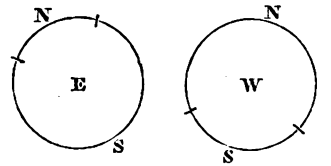
From vertical to horizontal Southerly; very slight changes, but with an inclination of 45° top to the Northward, South face attracted all round the North end of the needle, and the North face attracted the South end of the needle all round. Edges were nearly neutral.



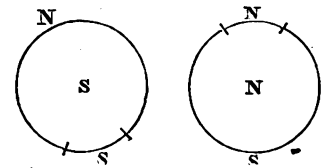
Inclined 55° Northward, North side attracted nearly all South, and South side nearly all North. Bottom faintly inclined to attract S.



Inclined either way; caused very little alteration.



Inclined 60° East, made East face nearly all South, and West face nearly all North.

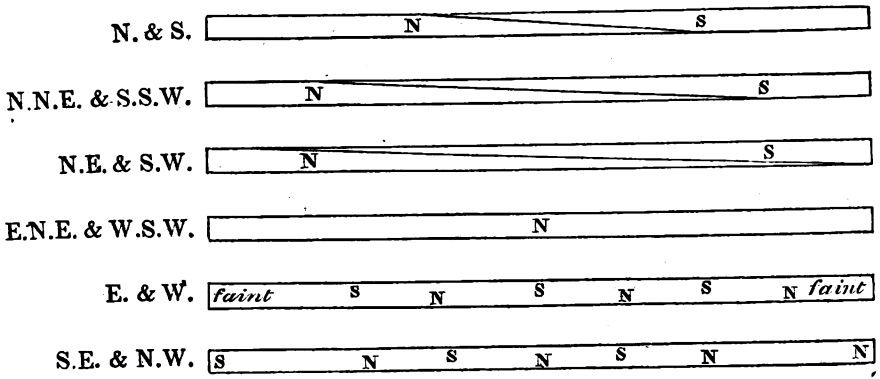


Compass placed at bottom of S. face, had its S. end attracted, but by inclining the ring 25° or 30° N. had its N. end attracted, and at bottom of N. face attracted S. with the ring at all Southerly inclinations. In shifting from N.W. & S.E. to W. and E. *note*, the W. face of the ring becomes the S. one, and the E. the N.

These experiments when carefully made, all tended to one universal result, and shewed that the magnetic effluvia moved in lines perpendicular to the plane or circle, held or placed as before directed; and the dip may always be found sufficiently correct to rectify this circle, by a bar of iron, to be held due North and South (magnetic)

and inclined till its ends become neutral, of which I shall say more hereafter. And after this circle is so set, by conceiving any iron body, as for instance, a gun or staunchion, placed so within this circle, that the plane of it shall pass through the centre of gravity of the body, then moving the body in any position or bearing whatever. So much of it as is on each side of the plane of this circle, shall have respectively North and South polarity, which shall be at a maximum, when the iron body is at right angles with the plane of the circle, and decrease as its longitudinal section is brought to correspond with the said plane; and the line of neutrality will be found to be nearly that line formed by the intersection of the plane of the circle, through the centre of gravity of the iron body, in whatever position it may be then held. From this it will be seen that the bearings of bars, in which the quantity of inclination necessary to produce a reversion of polarity, shall be a maximum or minimum, will vary with the dip, when there is any considerable quantity of dip, the minimum will be found somewhere near East and West, but where there is no dip, the bar may as a radius describe a vertical semicircle from East to West, and so from West to East again, without any reversion being produced; for the circle, if rectified for no dip, will stand vertical, because the dipping-needle will be horizontal; and so, likewise, when the dip is 90° the bar may, when laid horizontally, be turned quite round in that position without any reversion taking place, the polarity being in the upper and under halves of it, and the

bearings in which the ends will be neutral, will likewise appear to vary with the dip, as may be seen by referring to the experiments made in the different latitudes before shewn, and comparing them with the following one made in London, the dip for these latitudes and longitudes will be found sufficiently near in Mr. Bain's Work.



Dip.
70° 45′ N.

The vertical faces of a square bar laid horizontal, as per bearings, the letters at the right-hand end of the bar, shew which face is here taken; and in the three marked (+) the effect was very variable;

for, from the position of the bar, and the direction of the dip, the ends were varied with the slightest elevation or depression. The letters on the bar do not as before denote which pole of the compass was attracted, but denote the polarity of the iron in that part; this experiment will appear much clearer in England if tried with a cubical iron block.

The apparent uncertainty which I have noticed in the point or bearing in which the ends are neutral, arises from the circle of direction at a considerable dip N. or S., approximating to the direction in which the bar is moved round.

Having now sufficiently pointed out where this o wer is, and how it is to be traced, it remains to consider its effect on the compasses; and here it will be always found, that though these poles in iron have no attractive power for other iron, yet that they exert their influence on compasses, agreeably to the common laws of polarity in magnets, *viz.* that opposite poles attract, and similar ones repel.

The effects of this on compasses will of course be more or less according to the number of these poles in a ship: and as these poles vary instantaneously and in every direction, as the ship's head is shifted, the consideration of them will in a great degree be local, but the following general remarks will, I conceive, set the matter in a clear light.

1. Opposite poles, pointing to each other, cause the compass to vibrate till settled, and then render it inert, for they attract.

2. Similar poles, pointing towards each other, cause the compass to be repelled to the East or West, as the pole of the iron leans to the contrary.

3. When similar poles of iron bear from the compass, N. E. and N. W. Northerly, and S. E. and S. W. Southerly, they repel the pole of the compass nearest to them, strongly proportioned to their distance, number, &c.

4. When opposite poles of iron bear from the compass, N. E. and N. W. Northerly, and S. E. and S. W. Southerly, they attract the pole of the compass to them, strongly proportioned to their distance, number, &c.

