THE OBSERVATIONS MADE WITH THE COMPASS ON TASMAN'S VOYAGE AND THE ISOGONIC LINES ACROSS THE INDIAN AND PACIFIC OCEANS IN 1640

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(TRANSLATED FROM THE DUTCH MS. BY J. DE HOOP SCHEFFER.)

The magnetism of our globe itself possesses two chief properties, viz.: its distribution o globe; and its changes in process of time. It now becoming more and more evident that terre magnetism is most intimately connected with a good many and great problems, both of a terre and of a cosmical nature, we should not allow any materials to remain unused or any opportuniti slip by to increase our knowledge of both these properties. The more so, as candidly speaking knowledge of this subject is in many points rather deficient.

Never until the present century, and even then not before its latter half we have been to realize the distribution of the magnetic forces on the surface of the globe, so as to enable institute many successful researches. Also of the changes in the three elements (commonly called declin horizontal intensity and dip) a mass of materials no less satisfactory for certain purposes has collected in this century.

Yet in proportion to the slow progression of the changes of the magnetism of our pla century is but a rather short space of time, so that we see ourselves compelled to have recourse t ages. Going back in point of time we soon find that any observations as regards horizontal int are wanting, while the determinations of dip are very scarce and not to be depended upon. But declination it is quite different. Since the sixteenth century a great many observations of this el made in different parts of the earth are at our disposal, and though owing to entire absence of t and of the horizontal intensity a good deal of their value is lost, they, nevertheless, are of the h importance for the inquiry into the secular changes of the terrestrial magnetism.

For the times for which the three elements are at our disposal we can find critical points i declination, and by following these up to earlier times for which only declination is left to us w obtain results of more general value then could be acquired by the study of mere declination.

In a paper read before the "Koninklijke Academie van Wetenschappen" 1) I adopted this m for tracing up to the seventeenth century some peculiar changes observed during the years 1780— Hence for the study of the changes of the terrestrial magnetism it is necessary that we collect observations made in former periods. Every newly found observation may become a acquisition for the science of our day.

Fortunately observations of declination are indispensable for navigation; if not, our know of the magnetic field of former times would not merely be next to nothing, but even that of the p time would still be very imperfect.

The necessity of knowing the variation; the observation thereof; the annotation in the log-bo these are the sources from which the materials for drawing the earlier isogonic systems are gat It might be said that every new voyage of discovery has likewise been a voyage of discov the field of these isomagnetic lines.

1) Ueber die Linien gleicher säcular-Variation der Declination. Verslagen en Mededeelingen der Koninklijke A van Wetenschappen. Amsterdam. Meeting of 30th Nov. 1895.

In this respect Tasman's voyage, which extended over no less than 132 degrees of longitude, and for the greater part into unfrequented waters, at once opened a wide field of information to us.

The first who collected old materials was Chr. Hansteen. He laid down the splendid results of his numerous investigations in his standard-work "Untersuchungen ueber den Magnetismus der Erde, Christiania 1819."

An atlas containing isogonic maps for 1600, 1700 and for later periods, drawn from those materials, accompanies this work.

It is a matter of course that during this century many new sources have been opened and fresh investigations made, and consequently materials for completing the Hansteen maps obtained. In this respect a good deal was achieved by Charles Schott, who collected everything relating to North-America, and by the late de Andrade Corvo, who reduced the observations made by João de Castro in 1538.

It might be reasonably expected that Holland with its navigation could still contribute much, and, indeed, I succeeded, chiefly by investigating the records of the East-India Company, in bringing to light some thousand new observations made in the sixteenth and seventeenth centuries, and in tracing by this means a new series of isogonic maps for these two centuries.

The results have been collected in an academic dissertation: "De Isogonen in de XVIde en XVIIde Eeuw, Leiden 1893."

Subsequent researches have almost doubled the number of fresh observations, and having already reduced by the same method that vast body of materials, I intend to construct a new set of maps.

Already Hansteen utilized Tasman's observations, probably derived from an old description of that voyage; I myself made use in 1893 of Swart's edition, and now of Tasman's Journal itself, as it is now newly and more accurately edited.

Unlike in some other instructions of those days, in the one for Abel Tasman he is not specially enjoined to make a diligent and accurate observation of the variation. This was probably considered as a matter of course.

The collection of variation-observations in different parts of the globe was at that time considered as of great importance, especially for this reason that magnitude was then still taken to be a constant value.

Stephen Burrowes when navigating between the North Cape and Waigath was the first to discover this variation, while Gellibrand, professor at Gresham College, determined its amount and published in 1635 a paper on that subject. Accordingly, there are also continually found in other books on navigation tables of variations without any indication of the year in which these were observed. Likewise the Rev. Petrus Plancius, who so considerably stimulated 1) Dutch navigation, was at great pains to gather such a collection, which tables were inserted in Stevin's well known treatise the Λιμενευρητικα or "Havenvindingh."

Yet both Plancius' work and that of Stevin were based on the old idea, which from the time of Columbus down to the eighteenth century exercised so many minds, that by means of the declination (also dip) the longitude was to be found.

In their picturesque way our ancestors termed this the "Oost- en Westvindingh" (East and West findings).

There is no doubt that the observations of the declinations in some cases, when strong currents rendered the determination of longitudes entirely erroneous, were at that time very useful to the sailor, and I shall still have an opportunity to illustrate this with an example. (See van Diemen's voyage)

Of course, the Portuguese were the first to make and collect reliable observations of the variation. Accordingly, João de Castro on his voyage to Goa in the year 1538, was instructed to make as many observations as possible with new instruments. De Andrade Corvo 2) worked out in 1882 the journal and the observations, which are really very good. Indeed the importance of that material cannot be valued too high.

1) Compare: J. J. Dodt, Letterkundig Verslag van hetgene uit de landspapieren kan worden geput om daarna de verdiensten van P. Plancius omtrent de zeevaartkunde beter te doen waardeeren. Verhandelingen en Berigten betrekkelijk het Zeewezen en de Zeevaartkunde door G. A. Tindal en J. Swart, 1845 V, p. 77; 1846 VI, p. 69.

2) João de Andrade Corvo. Roteiro de Lisboa a Goa por D. João de Castro. Lisboa 1882. This book I got possessed of very lately only, and has consequently not been utilized for my outlined map of the isogonic lines for the year 1540. This map will consequently be altered, though the map drawn by Corvo will not be followed.

The observations of the compass are communicated in Tasman's journal with less minuteness as is customary in journals of shipmasters of those days. In the latter the bearings are generally given as observed either in the evening or in the morning, or in both, to which is still often added the observed amplitudes, and in a single case the readings of two compasses. The importance of those observations is not very much decreased thereby. It is true, its reliability is most certainly increased by the comparison with another compass, and it is fortunate that in the other journal of the voyage, now extant, variations are also given, but the advantage of having added thereto either morning or evening observations is rather imaginary, owing to the inefficient determination of the longitude.

There can be no doubt that the observations communicated are absolute and not relative values of declination, in regard to a compass, which owed already a certain variation to its maker. This constant variation, distinguishing Dutch compasses from Oriental, Venetian and other ones, has already caused a good deal of confusion.

Indeed, if a variation was mentioned without any indication whether the observation had been made with a corrected or dipping compass, it was in those days very difficult to determine such without having further data.

In an amusingly arbitrary manner Nautonier in his work: "Mécométrie de l'eymant (1603)" makes use of these relative variations, in order to wrest them into his system.

