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THE GEOMAGNETIC FIELD OF THE NETHERLANDS REDUCED TO 1945.0

BY

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PREFACE

On publishing this report I wish to express my gratitude to all persons who have taken part in the magnetic survey of the Netherlands. In the first place thanks are due to Mr. J. Oldeman, scientific assistant at the 5th department of the Royal Netherlands Meteorological Institute for his assistance and cooperation, to the staff of the magnetic observatory Witteveen, and to the other members of the staff of the 5th department, who undertook the troublesome work of reducing the measurements at De Bilt as well as at Witteveen, and further to Dr. C. P. Hartmann, seismologist at the Bataafse Petroleum Maatschappij, who performed the greater part of the Z-measurements during the years 1942 to 1944.
Moreover thanks are due to Messrs. Dr. P. Groen, A. Hauer, Dr. H. ten Kate, Dr. W. F. Schalkwijk and C. G. C. Schütte, members of the scientific staff of the Royal Netherlands Meteorological Institute, who bestowed part of their time on the survey during wartime. I wish to acknowledge the great amount of accurate work done by them.
Finally I am greatly indebted to the commander of the Netherlands Navy, Admiral J. J. L. Willinge, who several times put a ship at my disposal for the measurements in the Wadden Sea.

De Bilt, July 1950

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INTRODUCTION

THIS report contains the results of geomagnetic measurements carried out in the summers of the years 1942—1948. The idea of measuring the geomagnetic field of the Netherlands was suggested to the present author at the end of 1941 by Mr. C. P. HARTMANN, at that time cand. geol. From the first discussions a broader plan arose, which aimed at a detailed survey to be carried out by the Royal Netherlands Meteorological Institute. A number of members of the scientific staff, who could not perform their normal duties owing to war circumstances, were able to give their cooperation in making the measurements. They were Messrs. GROEN, HAUER, TEN KATE, SCHALKWIJK and SCHÜTTE. The assistance of Mr. OLDEMAN of the geophysical department must be mentioned especially. Mr. HARTMANN took part as a guest. The whole survey was under the direction of the present author.

It will be evident, that the war hampered this work. In different parts of the Netherlands, especially in the coastal region, fieldwork was forbidden by the Germans. The problems connected with transport, food and lodging of the measuring party were considerable, and in the last year of the war measurements were of course impossible.

During the summer months of the years 1942, 1943 and 1944 measurements were carried out in a great part of the Netherlands, with the exception of the coastal regions, the Zuid-Hollandse islands, Zeeland, Zeeuws-Vlaanderen and the Wadden islands. The results of these measurements have been used by HARTMANN for the composition of his thesis [1]).

After the liberation in 1945 the survey could be resumed, thanks to the fact, that the instruments and data had all been saved and that, moreover, the magnetic observatory at Witteveen had sustained the liberation without any damage. The measurements in the years 1945 till 1948 were carried out almost exclusively by Mr. OLDEMAN and the author. The country of Zeeland, Zeeuws-Vlaanderen and the Zuid-Hollandse islands was measured in the fall of 1945 and the summer of 1946. In the summer of 1947 measurements were made on the Wadden islands and on some sand-banks in the Wadden Sea. The Commander of the Netherlands Navy, the Admiral J. J. L. WILLINGE put a small yacht, Hr. Ms. Neptunus (RC 39) with crew under the kwartiermeester RUIJSAARD at our disposal during three weeks for transporting the instruments and the observers. When it became clear that an important anomaly was present in the Wadden Sea, the desirability was felt, to localize this anomaly more exactly by a number of supplementary observations. These were carried out in the summer of 1948. Support was asked from the Commander of the Netherlands Navy, who kindly lent the naval craft Doornbosch (RQ 2) for three weeks. Captain of the craft was Schipper VAN DER MEY. With the aid of this vessel fourteen measurements were performed on sand-banks in the Wadden Sea. The outcome of these observations has been given in a separate table. They have been used for the construction of the magnetic charts of the components H, Z and ΔZ.