5. When the poles of the iron are from the position of the ship's head, at right angles, or in a perpendicular direction from the needle of the compass, their effect will be weakest, as they will generally attract one pole of the compass, as much as they repel the other.

In fact the cause being once known, all material effects may be traced with little trouble.

The nearest bodies of any magnitude to compasses, are the guns; and they therefore require the most attention. And as their effect must be greater in proportion to their proximity to the compass, I have found, and I think it appears reasonable, that the smaller the ship, the more the compasses will be affected; for as her breadth decreases, the guns are brought so much nearer to the compasses. And from this, I conceive, that in a merchant vessel without guns, iron cargo, or

iron staunchions, hoops, &c. near the compasses, and those compasses placed four feet from each other, that no variation would be perceived in any position of the ship's head.

The method I should recommend to find out the quantity and direction of these attractions, would be as follows:

1. Make a draught of the relative situation of the compasses, and of all guns, staunchions, and other large pieces of iron near them.

2. Estimate by experiment, their greatest and least force on the compasses, which must be done when the ship's head is such, that the poles of the iron nearest the compasses, shall be at a maximum and a minimum.

3. Make proportions, or observe the strength of the attractive or repulsive power for the intermediate points, and enter it in a table.

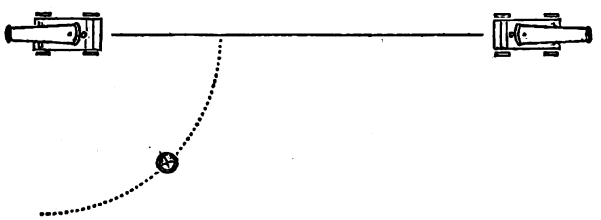
It will be seen, as the ship alters her situations, and the dip is thereby increased or decreased, this will require a proportionate correction. Tables of the whole might be easily constructed for all dips, but by attending to the directions in a preceding part of this Work, the dip may any where be found by an iron bar, even more correctly than by the best dipping-needles; the friction of which will always cause some inaccuracy. But, however, no such precision is here required; and by knowing the dip, and rectifying a circle at right angles to it, and in the plane of East and West (magnetic) as before shewn, it will give the posi-

tions of the poles of all iron, in any direction of the ship's head at sight, or they may all be found by a pocket compass, the smaller the better.

EXAMPLE.

At sea, the dip is ascertained to be 39° North; and the compass placed nearer a larboard gun than a starboard, and about 45° (on a circle described round the centre of the guns length) abaft the transverse section of the ship, where the guns are thus:

TRANSVERSE SECTION.



I wish to know the effect of these guns on the compass, on all positions of the ship's head.

I first with the dip, 39° and the before-mentioned circle rectified for that dip, find the poles of the inner parts of these guns to be as follows:

Ship's Head.	Larboard Gun.	Starboard Gun.
East.	S. Weak.	N. Weak.
E.N.E.	S. Strong.	N. Strong.
N.E.	S. Strongest.	N. Strongest.
N.N.E.	S. Strong.	N. Strong.
North.	S. Weak.	N. Weak.
N.N.W.	S. Faint.	N. Faint.
N.W.	Reversion.	Reversion.
W.N.W.	N. Faint.	S. Faint.

West.	N. Weak.	S. Weak.
W.S.W.	N. Strong.	S. Strong.
S.W.	N. Strongest.	S. Strongest.
S.S.W.	N. Strong.	S. Strong.
South.	N. Weak.	S. Weak.
S.S.E.	N. Faint.	S. Faint.
S.E.	Reversion.	Reversion.
E.S.E.	S. Faint.	N. Faint.

And also, that when the ship's head is N.W., the after sides of both guns have South polarity, and when her head is S.E., the after sides of both have North polarity.

I hereby find that the inner ends or arses of the guns have the strongest polarity, when the ship's head is N.E. and S.W., and have the weakest when her head is S.E. and N.W.; but as the compass does not stand opposite to the ends of the guns, but 45° abaft their longitudinal section,* I make a corresponding allowance of 45° or four points for the position of the ship's head, when the strongest and weakest powers are directly opposed to the compasses which will make the larboard gun present its strongest polarity to the compass when the ship's head is North and South, and its weakest, when her head is East and West; and for the starboard gun, to which I allow three points, (see the Figure) I find it presents its strongest polarity to the compass, when the ship's head is East by North, and West by South, and its weakest at South by East, and North by West.

* See the Figure, particularly with respect to the larboard gun.

This shews me that their effects must be thus:

The larboard gun commences its North polarity in the direction nearest the compass, at ship's head, East, and this North polarity increases to a maximum, when her head is South, therefore the South end of the needle will be progressively attracted towards the gun, and thus the compass will point to the Southward of what it ought.

While the ship's head is going from South to West, this effect diminishes in the same ratio, and at West is a minimum; but while any remains, it still causes the compass to point to the Southward of truth, by attracting the South end of the needle towards the gun. From West to North, South polarity in a like manner commences and increases till at North it is a maximum; and this power attracts the North end of the compass towards the gun, thus making it point to the Northward of truth.

And from North to East, this South polarity diminishes in a like ratio to a minimum at East; still while any remains, its effect is to attract the North end of the needle.

Again, for the starboard gun: this gun commences South polarity in the direction of the compass, when the ship's head is South and by East; and it increases to a maximum, when her head is West and by South; and therefore from S.b.E., it attracts the North end of the needle forward, and repels the South end aft more and more till the ship's head arrives at W.b.S.

From W.b.S. it decreases in strength, till her

head arrives at North by West, where it is a minimum; but while any of its power remains, it continues to attract the North end of the needle.

From North and by West, North polarity commences and increases in strength progressively, till the ship's head arrives at East and by North, when it is a maximum; consequently its effect is here to repel the North end of the compass, from it or aft, and thus make it point to the Eastward of truth.