In small vessels corrected compasses were always made use of. On board large East-Indiamen the card of the steering compass was from time to time corrected according to the readings of the azimuth-compass, but the indications of the variation are always absolute values. Only in a journal kept on board the yacht 't Duifke of the first voyage under the command of Houtman, I still found values given, which had been taken by corrected compasses. From additional communication I could conclude that at the end of the XVIth century a Dutch compass had $^1/_2$ point easterly variation and an Amsterdam one $^3/_4$ point. A dipping compass the author terms a sea-compass, as he writes: "Westerly variation on a compass south and north (i. e. a dipping) a maritime compass." ("Noordwesteren op compas van suiden en noorden ofte Halyaensch compas"). Moreover, the correspondence of Tasman's observations in the Indian Ocean and Archipelago with those of his contemporaries removes every possible doubt.

Tasman nowhere gives a description, nor does he mention with a single word the construction of his compasses. In this respect he does not differ from the rest, as in none of the numerous journals I perused the compass was described.

There has never been made any study of the compasses of those days so complete as to enable us to state with certainty what kind of compasses was used by Tasman. Consequently I shall restrict myself to quoting what I found with regard to its construction in works on navigation of those days, and particularly in those published in the Netherlands.

At the end of the XVIth century there seems to have been in use a great many worthless instruments. Accordingly Barlowe writes in his treatise: Magnetical Advertisements 1616, p. 66: "the compasse needle, being the most admirable and usefull instrument of the whole world is both amongst ours and other nations for the most part so bunglerly and absurdly contrived, as nothing more."

Yet in our country very good compasses were made in the seventeenth century.

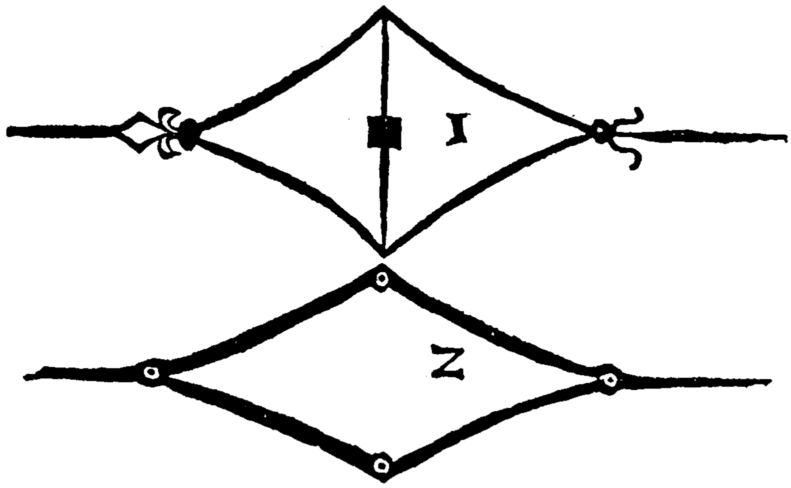
Schück 1) wrote a interesting paper on the magnets of the compasses, in which the most curiously shaped magnets are represented.

The quotation from the treatise of Keteltas, which I had formerly perused with a view to determinations of declination, I will copy here: Barent Evertsz. Keteltas, Het Ghebruyck der Naeld-wysinge tot Dienste der Zeevaert beschreven door —, Amsterdam 1609. Fol. 19. 9 Propositio: "wherein is represented the question of the compass-needles, and the shape and construction of needles which have been found to work with the most perfect precision."

"As much depends upon the construction of compass needles and upon the knowledge of the fittest material to be used for them this is the usual method of setting about it: two pieces of iron or steel wire, curved, and their ends filed into sharp points, so as to fit diamond-wise together, and thus pasted with a small bit of thin paper to the paper compass-card, having in its centre a small brass cup on which the card can

1) A. Schück, Die Magnete des Kompasses. Central-Zeitung für Optik und Mechanik, Leipzig XV, 3 & 4 Febr. 1894.

freely balance, which kind of compass needles do very well for ordinary compasses, as also for those having shifting cards, with which they hug the coast, which does not require so much accuracy as the determination of the needle's variation. But for observing the same the very best means should be employed, and we could not put up with the described ones, because these needles, being constructed in two parts and attached to a paper card, must, in order to be sufficiently solid, naturally be of too thick a paper as to point with sufficient accuracy, besides are easily liable to become rusty, owing to the dampness of the paste. To be able to observe the deflections of the needle with the utmost precision the needle ought to be made so that, with just a little care, it can be kept in perfect order for a long time; we will give a description of such a needle which we find to be accurate to a minute. It is made thus: Take the fittest steel, as described in the 2nd proposition, and have it stretched, split and bent diamond-shape, in accordance with the accompanying figures, and you are to make them entirely without any soldering.



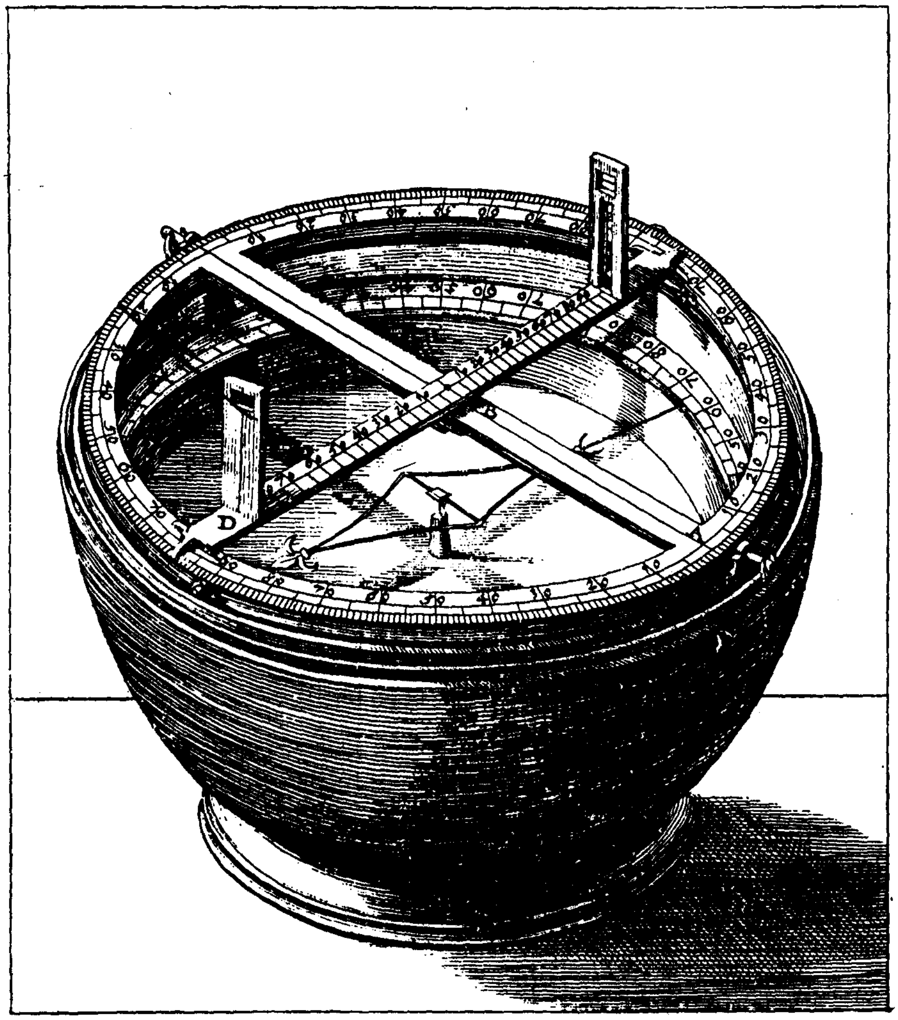
Facsimile from: Keteltas, Ghebruyck der Naeldwysinghe. 1609.