The geomagnetic field of the Netherlands had already been investigated previously. In the years 1889 to 1892 measurements were carried out by E. VAN RIJCKEVORSEL [1]) at more than 300 places in our country. The result was laid down in a bulky report: A magnetic survey of the Netherlands, for the Epoch January 1, 1891, edited in the series "Nieuwe Verhandelingen van het Bataafs Genootschap der Proefondervindelijke Wijsbegeerte te Rotterdam". Three components of the geomagnetic field were investigated by him: the declination, the horizontal force and the inclination. For the first and the second VAN RIJCKEVORSEL used an ELLIOT unifilar magnetometer, for the determination of the dip a DOVER dip-circle. All the measurements were performed by VAN RIJCKEVORSEL alone, a few times he was aided by a servant. Travelling was mostly done by train, less often by boat or carriage. Especially the travelling by train has strongly influenced the choice of many measuring-places. He writes about this matter:

"I do not at all take much care in selecting my station. As soon as I arrive at a place where I wish to observe, I put down my instruments on the first spot which looks likely to be good, without making a severe hunt for iron, or taking many informations about gaspipes or rails. Even, as many railway-stations, especially of the state-railways, have a large tract of enclosed ground, I very often observed there. I thus had the advantage of finding, without loss of time, a convenient spot, where there were no troublesome intruders, but of course I often came dangerously near to rails or waggons. I was quite aware of this objection to my method. But it gave me the great advantage of gaining time. It will be seen that I regularly took two stations a day and in one or two cases even more than that."

Owing to this method he worked close to the rails or other large iron masses in many cases. This becomes evident from the remarks given in the description of the stations, like: "20 m of corner of station", "near a shed containing a lot of machinery", "during part of work had to suffer much from smoke of locomotive". Moreover, VAN RIJCKEVORSEL used to choose his standpoint near a building. Repeatedly we find descriptions like: "garden of inn", "garden of stationmaster", "garden of hotel", "in front of the only house near the station", "marketplace", "within the town", "near front of old lighttower", "near church, within enclosure".

Very exclusive indeed was the measurement carried out at Nesserzand, a sand-bank easterly of the island of Texel: "In the sea with water nearly up to the waist. Geographical position kindly communicated to me by the commander of the torpedoboat, which had been lent to me. For the sun's observation, as I could not have the chronometer near me, the commander had it in the boat and gave the time for each single reading".

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[1]) PH. C. P. HARTMANN, Aardmagnetische Anomalieën in Nederland, Utrecht 1945.

[1]) Dr E. VAN RIJCKEVORSEL, A magnetic survey of the Netherlands for the epoch January 1, 1891 (Rotterdam 1895).

Out of the 328 measurements about 130 have been performed at places, which decidedly must be called bad from a magnetic viewpoint, whereas about 50 more are less favorable. Only 150 places can be qualified as good, judging from the description.

As a consequence of this lack of care in choosing the place where the instruments were mounted, a great number of the measurements (about a half) have been carried out in places which are magnetically disturbed, and therefore give an untrue picture of the magnitude and direction of the magnetic field. Besides, the present author cannot throw off the impression that the accuracy of the measurements is smaller than given by VAN RIJCKEVORSEL. In his discussion about the declination measurements for example, he estimates the accuracy of determining the magnetic meridian at $\pm 3''$. Our impression is that no accuracy better than $10''$ can be obtained with the instrument used by VAN RIJCKEVORSEL. The exactness of the chronometer, which is determinative for the accuracy of the geographic north, is estimated at ± 2 sec, although checking the rate of the chronometer took place only at the beginning and at the end of a 14 days' travel. Our experience with similar chronometers, which were compared with wireless time-signals every day, are much worse however. Finally the determinations of the vertical force, calculated from the horizontal force and the inclination, have been affected by the use of the dip-circle. This is an inaccurate instrument, as the position of the needles is apt to be changed by the slightest irregularities of the axis of rotation. The possible error of the inclination is estimated by VAN RIJCKEVORSEL at about $1'$, which corresponds to an inaccuracy of about 35γ in the vertical force. It is quite certain that in many measurements the error has been larger than this figure.