And lastly, from East by North this north polarity progressively decreases to a minimum, which is when the ship's head becomes South and by East, and its effect will be while any power remains to draw forward the South end of the needle, and make it point too much to the Southward, after her head has passed East.

These being the general properties, it then remains for me to estimate the quantities of this attractive and repulsive power, and to find the proper proportion for the different points of bearing, and it will clearly be seen how entirely local a thing this is. And how impossible it would be to give a rule suited to all ships, while the causes of the errors are so infinitely diversified; for one ship may have one gun; another a dozen; and another an hundred and thirty; and the positions of the compasses, with regard to their combined or single power may vary without end. Some compasses will be stronger than others, and therefore less acted upon, for their own magnetic power will tend to keep them firmer in their proper positions. It must be therefore left to actual experiment, to

determine the quantity of error caused by this power; and with a very little trouble, this may be done, while the ship is at anchor; and with a very little thinking any person will be enabled, after thoroughly understanding the nature of this power, and its manner of acting, to make the necessary allowances, which the alterations he makes in his dip in the course of the voyage, will occasion; especially as he may at all times, instantly determine the polarities of the iron in question, by presenting a pocket compass to it, and noting the paths of the magnetic effluvia; while at the same time he tacks his ship, and puts her head on every point of the compass. I have in this example, only taken two guns, but staunchions, mast hoops, &c. will very often interfere in every variety of manner. Some iron bodies, will, from their qualities, possess this polarity in a stronger degree than others; some, from having been laid to cool in a North and South direction, in places where the dip has been considerable, and from other causes, will have in particular parts a more permanent magnetic quality; and in many pieces I have observed a disposition to retain this variable magnetic property, more than in others, &c. so that actual observations must in every ship determine the quantity, and proportion of this force.

In finding the dip, the longer the rod is the better, for in one of nine or ten feet, an alteration of half an inch in its direction will produce a reversion of its poles, when lying horizontally; and in the proper position, an elevation of half an inch of its ends, will produce the same effects; so instantane-

ous is the operation of this effluvia; and the only thing to be observed is, that a perfectly horizontal surface is used to ascertain the number of degrees it is elevated; or if the ship has motion, to make a proper allowance for it, and it will always be found sufficiently accurate; although if experiments were required to ascertain the dip perfectly correct, other means might be used so as to cause this method to shew it better at sea than the most finished dipping needles, but in this case no such nicety is required.

From what has been shewn, it will easily be seen how iron staunchions affect compasses, although their powers are not so varied; therefore their effects and relative positions, must be carefully attended to in the way shewn for guns.

In the Northern magnetic hemisphere, their upper parts are South poles, and those poles increase in strength as the ship recedes from the magnetic equator; but in the Southern magnetic hemisphere, their upper parts are North poles, and they increase in strength in a similar manner: thus, suppose from the situation of the ship, the upper part is a South pole, and the staunchion is situated right before the compass, then when the ship's head is North, it will render the compass inert from its attracting it directly to itself; when her head is south, it will cause it to vibrate, from endeavouring to repel it from itself; and when East, it will attract the North end of the needle, and repel the South; and so likewise when West; and the variations caused by these actions must be observed, and so for the inter-

mediate points, and for other dips, other allowances must be made.

In estimating all these effects, care must be taken that in particular parts of the world, the poles of the iron do not shift from the rolling motion of the ship, for the action of the magnetic effluvia being so instantaneous, iron will in some positions and places be as much altered, from a heavy rolling motion of the ship, as from her having altered the position of her head four or four and a half points.

Thus an upright staunchion near, or on the magnetic equator, if the ship is going before the wind on any course near East or West, and rolling 10 or 15 degrees, on each side the perpendicular, will have when her head is to the Eastward, its upper part a South pole, when she rolls to starboard; and a North one when she rolls to port; and when her head is from S. W. to N. W. it will have its upper part a North pole when she rolls to starboard; and a South one, when she rolls to port; which may be conceived, by considering that there being here no dip, the ring or circle of direction will be vertical; but if she is on a wind, the weather roll not taking place, the iron will only be affected by the lee one.

Again, guns in an horizontal position, where the dip is near 90°, or as much as with the number of degrees the ship rolls, will exceed 90°, will when her head is westward, be affected thus, and also when it is Eastward.

STARBOARD ROLL.

Larboard Gun.	Starboard Gun.
Inner Part.	Inner Part.
North Dip.	North Dip.
N. Pole.	S. Pole
South Dip.	South Dip.
S. Pole.	N. Pole.

LARBOARD ROLL.

Larboard Gun.	Starboard Gun.
Inner Part,	Inner Part.
North Dip.	North Dip.
S. Pole.	N. Pole.
South Dip.	South Dip.
N. Pole.	S. Pole.

The outer parts will of course be in all cases opposite, but they need not be attended to; and note here, and throughout this work, I consider the guns to be placed directly athwart the ship's length, if they are not so, the proper allowance must be made.

Again, when the dip is great, iron staunchions will have a great effect; for the circle of direction being nearly horizontal, the point or line of reversion of polarity will be found nearly in the middle of their length, and guns will in a high dip, have the change of polarity longitudinally along their side; thus the line of neutrality in a gun, if standing on the same deck as the compass, and about the same height from the deck, will be nearly in a line with the needle of the compass, and therefore its power on it will be lessened, for the upper half being one pole, and the lower half a contrary one, their effects will, if the gun is the same height from

the deck with the compass is, in a great measure counterbalance each other; whereas, staunchions having their upper halves one pole, and their lower ones the contrary, and being generally or always on the deck below the compasses, they continually present their upper poles to the compasses in the strongest manner.