The ends of the needles are to be filed into long sharp points, leaving at one end of the diamond a small lily, at the other a small fork or something else, by which the north end may be distinguished from the south. They ought to be fashioned in accordance with the size of the instrument. Midway the needle, taken lengthwise, you are to make on it a subtile brass axis, having in the middle a small cup filed out, which is of great consequence, and you are to take good care that the cavity of the small cup be bored smooth and even, not too narrow so as to hinder its movements, nor too broad so as to cause the slightest eccentricity. This cannot be done better than with a perfectly square drill greased with a little oil, and you are further to construct the needles so that they can freely balance on a pivot, and they should be filed very subtile and thin, and they may be made as long as you desire, even if it were 8 or 10 feet. Let the diamonds of the needles be firmly constructed, and as they wear the more as they are heavier, the lighter they are the better, but they should stand their own weight without bending out. Now the needles which are used at sea are not required to be longer than at most 10 or 12 inches (25—30 c.m.), and therefore may be proportionately made somewhat thicker, and are to have at each end of the diamond a small hole for the purpose of attaching to it by means of two subtile brass nails a thin card of paper, as otherwise by the motion of the ship the needle is prevented from indicating, which is then kept steady by the card of paper, and you might also paste that card with a bit of thin paper on to the brass axis. But the . . . . . ."

"Now the needles, about six inches long, like those of the common azimuth-compasses, which are placed on a pivot, are to be constructed without any cross-axis. When placing it on a pivot, the point of the pivot will soon become blunt, and you are to make in that place the paper card somewhat thicker and to attach the needles to it by four subtile brass nails, securing the small cup to the paper in the same manner as is done with ordinary sea-compasses, but they do not indicate with the same precision as the aforesaid, unless your card be supported by a little screw-plate, as will be explained more fully when we come to speak of the instruments for needle-indication, in order so to avoid the wear caused by casting them on the pivot."

He further gives a description and representation (figure 42) of the azimuth-compass. ". . . . and is the horizontal compass of which we gave already some account in our preface: which instrument is common in daily use with steermen."

page 43. "Now this instrument is composed of a wooden or brass box, wide about sixteen inches, though it is customary to make them smaller, in many cases not more than eight or nine inches; the reason why this instrument is made so small is that if they were made larger, owing to their weight, the cards would always indicate imperfectly, as also because suspending instruments must always be unproportionately much heavier, so as to be kept steady on the agitated sea, and as otherwise it would be impossible to cast the card on the pivot. You shall therefore know, that the aforesaid have hesitated to take the larger size, not because they did not desire a larger one, but because they could not make use of one of a larger size. These difficulties we will now remove in this proposition, as neither the length of the needles nor the heavy weight of the instrument causes any pointing in a lazy or slow manner, and hinders us in no way to cast the needles gently on the pivot, for we therefore use a screw-plate, so that on account thereof the needles can easily be raised or lowered without any injurious effect. This method we have clearly expounded when speaking of the former instruments. We next take the circumference as wide as we wish, because in that manner every degree can be divided into four parts. Now this box is to be turned so as to form a half circular cavity measured in any direction, as we have mentioned in our account of the former instruments for needle indications. Further the compass shall be shaped into half a globe and be suspended by a ring on four axes, so as to be secure from the motion of the ship in its revolutions. Further the needles are to be made of good pure steel, as has



Horizontal-compass according to Keteltas (1609). (Facsimile).

been observed in the second proposition, shaping the needles as indicated in the ninth proposition." (See the former quotation from Keteltas), "diminishing the magnetic power of the needles so as to be able to keep the instrument in perfect order for a long time, of which a full account is given in the eighth proposition. Further the needles are to be supported by a screw-plate (as related before), and the pivot on which the needles are to float may also be made of steel, with a view to their steadiness but duly, very subtile; underneath with a screw, which with a brass nut is screwed fast in the bottom. One should also take good care that the hole in which the pivot is screwed be in the middle of the place where the needle-bearings are indicated on the ring, so that the pivot can be placed perfectly perpendicular. Further as regards the upper-part, take notice of the accompanying figures and letterings."

"It consists of a horizontal flat ring having a diameter marked A B, which ring should be turned perfectly even, and should also be a firm brass one, so as not to bent out when screwed up, as otherwise the hands could not everywhere travel horizontally. This horizontal ring shall be divided into 360 degrees, and each degree again into 4 parts, and you shall fix it so as to have its numbers exactly correspond with the numbers on the ring inside the instrument, whereon the bearings of the needles are indicated; to the centre B on the diameter a hand shall be attached, having fixed on it 2 sights, 10 inches distant from each other, and at the same distance from the centre marked C D, which should be able to go round over the whole circumference. The sights fixed on this instrument are to be made about 4 inches high, the nearer being furnished with a brass string, and the other with a narrow slit to observe the rising and setting of the sun. The upper ends of the sights shall each have a broad slit with a string, in order to take the azimuth when the sun is at a height of 30 or 40 degrees. These dioptrics shall be divided inside into some divisions; likewise from the hand of the sight to the middle, altogether into 100 parts, everyone of which parts to be of the same size, and they only serve the purpose of ascertaining whether your instrument be suspended horizontally, as this is of great consequence. For which sake square holes shall be made at top of the sights, both at the same distance from the plane of the horizon, and you shall pass through them a cross-string, so as by means of the sun to indicate on the divisions. At the side of each end of the hand there shall be made two projecting small feet, in order to keep the hand always right when moving along the horizon."

Keteltas further writes on the use of the instrument:

"This instrument was used in two different manners; in the one case by turning away the instrument; in the other by letting the sunbeams fall on it (as can likewise be done with the 2 before described instruments), to wit: in the morning as soon as the disc of the sun rises, place the sight with the slit before your eye, and when viewing the string right in the middle of the sun, some one else shall observe the difference between the hand and the needle, and you shall accurately note it down and by means thereof calculate on your planisphere how much your needle deviates.

Now the second manner is this, when the sun has some degrees of height, you are to turn the instrument to the sun, letting the sun's shadow fall on the line of the hands, putting the hand at a certain number, then you can see to how many degrees the difference between the needle and the sun amounts, which to avoid errors should be done three or four times successively, noting down your results each time, and while you are observing the difference between the sun and the needle, some one else shall by means of the astrolabe or cross-staff or sea-quadrant take the exact height of the sun, which you shall each time notice next to these differences, and go therewith to the planisphere or astronomical mirror."

In the "Stuermans Schoole" by Simon Pietersz., Instructor for navigation at Medemblik, Amsterdam 1659, on page 73 we find:

"Sixth instruction in navigation and steering excercise, Treating of the compass, of the construction and use of the same, Ditto of taking and correcting the variation of the needles.

The construction is first of all composed of a round wooden box or case, rather heavy, so as to be less unsteady. In the centre of the bottom a brass point is perpendicularly fixed, pointed at top, fully an inch in height. On this perpendicular point a small plate is laid, made of pure, clean and polished iron or steel, cast flat and thin, in the shape of an oblong diamond or leaf of a lily. In the centre thereof is a small cup having a cavity, which should also be even and pure, with which it is carefully, freely and nicely laid on the perpendicular point, travelling horizontally on it. The terminals of this lying piece of iron, called needle-points, after a loadstone having been properly passed along them, range themselves north and south. But as a compass for the use of navigation is divided into 32 points, which the man at the helm must always have before his eyes, and steer the ship accordingly, so in like manner a small round (called a card) is made of dry, light, strong paper, which is properly pasted on to the aforesaid needle or to the needle under it, properly. I say properly as these are not always in the same manner; and again as concerns the direction which the needle points, of which we shall speak further on.

On this card the 32 points of the compass are printed, thus freely floating horizontally in every direction on the needle, which lies underneath and is fixed in the aforesaid little box.

The north point was marked with a lily and the east point with a little cross.

At the top of this box or case a clear glass is laid, all around inserted in it, and well stuffed with wax, so that no air, wind or water can make its way into it.