The result of all is, that the geomagnetic field in the Netherlands has a highly disturbed character after VAN RIJCKEVORSEL's measurements. The differences between values at adjacent stations are most irregular. As a result the isomagnetic lines are drawn in capricious windings on his charts. This is especially the case with the chart of the vertical force. As this chart is of great importance for a geological interpretation of the irregularities, it seemed worth while to repeat the observations with more accurate methods. Besides, the geomagnetic field has considerably altered since 1891 by the secular change, so that a new survey was desirable.

CHAPTER I

INSTRUMENTS AND METHODS OF MEASUREMENT

The members of the staff who took part in the survey, joined the magnetic party alternatingly. In the years 1942 and 1943 the party was composed mostly of three persons. Later on it turned out, that the work could be done by two persons quite as well.

If the number of participants was three, each of them was occupied with one component of the geomagnetic field. Consequently there were participants who were specialized in measuring the declination D, others who were accustomed to the determination of the horizontal component H, again others for the vertical component Z. This distribution of work proved to be an advantage for the quality of the measurements.

When the party consisted only of two persons, that distribution of work was the best, in which one of them carried out one D-determination together with one Z-measurement, whereas the second combined the H-measurement with two more Z-determinations.

Transport of the party and the instruments took place by motorcar. The carrying out of one complete measurement D, H and Z took about two hours, and when the weather was unfavourable so that wind-screens had to be put up, three hours or more were necessary. Under favourable conditions it was possible to do three stations a day. At each station one D-measurement was carried out, H was determined at two places and Z at three places, the distances between two places being 20 to 50 m. This method had the advantage that already during the measurements an impression was got about the magnetic properties of the ground. In cases where the Z-observations differed strongly, it was supposed that a local disturbance was present and the station was moved to a better place. Such disturbances were discovered several times. In general much care was taken to avoid artificial disturbances. Minimal distances were fixed for diverse iron or iron containing objects. These minimal distances were: instrument case 5 m, motorcar 25 m, barbed wire 5 m, iron fence 30 m, iron pipe line 25 m, rails 200 m, mine shaft 500 m, buildings 100 to 500 m, ballasted roads 100 m. These distances were partly taken from "Physics of the Earth VIII", page 132, partly they were determined by experiment. Preferably the instruments