Again, near the magnetic equator, guns will have a great effect; and staunchions, comparatively little, for the circle of direction being here nearly vertical, the inner half of the gun will have one polarity all round, and the outer half a contrary one, thus presenting to the compass a very strong power of attraction or repulsion, when the ship's head is East or West. But staunchions, or vertically placed iron, will have one side one pole, and the other a contrary, and the power will be very weak. Here it may be noticed, how very incorrect the magnetic qualities of iron are said to be in the different treatises on that subject. In them it is stated, that iron will become magnetical permanently, by being long kept in a vertical position; this may be the case in a high North or South dip, in each of which it would acquire a different polarity, though this point is not noticed by them; but on or near the magnetic equator, it would require to be laid horizontally, and North and South; and in any part of the world, such an effect, if required to be produced in the quickest and strongest manner, could only be obtained by placing the iron at North and South, and perpendicular to the plane of the circle of direction, when rectified for

the dip of the place, or in other words, the iron must lie exactly in the same direction that the dipping-needle does in that part of the globe.

As the foregoing remarks are all founded on actual experiments made on the visible effects of this magnetic power, they must stand while nature does, and it is from them alone we must deduce the remedies for the alterations they occasion. It was from not knowing these causes that Capt. Flinders gave a rule which, though founded as it must have been on the most tedious and painful research, is totally inadequate to account for these infinite variations in compasses, and would at best only hold good while the position of the compass, and that of the local attraction, were kept relatively the same as when it was deduced. I will now consider that rule.

In the first place, the way of obtaining the common multiplier, must, from a consideration of the causes of the error, be completely a local thing in every ship, except the quantity and position of the iron, and the position and strength of the compass, are exactly the same; and then it would only hold good, while the ship continued in the same dip, or only slightly varied it.

If the compasses were tried in other parts of the ship, or the local attraction relatively altered, it would not only render it incorrect, but in some cases reverse it, and thus cause double error: for instance, with the head West in the Northern magnetic hemisphere, Capt. Flinders gives his correction minus, because the North end of the needle

was drawn forward. Now by reference to the experiments given in the former part of this work, it will be seen, that when the ship's head is in this position, and the needle has North dip, that all the inner parts of the starboard guns, are South poles, and all the inner parts of the larboard ones, North poles; and it necessarily follows, that when the multiplier was obtained, the compass was placed abaft the centre of the sphere of these gun's attraction, if no other iron body operated at the same time: for instance, if the whole of them on the deck are considered, then if they were equally placed along the deck, and the compass was placed near the mizen mast, their compound attraction with the head at west, would be to draw the North end of the compass forward, by their South poles on the starboard side, attracting its North end stronger than the North ones would its South end from the larboard side, particularly if it stood at the height from the deck compasses usually do, because the more the dip increases, the higher the South polarity is raised in the starboard guns, and the lower the North polarity is thrown in the larboard ones; but if the compasses had been placed on the forecastle, the effect would have been quite contrary, for then the compound attraction of the South poles, on the starboard side, would have drawn the North end of the needle aft; and had it been tried on both sides of the deck, its direction would have been different on each, and both would have been different from that which it would have shewn, when placed amidships.

Again; if in the same place it was first tried on the deck, and then tried elevated on a stand, a little above the height of the guns, it would point quite different, and the more so, as the dip was considerable, by considering that the circle of direction, if rectified for a considerable dip, would point out that the South polarity, with the head West, would, as I before said, lie high or towards the upper surface of the starboard guns, and the North polarity would lie low or towards the under surface of the larboard ones (their inner ends are of course here meant) thus, when standing on the deck, the compass in midships would be below the effects of the South attraction in the starboard guns, or nearly so, according to the dip, and thus be nearly in the line of reversion or neutrality, and consequently acted on by that attraction but slightly, while it would be thrown considerably into the sphere of the attraction from the North poles of the larboard guns, by being brought from its low position, nearer to the perpendicular of the plane of reversion of those guns in which perpendicular the strongest attraction lies.

But when on the stand it would be nearer in the line of neutrality of the North poles of the larboard guns, and therefore opposed to its weakest power, but would be thrown nearer to the perpendicular of the plane of reversion of the starboard guns, and thus would approach their strongest power.

I have been thus particular on this point, because the same remarks extend to all other positions of the ship's head; and likewise, if instead of the

compound attraction of a number of guns on the deck, that of only one is considered, still the errors of the rule will be the same; for if the compass were placed six feet before the longitudinal section of that gun, the effect of the gun's attractive power would be directly contrary to what it would be, if the compass was placed six feet abaft that section, in the former case, with the head at West; if it was a starboard gun, its South pole would draw the North end of the needle aft, and in the latter case it would draw it forward.

Again, if staunchions or other iron bodies interfered their attractions, the effects of the rule would be still more uncertain; and from what I have already shewn, I think it must be clearly seen how the direction of a compass would be altered, if placed within the attractive power of a staunchion, if that staunchion's lower end was unshipped and triced up to the beams of the upper deck, as is the case in sloops of war, frigates, &c. under the half-deck, when the capstan is about to be worked, for suppose the dip 70° N., as it is nearly about England, the staunchion while vertical, would have its upper half a strong South pole, but when triced up and thrown into a horizontal position, would have the end nearest the compass nearly neutral.

In fact, any person who considers Capt. Flinders's account of his observations which he deduced from effects, and traces in similar situations, what effects would arise from the causes as I have here pointed them out, will often find striking coincidences, particularly in his account of the different variations

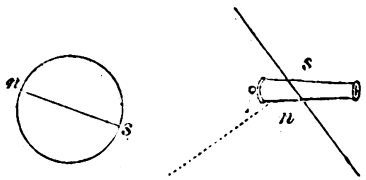
perceived in the compasses in the Northern and Southern magnetic hemispheres, which could only arise from the different polarities of the iron in those two parts of the globe, as I have here shewn, and it is a complete proof that, although that officer's rule fails, which indeed it is almost impossible but that it should, yet that he must have paid the closest attention to the subject, to have observed the effects so closely, without being aware of the causes.