A compass thus far being constructed, this box is jointed at top by means of two opposite nails to a larger case, so that this box containing the card may freely and horizontally swing inside of it, without touching anywhere. This compass being a delicate instrument which requires great exactness a steersman should take good care of it, and pay attention that both the compass he has in the cabin and the one in the binnacle near the man at the helm have neither iron nor steel in their vicinity, nor that another compass be standing close to it, as the needles would be attracted by it, in consequence of which great mistakes might arise, by which loss and accidents might be caused.

This instrument is of such importance and use for the navigation that one could do nothing or little without it. But it would still be of more utility if it did always point right, which would be the case, if the impregnated needle did point directly north, but in various parts of the globe it has been found to have variations. In our country and in its neighbourhood 6, 7, 8, 9 degrees easterly have been observed, on account of which the compasses used here in common navigation should be corrected, so that the lily must be placed two thirds of a point west of the needle for the north point to indicate the true north 1). Except this one, another variation is found to be occasioned by the magnetizing of the needles by the compass-makers, which is such that even if a compass-maker draws one and the same stone along 3,. 4 or 5 compasses which have the cards of the same angle with the needles, they will not indicate the same point in the horizon, which must be caused either by the iron of the needles being of a different temper or by the one needle being more and the other one less magnetized, to which the compass-makers are to pay attention. It is therefore of the highest importance that a steersman navigating in large waters should know to find and correct the variation of the compass.

For this purpose a compass is wanted having the lily placed right above the needle, and constructed at the same time so that when observing we can see how many degrees the sun rises to the eastward and sets to the westward, which compass must all round be divided into 4 times 90 degrees on a small brass circle having alongside its border an adjustable small point, which we can see traversing the middle of the compass in an exact line with the sun at the horizon.

To correct this variation it is of great use to have a compass with a shifting card, made of light wood or strong paper, which is laid flat on the top of the compass, to wit, on the pivot on which the card balances, but the upper end on which this card rests must have at the inside a rim along which this card moves.

This card must be fully one inch in breadth, on which the 32 points are indicated, so that by removing this card the numerical value of the variation is found; by this means one shall always have a corrected compass, for instance . . . . . ."

For curiosity's sake I still quote the questions put at the end of the sixth lesson:

"*Question.* What other precautions in regard with his compass has a steersman to take?"

"*Answer.* As regards this I have made a little poem in my own fashion."

"*Question.* How does it run?"

"*Answer.* "*Dat de Naalde wel is aangeleyt en gestreken*,"
(The needle should be well adjusted and magnetized)
"*Dat het Kasken en Roose vrij waterpas drijft*"
(The box and card should freely float horizontally)
"*Dat'er geen lucht, wint, noch water in komt geleken*;"
(Neither air, wind nor water should make their way into it)
"*Dat geen ijser noch staal daar omtrent verblijft;*"
(Neither iron nor steel should be in its vicinity)
"*Op dese vier dingen moet een stuerman t' allen tijden*"
(Of these four things a steersman should at all times)
"*Wel toesien, om ongeluck te mijden.*"
(Be careful, in order to avoid accidents.)

1) The variation of from 6° to 9° easterly was in the beginning of the 17th century observed in the neighbourhood of our own country. The keeper of the journal on board "'t Duyfke," in 1595 states an Amsterdam compass to have 2/3 point easterly variation. Accordingly it is evident that this Simon Pietersz. refers to compasses of an earlier date than the one at which his book was published (1657).

"*Master.* Well disciple I am content, now let us proceed to the following lesson.

Disciple. Je le ferai mon Maistre (I will do so, Master.)"

Dirck Makreel writes in his work: *De lichtende leydstarre der Groote Zeevaert.* Amsterdam 1671. 6^{th} chapter p. 78.

". . . . . . accordingly it is highly necessary that one should know how to find how much and in what direction a compass varies in the place where one is, and finally also how to correct and compensate the variation, either by removing the card, or when not making use of a removable card (as is usually done) . . . . . ."

Very interesting too is the following passage in "*'t Vergulde Licht der Zeevaart ofte Konst der stuurluyden*" by Claas Hendriksz. Gietermaker. Amsterdam 1677. (At the top of the pages: "*Schatkamer, ofte Konst der Stuerlieden.*")

Instruction p. 7. "Instruction for the needles which are lying parallel under the card of the compass.

Besides this change in the variation, there is also found a marked difference in the bearings of compasses on which the needles, according to the usual method, are laid into diamonds under the card, so that several compasses, made by one and the same compass-maker and along which the same stone had been drawn the same number of times, differ a fraction of a degree, as shown by this note.

Anno 1649, two compass-makers have each made six cards and, according to the usual method laid the needles into diamonds under the cards, after which every one of them has in our presence drawn his stone along his card, which, having taken the bearings of the same object indicated:

	Degrees		Degrees
The one six cards	32	And the other six cards	31
	$29^1/_2$		33
	32		30
	$33^1/_2$		$30^1/_2$
	28		31
	32		33

It is probable that these differences originated in the one needle possessing less power of attraction than the other one, either owing to its inferior temperament, or because of one side having been in firmer contact with the stone than the other one, when drawn along it: which cannot be remedied by drawing it along again.

And in order to prevent the irregularity resulting from it, we have laid under the card two needles, both of the same length, parallel, and each at the same distance from the south and north, and their terminals reaching to the margin.

Of these cards, having the needles parallel, C. J. Lastman in the year 1649, in the presence of the above mentioned compass-makers, drew six cards along his stone, and having taken with them the bearing of the aforesaid object, the six cards were found to indicate:

Degrees
32
$31^3/_4$
32
$31^3/_4$
$32^1/_4$
$32^1/_2$

Gietermaker next points out, how much smaller the mutual differences are, with the first, viz. respectively $5^1/_2°$ and $3°$, with the last, being $^3/_4°$ only.

Finally he writes:

"But it should not be forgotten that the compass is a delicate instrument, which trifling causes can easily prevent from working with exactitude, so that good care should be taken that the point on which the card balances be rather sharp and that the little cup be well-constructed, and likewise that the card swing horizontally, and the box which contains the card must be well closed so that no air can make its way into it, and it also requires to be suspended horizontally. Likewise one should take precautions that neither iron nor steel be in the vicinity of the compass, nor that one compass be placed too near another compass."

From these quotations may be at once concluded that the variation was determined by azimuth-compasses and that for steerage-compasses removable cards were in use. Indeed, in the journals we find continually mention made of azimuth-compasses. Most likely the needle was diamond-shaped, at least both Keteltas in 1609, and Simon Pietersz. in 1659 mention such a shape as the common one for needles.

The immovable card and likewise the small cup were thus fixed to the needle.

Though of course not having any certainty, we may take the instrument described and figured by Keteltas for a specimen of the construction of Tasman's azimuth-compasses. The chief deficiency of the instrument was no doubt the collimation-error of the needle. The inaccuracies by the divisions of the circle and the errors in the index of these circle-divisions were probably inconsiderable. That those collimation-errors could be considerable is shown by Lastman's experiments communicated by Gietermaker. An example thereof is likewise given by the observations made on board "'t Wapen van Delft," a vessel of the Nassau fleet, sailing in 1623 under the command of admiral Jacques l'Hermite to Chile.

In this journal we read under date of the 30th of Aug. 1623: "The compass with which we took observations here had at Rotterdam no more than 5 degr. 30 min. easterly variation."

On the 21st of September they observed with that compass $2^1/_2°$ easterly, and "with the compass, which we had from Amsterdam we found there 4 degrees easterly variation. This aforesaid Amsterdam compass yields a north-eastering of 7 degr. 6 min. at Rotterdam."

Afterwards observations are taken with the two compasses, and as well the bearings as the name of the compass employed are properly given. From the 20th of August 1623 to the 3rd of February 1624 it was done 27 times, and the variation indicated by the Amsterdam compass remains always a couple of degrees more easterly. The latter, according to the journal, constructed by David Davidsz., I will name the Rotterdam compass.

Difference between the variations 1) observed with an Amsterdam and a Rotterdam compass in the ship "'t Wapen van Delft," sailing from Sierra Leona to Acapulco, 1623—24.

DATE 1623	A—R	½ △	DATE 1623	A—R	½ △	DATE 1623/24	A—R	½ △
Aug. 20	— 1° 0'	0° 25'	Oct. 2	— 2° 0'	0° 5'	Dec. 14	— 2° 0'	0° 5'
Sept. 5	1 0	0 25	28	1 50	0 0	17	1 50	0 0
16	0 0	0 55	Nov. 20	2 0	0 5	19	3 0	0 35
18	2 0	0 5	25	3 0	0 35	20	2 0	0 5
22	1 30	0 10	27	1 40	0 5	25	2 12	0 11
24	1 15	0 18	29	2 0	0 5	1624		
25	1 30	0 10	30	2 0	0 5	Jan. 11	2 15	0 18
26	1 30	0 10	Dec. 2	2 0	0 5	20	1 20	0 15
28	2 0	0 5	12	2 0	0 5	24	1 30	0 10
						Febr. 3	1 30	0 10
						Mean	— 1 50	0 13

The difference remains thus very constant and the mean error of every determination, being 0° 13', is remarkably small. Another example, to which I already referred in my dissertation, "De Isogonen in de XVIde en XVIIde Eeuw," I found in the journal of the ship "'t Huijs ter Duijne" who sailed in 1696 from Holland to the Cape. In this case the observations were made with an Amsterdam and a Sealand card, and I find the following differences:

DATE 1696	A—S	DATE 1696	A—S	DATE 1696	A—S	DATE 1696	A—S
Aug. 13	+ 1° 5'	Aug. 21	+ 2° 15'	Sept. 2	+ 1° 36'	Sept. 18	— 1° 30'
»	+ 1 15	23	+ 2 30	25	+ 0 30	19	— 1 40
14	+ 1 30	25	+ 1 25	Oct. 6	— 1 15	20	— 1 30
»	+ 1 41	»	+ 2 0	7	— 1 23	23	— 3 15
16	— 0 11	26	+ 2 0	12	— 2 0	25	— 1 30
»	— 0 16	27	+ 1 30	»	+ 2 0	29	— 1 45
19	+ 1 45	»	+ 2 0	13	— 1 30		
»	+ 2 0	29	+ 1 35	16	+ 0 12		
20	— 0 33	Sept. 1	+ 1 16	»	+ 0 12		
»	— 0 55	»	+ 1 0	17	— 2 0		

Though being 70 years later in date, the results here are seen to be less satisfactory.

Respecting the compass observations on board "'t Wapen van Delft" I have simply applied for each of the compasses a correction of 0° 55', hoping by doing so to have come nearer to the real state

1) As usual, westerly variation is taken positive, easterly negative.

of things. From Acapulco the ship crossed the Great Ocean and observations were then taken with the Amsterdam compass only. These observations are of the highest importance, as they are the first real series of observations taken over this wide surface. Except the solitary observation of Willem Schouten in 1616 near the Honden island, the earliest observations known were those of captain Woods Rogers, who sailed in 1710 from California to the Ladrones. (Phil. Trans. 1721, N°. 368, p. 173.)

Consequently the observations made on board the Nassau fleet carry us about a century farther back in time, and it is therefore of the highest importance that a passable collimation-correction can be applied to these observations.

Yet there are still three more tests to which Tasman's observations can be put. Firstly, the bearings of the compass having also been noticed in the second journal; secondly, the progression of the values found at adjacent places; thirdly, the circumstance that Tasman's track traverses that of contemporaries who have likewise recorded bearings of the compass. I have not found by whom that second journal was kept, but apparently the determinations of longitude and latitude and of the variations of the compass have been calculated independently of others. Especially the longitudes differ now and then very much, the latitudes, however, less. Yet there is no reason whatever why these observations should be valued at a different rate. In the following table I give the variations (with longitude and latitudes) as observed at one and the same date.

Observations according to Tasman's Journal.				Observations according to the other Journal.			Differences of Variation.
DATE.	Variation.	Latitude.	Longitude.	Variation.	Latitude.	Longitude.	
1642 Aug. 21	5° 0' W	11° 2' S	116° 42' E	6° 0' W	11° 6' S	118° 11' E	— 1° 0'
» 27	12 30	16 40	103 32	13 3	16 3	106 40	— 0 33
Oct. 2	20	20 28	89 29	21 30	20 40	88 35	— 1 30
» 12	23 30	25 18	77 51	22 39	25 19	78 9	+ 0 51
» 17	25 30	31 51	78 26	24	32 2	78 17	+ 1 30
Nov. 16	16	44 10	144 42	16 0	44 25	142 59	0 0
» 18	12	44 16	150 6	12	44 34	149 10	0 0
Dec. 16	9 23	40 58	189 54	8 19	40 50	196 28	+ 1 4
1643 Jan. 1	8 30	36 12	191 7	9	36 18	196	— 0 30
» 11	10	31 10	193 35	9 16	31 10	198 57	+ 0 44
» 12	9 30	30 5	195 37	7 16	30 0	200 58	— 2 14
» 14	8 30	28 40	197 5	8 15	28 35	202 4	+ 0 15
» 17	8	25 23	200 50	8 11	25 30	206	— 0 11
						Mean	— 0° 7'

The differences diverge more than those of the observations made on board "'t Wapen van Delft," which should partly be ascribed to the circumstance that some of them have probably not been made simultaneously, but that some were based on observations in the evening; others again on those made in the morning.

No mention thereof is indeed made in the journals, though the large decline of the variation may on account thereof now and then cause a difference of as much as one degree.

On the other hand the mean 0° 7' is so small that it looks highly probable that the collimation-error of the instruments was very slight; which of course may be called a very satisfactory result indeed.

As to the second criterion, a mere glance at the observed variations recorded on the annexed map shows that their progression was a regular one. Nowhere do we find a value of an irregular character. Finally, Tasman's route crosses to the south-east of Madagascar the tracks of Anthoni Caen (1636) and of Anthonio van Diemen (1633); and by making some allowance for the secular change, the agreement of the values (compare the map) may be called satisfactory.

Near the island of Gilolo the observed variations correspond very nicely with the values found by Maarten Gerritsz. Vries in the same year.

The final conclusion may therefore be that Tasman's observations can be made use of quite safely, and that if a value for some possible mean error should be given the amount of one degree would probably be sufficient.

Yet his calculations of the geographical position are less satisfactory.

It not being mentioned whether the observations were made in the evening or in the morning, no choice is left but to take the position at noon, and even that position cannot always be determined with the same degree of certainty.

The latitude causes little difficulty, as an error of from 10′ to 20′ is but a very slight one for our purpose, and Tasman's determinations of latitude in known places prove the errors never to exceed 10′.

The longitude on the contrary does indeed offer difficulties. As is known, in Tasman's time, the only method to determine the longitude was by calculating or guessing the velocity of the ship through the water. The inaccuracy of that method combined with the influence of sea-currents are the cause that these errors are now and then considerable. These two sources of errors are no longer to be separated. That the first is not trifling is clearly proved by the fact that the longitudes between Mauritius and van Diemensland, as given in the two journals, show a difference amounting to 6°. It is, moreover, known that nothing is so changeable as the sea-currents, so that it is impossible to find a constant value for their rapidity. It is therefore clear that if a ship has traversed a distance where there is commonly but one current of equal rapidity the error in the determination of the longitude, that is to say, the error in the difference of longitude between the land of departure and that of arrival obtained by the steersman, should be equally divided over the whole passage. The case, however, becomes more serious, should there be running in that track currents from a different direction and of a different rapidity. We must take these into consideration even if we had to content ourselves with hypothetical values.