With regard to that part of it which states, that the error at any position of the ship's head, would be to that at East or West, as the sine of the angle between the ship's head and the magnetic meridian is to the sine of eight points or radius; this would, I think, often be a near approximation; but from the complete locality attending every part of this attraction, it must be used with care; and I will here point out where it will be of service, and where it will lead to error.

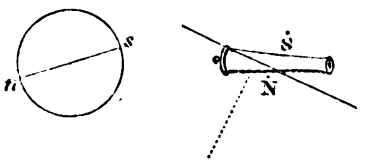
Whenever, from an alteration of eight points in the ship's head, the attractive or repulsive power on the compass uniformly appears to increase or decrease, from a maximum to a minimum, without the longitudinal section of the compass-needle passing through the direct line of that power, the rule will be of great use, for it will materially assist in finding the proportions of correction for each point, which will be often small, and the relation of the sines to the angles will be quite correct enough for the purpose; unless the power acting on the compass is very strong; but if it is, it will not answer.

But, if the longitudinal section of the needle passes the line of direction of the magnetic power, the rule must never be used; for in these situations the error in the compasses, will hardly ever be uniform either in its increase or decrease, of which I shall give two examples.

Suppose a starboard gun, to be right abeam of the compass, then if the dip is 30° or 40° North, the line of reversion will lie about N. E., then when the ship's head is E. N. E. its effect will be thus:

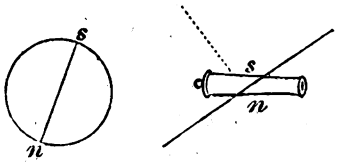


strongest in the perpendicular to the line of reversion, or in the direction of the dotted line, and therefore attracting the South end of the needle, and causing the compass to shew too much to the Eastward; but when her head is arrived at E. S. E. it will then stand thus:



Its power now on the South end, will be consider-

ably weaker. Now let her head be put S. S. E. and it will be thus:



Where South repulsion acts on the South end of the needle, by which it will be seen, that while the ship's head was going round these eight points, the south end was first drawn forward; secondly, it would point correctly (when the line of neutrality pointed directly to it); and, thirdly it would be repulsed forward, after it had passed that line.

Now, in the second place, suppose an iron staunchion, right before the compass, then when the ship's head is S. W.

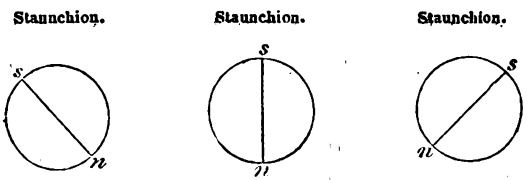


Fig. 1. Fig. 2. Fig. 3.

The staunchion, (which in North dip will have its upper part a South pole, proportionate in strength to the quantity of the dip) will repel the South end of the needle aft.

When her head comes South, its repelling power

will cause the compass to vibrate, if it has the least motion; and if the ship comes steadily round, it will appear to hang a little to the Westward of South, till the ship's head, by continuing to go round, at last causes the power of the compass to overcome that of the staunchion, and then the compass will suddenly pass the direct line of repulsion, and the staunchion will repel its South end to the right, as it before did to the left, so that from pointing South half-West, it will quickly fly round to South by East, more or less proportioned to the power of repulsion in the staunchion.

Other examples might be pointed out, but the above are sufficient to shew that the rule of Capt. Flinders must not be used in situations like these, where the effect of the magnetic effluvia is thus varied, without the greatest caution.

I will now account for the following appearance, which I have no doubt every seaman will recollect to have noticed.

That when the ship has been tacked, or more particularly in light breezes, when she has had a slow, steady motion, the compass has appeared to hang for some seconds, and then traverse rapidly round, as if the motion of her head in coming round had become very slow, and afterwards suddenly quickened.

But by a little reflection it will be seen, that it could not arise from a want of uniformity in the motion of her head, which must have been very considerable to have occasioned such an appear-

ance, in so small a circle as the compass card, but it arose from the North or South end of the needle approaching a similar pole of some iron body, by which, as the ship's head came round, it was repelled, thus occasioning the card to traverse slower than the ship's head, as it continued to approach the direct line of this repelling power, till, when nearly in that direct line, the ship's head continuing to go round, at last caused the magnetic power in the needle to overcome the repelling power of the iron body, and pass the direct line of that power which would then act on the other side of it, and which then acting in conjunction with the needle's own tendency to restore itself to the magnetic North and South, from which it had before been repelled, would suddenly cause it to traverse round a point, or a point and a half.

And this effect will much oftener be produced by staunchions than guns; for guns lying horizontal, the polarity in them will travel all round them with the ship's motion, and it will be found that in most situations, their power will be attractive on that end of the needle nearest them, from the necessary consequence of the magnetic effluvia giving, generally speaking, to iron, a North polarity to the Northward, and a South polarity to the Southward; and thus in most situations of the guns and compass, opposite poles will be next each other, and therefore the power will be attractive, whereas in staunchions, their upper parts, excepting very near the magnetic equator, will be either North or South poles all round, and

their power will be as often repulsive as attractive.

The considerable differences, so often observed, between the binnacle and azimuth compasses, are produced by the very same cause: and this would be more so, when the dip was great, for the guns having their upper parts one pole, and their under ones the contrary; the compasses in the binnacle are generally low enough to be acted upon by the under polarity, while the azimuth compass, elevated as it usually is, on a high stand, is thrown completely into the sphere of the upper one. Any seaman may verify this, by placing one compass about three feet over another, and holding between them, an iron bar, in a vertical position; when the one end of the needle of the upper one, will be attracted or repelled, directly contrary to what the same end of the lower one will be; for the upper end of the bar will have one polarity, and the lower end, the contrary one; the upper end being a South pole in North dip, and a North pole in South dip.