For the great many journals, which I used for my purpose, I adopted the following method. At the points of departure and arrival the error in longitude, or rather the amount by which the given longitude is to be reduced to that of Greenwich, was computed with as much precision as possible. On the Wind and Current Map of the Hydrographic Office, 1872, on which the currents are laid down with an indication of the maxima and minima of their observed rapidity, I projected the course and took such values for the rapidity of the currents as to produce the found change in reduction.

The reductions so computed were next added to the values of longitudes and the numbers so found were completed to whole degrees. The most difficult part of Tasman's voyage is that lying between Mauritius and van Diemensland. South of Mauritius the east-western current was no doubt experienced, while afterwards when navigating about the 40th parallel he must have encountered the west-eastern current of the higher latitudes. Now, down to the 35th degree of south latitude I have supposed an east-western current with a daily value of 35′ (minutes of longitude) and regularly diminishing until the value 0′ is reached; and from the 19th of October to the 23rd of November the weak current of 10′ daily. In this manner the change of reduction of from — 21° 13′ to — 18° 50′ is rather easily explained. Between van Diemensland and New Zealand I must take a west-eastern current of 13½′ daily, which is also very probable, as likewise the 8′ daily between Driekoningen eiland (Three Kings island) and Pijlstaart eiland (Tropic Bird island). Between the Fiji islands and Onthong Java I expected an east-westerly current, but found that a west-easterly one of 4½′ daily should be applied.

For determing the positions on the coast of van Diemensland I followed Dr. Hocken 1).

The following computation of the ship's course, according to Tasmans journal, and reduced by the aforesaid method, will be sufficiently clear so as not to require any further explanatory comments.

(The numbers marked with an asterisk indicate the surmised latitudes, the others the observed ones.)

DATE.	According to the Journal.			Correction for longitude.	Reduced values.			
	Variation.	Latitude.	Longitude from Teneriffe.		Variation.	Latitude.	Longitude from Greenwich.	
1642 Aug. 17		6° 20′ S	124° E	— 19° 10′		6° 20′ S	104° 50′ E	At noon the southernmost of the Prince islands bore 5 miles east south-east from us. From this observation a longitude correction of — 19° 10′ has been deduced
19	3° W	8 38	120 35′	— 19 56	3° 0′ W	8 40	101	
21	5	11 12	116 42	— 20 42	5 0	11 10	96	
25	8 20′	15 13	107 20	— 22 14	8 20	15 10	85	
26	11	16	105 12	— 22 37	11 0	16 0	83	
27	12 30	16 40	103 32	— 23 0	12 30	16 40	81	
Sept. 2	20	20 28*	89 29	— 25 18	20 0	20 30	64	
4	22 30	19 55	85 13	— 26 1	22 30	20 0	59	By night saw Mauritius.
5		20	83 48	— 26 1		20 0	57 47	Anchored in the bay (Grandport). They supposed themselves to be still 50 miles eastward of the island. The driving off of 6° 51′ agrees with the east-westerly current. I have equally divided 23′ daily over the whole period

1) Abel Tasman and his journal. A Paper read before the Otago Institute, 10th of Sept. 1895, by Dr. Hocken F. L. S.

DATE.	According to the Journal. Variation.	Latitude.	Longitude from Teneriffe.	Correction for Longitude.	Reduced values. Variation.	Latitude.	Longitude from Greenwich.	
1642								
Oct. 8		20° 12' S	78° 47' E	— 21° 13'			57° 34' E	"The island of Mauritius, its south part, lies in south latitude of 20 degr. 12 min. and longitude 78 degr. 47 min." The south part of Mauritius is actually lying in 20° 30' and 57° 47'. The statement is consequently rather incomprehensible, but the longitude-correction — 21° 13' is at all events sufficiently accurate.
12	23° 30' W	25 18	77 51	— 23 0	23° 30' W	25° 20' S	53	
14	23 30	29 20	78 45	— 23 20	23 30	29 20	55	From the 8th to the 19th of October I compute an east-westerly current decreasing from 30' to 0'.
16	25 15	31 17	78 13	— 23 30	25 20	31 20	55	
17	25 30	31 51	78 26	— 23 35	25 30	31 50	55	
18	24	33 56	78 56	— 23 40	24 0	34 0	55	
22	24 40	38 11*	78 57	— 24 10	24 40	38 10	55	
27	26 45	43 *	88 6	— 23 20	26 50	43 0	65	
30	26 45	45 43	91 51	— 22 50	26 50	45 40	69	
Nov. 6	26	49 4*	114 56	— 21 40	26 0	49 0	93	
8	25 30	46 26*	121 19	— 21 20	25 30	46 30	100	From the 19th of Oct. to the 23rd of Nov. I compute a west-easterly current of 10' daily.
10	21 30	43 20	126 45	— 21 0	21 30	43 20	106	
12	21	43 50	129 17	— 20 40	21 0	43 50	109	
15	18 50	44 3	140 32	— 20 10	18 50	44 0	120	
16	16	44 10	144 42	— 20 0	16 0	44 10	125	
18	12	44 16*	150 6	— 19 40	12 0	44 20	130	
19	8	45 5	153 34	— 19 30	8 0	45 10	134	
21	4	43 40	158 12	— 19 10	4 0	43 40	139	
23	1	42 50	162 51	-- 18 50	1 0	42 50	144	About 4 o'clock in the afternoon saw land by 10 miles.
25		42 30	163 50	— 18 50	0 0	42 10	145 0	"Here near the coast the compass stands right, have also fixed together and averaged the middle longitude, by which we find this land to be in longitude 163 degr. 50 min."—According to Dr. Hocken they were on the northcoast of Macquarie bay.
30		43 41	168 3	— 20 33	0 0	43 40	147 30	Driven off the coast by storm. "The compass here stood right." It cannot be settled where they exactly were. Latitude at noon 43° 41'.
Dec. 3	3	43 40	168	— 20 0	3 0	42 50	148 0	In Tasman's Frederik Hendrik bay; Blackman bay according to Dr. Hocken.
7	5 45	42 13*	174 31	— 19 20	5 50	42 10	155	
9	5	42 37	176 29	— 18 53	5 0	42 40	158	Between Tasmania, and New Zealand a driving off of 13½' daily has been computed.
11	7	42 48	181 51	— 18 26	7 0	42 50	163	
12	7	42 38	185 17	— 18 12	7 0	42 40	167	
13	7 30	42 10	188 28	— 17 58	7 30	42 10	170 30	
14		42 10	189 3	— 17 43		42 10	171 20	2 Miles from the coast.
15	8	41 40	189 49	— 18 19	8 0	41 30	171 30	At noon Cape Foulwind S.E. 2½ miles. In the evening 8° easterly variation. I compute the rate of sailing from noon till evening at 10', as they traversed a distance of 42' during these 24 hours.
16	9 23	-40 58	189 54	— 18 20	9 20	41 0	171 40	Cape Farewell E. by N.
17	9				9 0	40 30	171 52	At the east-end of Farewell Spit.
18	9				9 0	40 50	171 40	In the Murderers-bay.
19	9 30				9 30	40 30	172 0	
26	8 40	40 13*	192 7	— 18 20	8 40	40 10	173 50	
27	8 20	38 38	190 15	— 18 20	8 20	38 40	172	
28	8 30	38 2*	192 23	— 17 33	8 30	38 0	174 50	Saw land.
30	8 40	37	191 55	— 17 33	8 40	37 0	174 20	Saw land.
31	8	36 45	191 46	— 17 33	8 0	36 50	174 10	Saw land.
1643								
Jan. 1	8 30	36 12	191 7	— 17 33	8 30	36 10	173 30	Saw land.
2	9	35 55	190 47	— 17 33	9 0	36 0	173 10	Saw land.
3	8 40				8 40	34 3	172 30	To the east of the Driekoningen island.
5		34 25	190 40	— 18 28		34 10	172 12	Situation of the Driekoningen island.
7	8 30	33 25	191 9	— 18 44	8 30	33 30	172 30	
8	9	32 25	192 20	— 18 52	9 0	32 30	173	
10	10 30	31 28	192 43	— 19 8	10 30	31 30	173 30	
11	10	31 10*	193 35	— 19 16	10 0	31 10	174	
12	9 30	30 5	195 27	— 19 24	9 30	30 10	176	
13	9	29 10	196 32	— 19 32	9 0	29 10	177	
14	8 30	28 40	197 5	— 19 40	8 30	28 40	177 30	
15	8 15	27 43*	198 9	— 19 48	8 20	27 40	178	
17	8	25 20	200 50	— 20 4	8 0	25 20	179	
19	7 30	22 46	203 27	— 20 17	7 30	22 50	183	Saw the Pylstaart island, which according to Tasman is lying in 22° 35' south latitude and 204° 15' east longitude. The true longitude from Greenwich is 183° 58' E, so that the reduction amounts to — 20° 17'. I computed this increase in proportion to time (8' daily).
20	7 15	21 30	204 54	— 20 28	7 20	21 30	184 26	At noon the Island of Middelburg E. 8 miles.
24	7				7 0	21 0	184 48	Eastward of Namuka.
25	6 20	20 15	206 19	— 21 21	6 20	20 15	184 58	At anchor near Namuka.
Febr. 6		17 9	201 35	— 20 35		17 10	181 0	Near the Fiji islands.
March 2	10	9 11	192 46	— 18 45	10 0	9 10	174	Bad weather prevented them from taking observations during the month of February.

DATE.	According to the Journal. Variation.	According to the Journal. Latitude.	According to the Journal. Longitude from Teneriffe.	Correction for Longitude.	Reduced values. Variation.	Reduced values. Latitude.	Reduced values. Longitude from Greenwich.	
1643								
March 5	10° 30′ E	8° 32′* S	191° 42′ E	— 18° 32′	10° 30′ E	8° 30′ S	173° E	
14	8 45	10 12	186 14	— 18 0	8 50	10 10	168	Likewise from 5 to 14 March.
15	8 40	9 33	185 40	— 17 55	8 40	9 30	168	
16	9	8 46	184 51	— 17 51	9 0	8 50	167	
18	9	7 40	183 33	— 17 43	9 0	7 40	166	
20	9	5 15	181 16	— 17 34	9 0	5 20	164	
22		5 2	178 2	— 17 26			160 36′	Onthong Java directly ahead 4 miles. As a westerly driving off was to be expected and contrary to it an easterly was found, I have the 3° 9′ change in longitude-reduction, divided in proportion to time, 4½′ daily.
26	9 30	4 33	174 30	— 18 17	9 30	4 30	156	
	9 30	4 1	173 36	— 18 17	9 30	4 0	155	
28		4 11	172 32	— 18 17			154 0	
29	9	4 20	172 17	— 18 17	9 0	4 20	154 0	Groene islands W. 4 miles.
April 1	8 45	4 30	171 2		8 50	4 30	153 10	Near the Groene islands.
8	10	2 26*	167 39	— 17 49	10 0	2 30	149 50	Eastward of the Cape St. Marie.
9	10	2 33	167 4	— 17 49	10 0	2 30	149 20	Eastward of the Portland islands.
14	9 15	5 27	166 57	— 18 0	9 20	5 30	149	
15	9	5 18*	166 36	— 18 10	9 0	5 20	148	
17	8 45	5 8	166	— 18 30	8 50	5 10	147 30	
19	9	5 9	164 50	— 18 50	9 0	5 10	146 0	
20	8 30	5 4	164 27	— 19 0	8 30	5 0	145 30	In the evening saw the Vulcan island.
24	8	2 22*	158 36	— 17 37	8 0	2 20	141	
25		2 11	156 47	— 17 37		2 0	139 10	Near Yamna.
May 8	8	1 30	156 22	— 17 22	8 0	1 20	139 0	Arymoa S.W. and S.W. by S. 5 to 6 miles
9	7 30	1 35	155 25		7 30	1 20	138 30	Arymoa S. E. by E. 3 to 4 miles.
11	6 50	1 3	154 28	— 17	6 50	1 0	137	
12		0 54	153 17	— 16 57			136 20	The north point of Willem Schouten's island W. 6 miles.
13	6 30	0 54	152 6	— 17	6 30	0 50	135	
15	6	0 41*	149 53	— 18 23	6 0	0 20	131 30	Cape of Good Hope S. 3 miles.
16	5 50	0 16	149 9		5 50	0 0	130	Find a westerly current.
18	5½	0 26*	— —		5 30	0 10	129 0	Probably near Waigen.
19	4 30	0 55*			4 30	0 50	129 30	Longitude deduced from the rest of Tasman's account and map.

Another way to diminish the influence of a great many remaining errors is by drawing isogones.

The accurate magnetical observations during the lasthalf of this century have proved the isomagnetic lines not to run across the land as uniformly as it was formerly thought. In respect to the sea the observations are not sufficiently accurate to prove this. In my opinion, it is not improbable that the irregularities of the lines across the sea are much smaller; yet apart from this the isomagnetic lines drawn after these irregularities having been eliminated, have just as high a theoretical value as the true lines. It is therefore desirable to project a system of regularly progressing lines of equal variations based on Tasman's observations. That thereby the observations of voyages made in adjacent parts should be taken into consideration is a matter of course, and thus going on we should at length come to making use of all the voyages known to have been made about 1640.

It is to be understood that I will now confine myself to the Indian and Pacific Oceans.

In my dissertation "De Isogonen in de XVIde en XVIIde eeuw" I drew a similar set of isogones for the year 1640, but the material being now increased and arranged with more accuracy, I have again traced in the map attached to this work the lines across both the said oceans.

It is of course impossible to select voyages made in the same year. Differences of time of some 10 and more years are simply not to be avoided, in consequence of which we come into conflict with the secular variation which generally is of an unknown quantity.

Chiefly making use of the material arranged in my dissertation I some time ago subjected the secular change to a general investigation.

In August 1895 1) I edited a map on which the secular curve of the declination was represented for a great many points uniformly dispersed over the globe.

I derived therefrom the lines of equal secular changes of the declination 2), but the material employed renders these lines for the year 1640 for the Indian Ocean very uncertain.

In consequence of the extension I could give to my materials, my previous work can be improved, but as this takes up much time, I have not yet been in a position to do so. I will therefore not apply defined corrections for the secular change, which omission, when we take into consideration that the

1) Compare, Kon. Akad. v. Wetensch., Zittingsverslag 28th Sept. 1895.

2) Compare, Kon. Akad. v. Wetensch., Zittingsverslag 30th Nov. 1895.

voyages employed for our object were made a few years only before or after 1640, can occasion but very slight errors.

As to the Pacific the case is quite otherwise and for these parts I am unable to obtain for that period allegeable values for the secular change.

Yet I shall have occasion to recur to this lower down.

The materials of observation from which I derived my variations and of which use has been made by constructing the annexed map is all fresh, except Tasman's observations, and the one of Schouten used already by Hansteen.

They are:

Queiros, 1606.

Pedro Fernandez de Queiros took his departure on the 21st of December 1605, accompanied by Luis de Vaes de Torres of Callao, and sailed across the South Pacific Ocean. He got separated from de Torres in the neighbourhood of New Guinea and returned to America. De Torres sailed through the strait called after him to Manilla, and wrote from there a letter to the king of Spain about the voyage.