I have often seen, in comparing the binnacle compasses with the azimuth one, that the latter has been elevated on this high stand, and the former placed on the deck, and the officer examining them has most carefully ascertained, that none but copper nails were in the deck, near the compasses, but has omitted to consider that the staunchions of iron, which in all frigate built ships, &c. support the quarter deck, and whose upper parts are strong South poles, in the Northern magnetic

hemisphere, and vice versa in the Southern, would have a great effect on the compass which stood on the deck, in all directions according to the relative positions of the compass and staunchion; while the azimuth compass, though nearly in the same place, would, from being placed high up on a stand, be considerably more out of the sphere of its attraction; and this has frequently caused such remarkable differences between the two, as may be easily tried, and the effect will be more striking, if without any alteration of the positions of either compass or the ship's head, the difference is observed first with the staunchion in its vertical position, and afterwards with it triced up to the beams of the upper deck.

All the differences and discordant results of azimuths and amplitudes, taken with the same compass, and in the same latitudes and longitudes, recorded by so many able navigators, are to be referred to the same causes: for with the slightest alteration in the ship's head, the polarities of the iron in her are instantaneously shifted in their directions, and consequently, their effects will be varied in proportion; and the more so, if the sights are at one time taken before a gun, or staunchion, and at another a beam of them, or abaft them: and the observed variation can only be reduced to the true, by correctly estimating the quantities, and directions of the variable magnetic qualities of the iron which acts on the azimuth compass.

So also, if it were possible for a ship to be in a

river, turned round on a pivot, which pivot should be in the centre of the compass card; yet, the bearings of all objects on shore, as shewn by that compass, would vary continually during her motion, by reason of the poles of all the iron in her being shifted, all round the said iron, while she is performing her revolution.

I will now point out those effects, noticed in Mr. Bain's work, which will most evidently be seen to arise from the causes I have here traced, and enlarge upon a few others.

Page 54, the remarks of Mr. Wales.

Page 55, the 1st and 4th cases.

The 2nd would be found likewise to arise from an alteration in the ship's head, or in the position of the compass.

The 3rd, from the ship's head being on a different point of the compass.

The 5th, from the same reason.

The 6th, if the ship's head were the same when they were each tried, and their place was the same in the ship, yet if they were not of equal strength in themselves, the result would be different; to prove this, refer to the experiment on two compassess acting on each other, (Page 7,) when it will be seen by trying different compasses, that when a weak and a strong one are placed within each other's attractive or repulsive powers, the weak one will be drawn towards the strong one, and the last will not point materially different, although the difference between the two may be upwards of a point; and thus will a weaker com-

pass be drawn more towards the poles of an iron body, or repelled from them, than a strong one; for its own virtue of pointing North and South, being less, is the more easily overcome.

Page 57, will be evident, as will also page 60, and the remarks on chacing, page 89; those on the differences of the observed variation, page 101; all page 105; the case at the bottom of page 108; in page 23, lines 14 to 18, the indeterminate nature of the variation, is from the azimuth compass being influenced by the polarities of the iron; and again, in page 26, the uncertainty in the Asian Archipelago.

Page 129, at the bottom; the force causing these changes of variation, and those producing the ordinary variation itself, are essentially different; and the former is at any rate, so far identified with that power causing the dip, that its direction is always relatively the same, and I say that the dip, the polarity of the compass needle, and the variable polarity of iron, are all caused by different modifications of the same power; the ordinary variation arises from other considerations which I shall not here enter into.

Page 130, the iron in a ship will not have its power lessened, or increased, by any change in the ordinary variation of the compass; its polarity, as it regards its effects on the compasses, will be exactly the same in strength. In page 131, I differ from Mr. Bain, for I think a small vessel, though possessing less attraction than a large one, from having fewer guns, &c. will yet generally have

her compasses more affected by it; for I have always found that the bodies which operated most, are the guns on the upper deck, and the staunchions of iron supporting it, and I think that in a small vessel, the guns being brought so much nearer to the compasses, from her breadth being less, they will occasion more error than in a large one: and with respect to the iron ballast, I should think, that from its distance from the compasses, its effect would be so weakened as to be lost, or its direction overcome by the bodies so much nearer to them.

Page 132, line 12. I here differ from Mr. Bain for, from the polarity of iron shifting so instantaneously, I conceive the effects on the compasses, when placed amid ships, would be very different; I will point out one case in which it would be completely reversed. If the ship sailed from a place having North dip, all the upper part of the iron would have South polarity; if she went on the magnetic equator, the upper part would be neutral, in the line of East and West, and have North and South polarity on each side that line; when she South got into dip, the upper part would have North polarity, and although the compass was placed in the centre of the ship, yet more iron considerably would be before and abaft it, than on each side.

Page 133, Mr. Bain's wish can now be realized, as by an iron rod, the dip can be obtained perfectly accurate, with scarcely any trouble; and at the end of this work, I will describe what appears to me the best method of obtaining that end.

Page 65, Capt. Flinders here observes, that with the head West, the North end of the needle was drawn 4° farther forward at the binnacle than on the booms, off the Start. Here from the dip, the upper parts of the inner ends, of the starboard guns would be south poles, and the compass that stood on the binnacle, would have been thrown into the sphere of their action, while the guns on the larboard side, had their North polarity under them, and thus had no effect to counterbalance the attraction of the starboard guns, from the compass being above them; and thus the North end of the needle was drawn forward; and when her head was East, the effect would be exactly the same: for the polarity had completely changed sides, and its power would remain nearly the same; while with the compass placed on the booms, their effect would (if the iron bodies were equally divided along the decks,) be to draw the North to one side of the ship, and the South to the other, and thus, with the head at East or West, cause no error.

But the same effects are as likely to have been caused by iron staunchions, which are in almost all ships before the compass, when at the binnacle; and at this dip, would have drawn the North end of the needle forward, or repelled the South aft, in all positions of the head, from their upper parts being strong South poles. And, I am induced to think, from the observations of Capt. Flinders, quoted in the same page, that these bo-

dies acted on his compass, from the fact, of the North end of the needle being drawn forward in the Northern magnetic hemisphere; and the South end in the Southern one, which is the identical effect, that an upright iron body would have, when placed before a compass, from its upper part being a South pole in the Northern magnetic hemisphere, and a North pole in the Southern one; which quality, as I have before stated, changes when crossing the magnetic equator, at which place Capt. Flinders says, (p. 114, line 11.) "there seemed to be no attraction," which is the case, for the ends would be neutral, the circle of direction then being vertical. Again, Capt. Flinders, (p. 113, bottom line,) "the quantities (of error) varied with the ship, being greater in high, and less in low latitudes, and yet they did not increase or diminish, in proportion to the latitude;" so the power of a staunchion will increase, or diminish, in the high or low latitudes, which Capt. Flinders passed through, but not in proportion to the latitude, but to the dip. And again, (p. 114, line 18.) "The errors increased, as the dip augmented; and in bass's straits, where the South dip is nearly as great as the North dip in the English Channel, the attraction produced almost as much error as when we left England, but it was of an opposite nature;" which is a remarkable coincidence. Again, (p. 114, bottom line,) "The compass stood right at N. and S. in both hemispheres, and erred most on one side when the head was West, and on

the other when it was East;" this argues that it was not wholly a staunchion, for that body would make the compass point right with the ship's head North, in the Northern hemisphere, by attracting towards itself, but would repel with the head South; and vice versa, in the Southern hemisphere. If it had been wholly a staunchion, so accurate an observer as Capt. Flinders would have perceived this, and never would have said, that the sines of the angles between the ship's head and the magnetic meridian were proportional to the errors; so that in these cases, a compound power must have acted from the polarity of some other iron body interfering.

Page 91. Here in steering S. 53° W. the inner parts of the starboard guns would all be strong South poles, and the larboard ones North poles; and the South end of the needle being drawn forward by the North poles of the larboard guns, as it would be, standing low down in the binnacle, and thus acted upon by the attraction from their under parts, more than from that of the upper parts of the starboard guns, caused the ship to be to the S. E. of her reckoning, as is almost always the case in the run to Madeira, &c.

The same causes hold good at p. 82, in the run across the Bay of Biscay, where the error has so often been noticed by navigators, and generally placed to the indraught of the Bay.

In fact, there is not a case in the whole work of Mr. Bain's, but what would naturally arise from the effects of the respective polarities of the iron

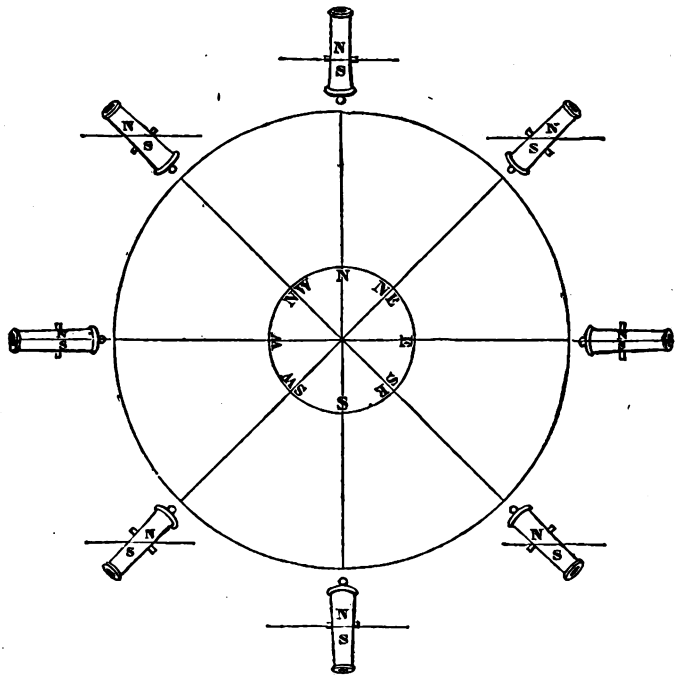
bodies in a ship; and I have been very particular on that work, as it is the only one which has shewn these errors; and is, I think, worthy the attentive reading of all nautical men: although the rules it gives for the correction of these errors must be insufficient, from a consideration of the complete locality of their causes, and of the multiform variations to which they will be subject.

The method which I have laid down in the former part of this work, for computing the power, and tracing the direction of this magnetic effluvia, will enable the seaman to form his corrections from the visible effects of the causes of error, and they will be found as simple in the application, as correct in the result. I have aimed in this work at stating the subject in many ways, and shewing it in different lights, in order to conduce to a full understanding of the nature and manner of acting of this power, which has been the hidden cause of these hitherto unaccountable variations.

The following plate shews the polarity of all the guns in a ship, in eight positions of her head, when on the magnetic equator, where the line of reversion lies East or West.

I have before said, that in considerable dips this line will have an alteration in its direction. In North dip, it will approach towards N. E. &c. and in South dip to S. E., &c. in horizontal iron; and in some iron a difference will arise, if it has been subject to the action of fire in any particular direction, as that will often render the bar perma-

nently magnetical; but this will not be often found in either guns or staunchions, at least as far as has fallen under my observation.