This letter dated Manilla, July 12th 1607, is quoted in the IV appendix of nº. 30 of the works published by the Hackluyt Society, entitled: The Philipine islands by Ant. de Morga, edited by Henry E. J. Stanley. In that letter I found two records of the variation of the magnetic needle.

p. 403.... "we found four triangular isles of five or six leagues each, flat, uninhabited and without soundings. We gave them the name of the Virgins; here our needle varied to the north-east." They were then southwest of the Paumotu group.

p. 405.... "we went steering to the northwest and a quarter north until reaching ten degrees and three quarters; in this neigbourhood we saw an island which was understood to be San Bernardo, as it was in pieces, but it was not, from what was seen later. We went away from this above-mentioned island to the west a quarter northwest. Here we found that in this meridian the needle varied to the north-east by about a quarter." This island was probably Gente Hermosa.

The places of observation are not to be determined with absolute certainty, though sufficiently so for our purpose.

I accordingly assume, taking "a quarter" (of a rhumb) as to 3 degrees:

DATE.	Latitude.	Longitude from Greenwich.	Variation.
1606. February 5	20° 0′ S	144° W	easterly
„ 22	10 40 „	171 „	3° 0′ E

Willem Cornelisz. Schouten, 1616.

There is but one observation known to us made by Schouten in the Pacific, which Hansteen found in the account given by Purchas in his Pilgrims (IV, Lib. II, p. 88).

According to this they found on the 3rd of April in 15° 12′ of south latitude the variation to be zero, and by steering a continual westerly course they arrived at Honden island on the 10th of April. Hansteen takes the distance daily traversed to be 1°, and by doing the same, I obtain:

DATE.	Latitude.	Longitude from Greenwich.	Variation.
1616 April 3	15° 10′ S	130° W	0° 0′

Nassau fleet, 1623. Observations taken on board the yacht "'t Wapen van Delft."

In the manuscript-journal (State Archives at the Hague) the observations with the compass have once more been collected into a separate list. Every one of those undertaken in the Pacific were observed with the Amsterdam compass, and, as said before, I applied to them a correction of −0° 55′.

DATE.	Latitude.	Longitude from Greenwich.	Variation.	
1624				
April 1	38° 30' S	75° 30' W	3° 0' E	
16	32 40	77 20	1 0	Juan Fernandez S. W. 24 miles.
30	21 20	76	3 0	
Sept. 20	0 0	88	0 30	
Oct. 2	9 0 N	98	1 0	
11	13 0	99	0 0	
Dec. 3	15 30	106	2 0	
10	15 0	116	2 0 W	
22	14 20	144	4 0	
27	14 40	153	4 0 E	
30	15 0	160	6 0	
31	15 0	163	7 0	
1625				
Jan. 4	14 10	169 40	10 0	Johnston's island N. by W.
7	13 40	173	10 0	
10	14 50	178	16 0	
11	14 50	180 E	17 0	
13	14 50	174	17 0	
15	14 40	169 30	16 0	Galparico (Smith island) E. 10 miles.
22	13 10	151	2 0	(Should this be 12° 0'?)
Febr. 11	13 20	144 40	11 30	Near Guam (Ladrones).
15	9 40	138 10	9 0	
17	7 30	135 20	8 0.	Babelthuap W.N.W. 10 miles.
26	3 40	130	6 0	
March 2	2 0	127	5 0	Near Gilolo.
30	0 0	127 30	4 0	In the road of Batjan.

Antonio van Diemen on board the "Amsterdam" in 1633 from Holland to Batavia.

The copy of the manuscript-journal existing in the State Archives at the Hague is for two causes important. Firstly, they made a determination of the longitude by the aid of the variation; secondly, they navigated between the islands of St. Paul and Amsterdam.

After the Cape Verd islands had been sighted no land was seen, so that in the neighbourhood of the Cape (which was not touched at) the longitude had become very doubtful. On the 20th of May they find ½ degree increasing westerly variation, and according to that observation determine the ship's position in the direction of north and south from Cape False.

By means of the curve for the secular variation of the declination at Cape-town, for which at present a great many observations are available, I find the declination to be there in 1633 2° 30' W, and according to my isogonic map for 1640, the variation changes 1° for 2° of longitude; besides that the difference of latitude between the parallel in which van Diemen sailed and the one of Capetown exercises no appreciable influence. According to this, they were in 14° 30' E. longitude from Greenwich. I don't believe they corrected their longitude, yet an error was still left.

DATE.	Variation.	Latitude.	Longitude from Greenwich.	
1633				
May 21	2° 0' W	36° 10' S	24° E	
24	2 30	38 30	29	(In the number 2° 30' is apparently an error).
25	7 0	38 30	30	
26	8 30	38 50	31	
28	11 0	38 30	35	
31	14 0	40 40	41	
June 4	22 0	41 20	48	
7	22 0	41 0	54	
9	25 0	41 0	57	
17	25 0	38 20	77 30'	Between St. Paul and Amsterdam.
19	23 30	38 0	85	
20	23 0	37 30	88	
22	19 20	38 10	92	
27	11 20	29 20	105	
29	8 30	26 10	107	
30	7 30	24 40	108	
July 1	7 10	23 20	108	
2	6 0	21 30	109	
3	5 40	19 40	110	
4	3 50	17 30	110	
5	2 50	16 30	110	
9	2 30	10 30	109	
10	2 0	9 10	109	

The yachts "Clein Amsterdam" and "de Wesel" in 1636 from Batavia to New-Guinea.

The copy of the manuscript-journal (State Archives at the Hague) gives only one observation with the compass.

DATE.	Variation.	Latitude.	Longitude from Greenwich.	
1636 May 11	4° 0′ E	5° 10′ S	133° 20′ E	Aru islands S. E.

Anthoni Caen in the ship "Banda" in 1636 from Holland to Batavia, steersman Symon Cornelisse Lastman.

Original manuscript-journal (State Archives at the Hague).

DATE.	Variation.	Latitude.	Longitude from Greenwich.	
1636 June 2	2° 30′ W	34° 30′ S	18° 10′ E	
6	8 30	35 30	30	
7	9 40	36 20	33	
13	21 0	38 20	51	
14	23 0	38 40	53	
16	23 30	38 40	58	
17	25 30	38 20	61	
21	27 0	38 30	73	
22	27 0	38 30	77	
28	13 50	38 30	95	
July 1	11 30	33 30	102	
2	9 20	30 0	103	
3	9 0	28 40	104	
4	8 0	26 50	105	
6	8 10	26 30	107	
7	5 20	24 30	109	
9	4 50	21 30	111	
10	4 40	18 0	112	
13	2 20	10 20	110	

Barent Pieterssen Hollaer (merchant) in the ship "Swol" in 1636 from Batavia via Muscatta to Holland.

Manuscript-Journal (State Archives at the Hague).

DATE.	Variation.	Latitude.	Longitude from Greenwich.	
1636 Sept. 9	4° 50′ W	10° 30′ S	92° E	
11	6 20	11 0	87	
12	8 40	11 0	86	
14	9 0	10 40	82	
16	11 10	11 0	78	
17	12 40	10 50	75	
24	21 0	8 0	62	
25	20 30	6 0	62	
26	19 30	4 10	62	
28	19 30	2 0	62	
29	19 30	0 10	63	
Oct. 1	18 30	2 20 N	63	
2	18 20	3 20	63	
6	17 20	7 30	64	
10	17 20	9 20	64	
11	17 30	9 30	66	
12	17 30	10 0	65	
22	14 0	11 20	74	
Dec. 8	16 30	21 50	70	Near the coast of Gatsch.
21	16 30	24 50	64	
24	16 30	25 20	62	
28	18 0	25 20	57 30	
1637 Jan. 1	16 30	20 10	59	3 Miles from Cape Djask.
2	17 0	18 40	58	
4	17 10	17 40	58	
5	17 30	17 30	57	
8	17 10	16 50	57	
10	17 30	15 0	56	
11	17 30	13 20	56	
12	17 30	12 10	55	Socotra N.W. by W. 10 miles.
Febr. 13	17 50	10 50	52	
15	18 0	9 40	51	
16	18 10	8 50	50	