Here the lines drawn through the guns are the lines of reversion; and though represented by lines, it must be remembered that they are to be supposed planes, which here on the magnetic equator are vertical, and incline at all dips, so as to be at right angles with the dipping-needle, and therefore, when the dip is 90° North or South, these planes will be horizontal; the upper half of the gun being, when the gun is in a horizontal posi-

tion, a South or North pole, and the lower half a contrary one, according to the name of the dip; and it will therefore be evident that, in these places, any horizontal iron may be turned quite round, without its polarity being changed in the least.

In using this plate, the two guns which are eight points to the right and left of the point the ship is on, shew the polarities of all the guns, on the right and left sides of the ship; thus, with the ship's head N. E., the gun bearing S. E. from the compass, shews the polarity of all the starboard guns in the ship; and the gun bearing N. W. shews the polarity of all the larboard guns, supposing them all to lie directly athwart the ship's length. And with the ship's head S. E. the gun bearing S. W. from the compass, shews the polarity of all the starboard guns, and the gun bearing N. E. shews that of all the larboard ones.

I shall now close this work with a statement of what I consider the best machine for correctly ascertaining the dip at sea, and which is represented in the following figures.

Dip 45° South.

Fig. 1.

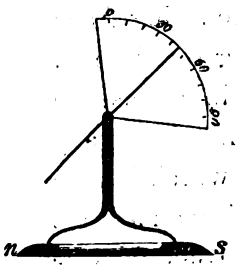
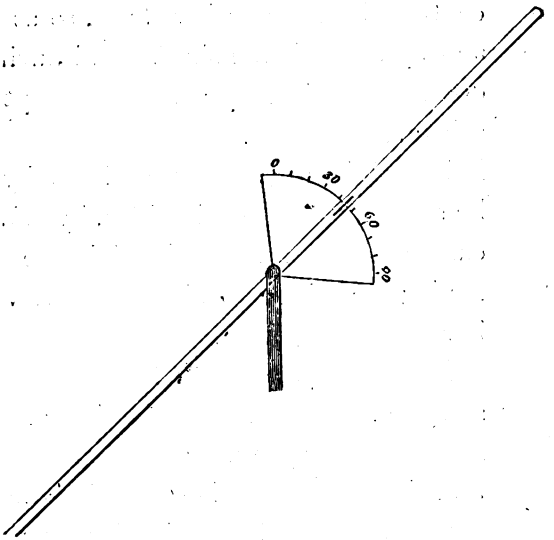


Fig. 2.



Here, Fig. 1, would answer for a bar of about two feet long; and Fig. 2, might be more commodious for a longer one, the stand being the same in both and every part of the frame, arc, screws, pins, &c. being brass or copper. The arc must be rather more than 90°, especially at the perpendicular; and after the ship crosses the magnetic equator, it is only turning the stand round, so that the arc may stand South in South dip, and North in North dip. The degrees had better be engraved outside the arc, as in Fig. 2; and the end of the bar allowed to project about an inch beyond it, having a line inlaid with silver in the middle of its face, to read off from, as in Fig. 2.

The stand must be fitted with a spirit level at the bottom, as in Fig. 1. for observations while at

anchor. But for accurate observations at sea, the whole instrument must be slung in gimballs, by the central pivot to another stand, so as to swing free; and by altering the ship's head during the time of observation, it may always be kept in a position athwart her deck. The bar must not have any holes drilled in it, but the pivots by which it is to be slung must be provided for, by driving on a brass case to its centre, out of which, the pivots must be made; and there should be a screw to detain the bar in any position.

Now to observe with this instrument, place the stand N. and S. having the Arc on the side of the same name as the dip; and ascertain by the level, that it stands on a horizontal plane; then having moved the bar till one side is all one pole, and the other all the contrary one, and the ends neutral; the division on the arc will give the dip the observer is then in.

When a bar alone is used, which is sufficient for common purposes, a convenient way of measuring the angles will be, by having the length of their sines, for the radius or bar used, marked on a rule or scale, which may be then held vertical, and applied to the elevated end of the bar, the lower end of the scale resting on the same horizontal plane that the lower end of the bar is on, and the length of the sine, thus shewn, will give the angle.

But, in choosing the bar to be used in the above instrument, great care must be taken, that from the action of fire, or any other cause, it has no permanent magnetic quality, in any part; or that

from any beating, twisting, or bending, it may have received, in any particular part, its pores are confused, or thrown into different directions; but it must be moved in all ways, and a delicate compass made to follow the course of the magnetic effluvia in every direction, till it is ascertained that the polarity is uniformly, and equably received and admitted, by all parts of the bar; the best sort of compass to use for this purpose is one with the shortest possible arms, and may be set in a watch seal.

The permanent magnetic quality, if found in iron, may always be destroyed by fire; but it must be examined cautiously afterwards, as above directed.

THE END.

ERRATA.

Page.	Line.	
12.	14.	*for* on, *read* are.
19.	7.	dele the full stop.
21.	15.	the word at the beginning of the line is power.
22.	8.	the comma should be after strongly, an the same in line 13.
24.	11.	*for* on, *read* in.
28.	20.	*read* has not been considerable.
32.	1.	dele is.
40.	22.	*for* or, *read* and.
46.	24.	*read* got into South dip.
49.	4.	*read* by attracting it towards itself, but would repel it with, &c.

ADVERTISEMENT.

The subject of Magnetic Attractions has long engaged the Author's attention; and the experiments, as will be seen in the following Essay, were made during his station at St. Helena, in H. M. S. Conqueror, and on the voyage home to England.

Having discovered that a Work of a similar nature has been published by Mr. P. Barlow, of the Royal Military College, it becomes his duty to state, that he never saw or heard of that Gentleman's Essay, until after his own Work went to the press.

London, Dec. 9, 1820.

J. Haddon, Printer, Finsbury.