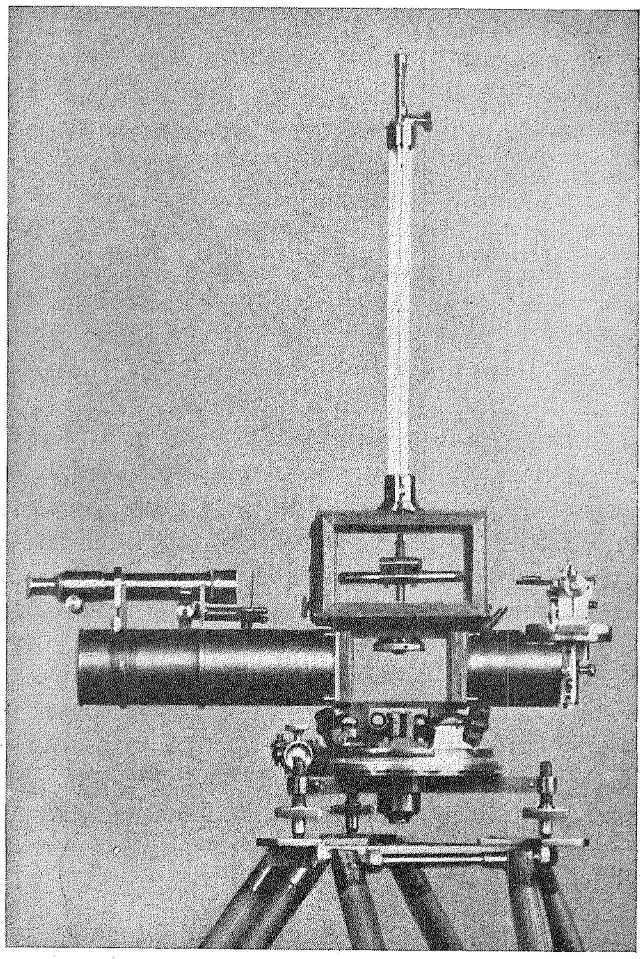

Fig. 1. Theodolite for declination measurements.

were set up in meadows, on arable ground or uncultivated sandy ground. In order to avoid mutual disturbances minimal distances of 15 m were kept between the instruments.

All measurements of the magnetic elements were made at the moment of the minute-record in the magnetic observatory Witteveen, where every minute, a one-second snapshot of the geomagnetic field is taken.

Measuring the declination.

The instrument (fig. 1) was a theodolite after ELLIOT left by VAN RIJCKEVORSEL, which permitted us to read directions with an accuracy of 10″. With a view to the declination-measurements several changes were introduced. To enable the triangulations to be carried out, a little telescope (with an object-diameter of 25 mm) was fixed. For the astronomical measurements the mirror as well as the mirror's axis were constructed with the utmost accuracy.

First a description will be given of a declination-measurement by means of a sun's observation.

The theodolite is mounted on a tripod as firmly as possible. Then the axis of rotation is adjusted vertically by levelling. The axis of the mirror must then be horizontal, and this can be checked by a levelling instrument. If necessary the position of the axis is corrected. Besides, the mirror's axis has to be perpendicular to the optical axis of the telescope, and the reflecting surface of the mirror has to be parallel to the mirror's axis. These conditions cannot be checked in the field, for this requires a dark room. The checking was carried out several times a year in the observatory. The reticles of the telescope are illuminated from one side and the mirror is manipulated in such a way that the reflection of the reticles coincides with the object. It goes without saying that the vertical reticle must be vertical indeed, when the angles between objects of different altitudes like the image of the sun and church-steeples are measured.

Now an image of the sun is projected in the telescope by help of the mirror. Two small blue glasses can be placed in the ray path in order partially to absorb the sunlight. Then several times the moment is read, at which the left and right limbs of the sun touch the reticle-wire. This can be done in the most simple way by an assistant counting the seconds of the chronometer. At the same time the azimuth of the theodolite is read. This series of readings is repeated after the mirror has been lifted out of the supports, turned halfway round its vertical axis and let down in the supports again. This enables us to eliminate the error introduced by the mirror's axis and the mirror not being parallel. An eventual error in the position of the mirror's axis with respect to the axis of the telescope is removed by a determination with the sun in front of the observer as well as behind him. If it turns out that in the first case the direction of the astronomical north is read by an angle A, and in the second case by an angle B, the true azimuth N is given by[1])

$$N = \frac{A+B}{2} + \frac{A-B}{2} \cos h,$$

where h is the elevation of the sun, computed from the formula

$$\sin h = \sin \varphi \sin \delta + \cos \varphi \cos \delta \cos \tau$$

or from

$$\cos h = \frac{\cos \delta}{\sin \alpha} \sin \tau.$$

In these formulas φ is the geographical latitude of the station, δ is the declination of the sun, τ is the local true hour-angle of the sun, and α is the sun's azimuth. The azimuth of the sun is computed from

$$\operatorname{tg} \alpha = \frac{\sin \tau}{\sin \varphi \cos \tau - \cos \varphi \operatorname{tg} \delta}$$

The hour-angle is derived from the true local time, calculated from the observed Greenwich-time, plus the longitude of the station converted in time, and minus the equation of time. The coordinates of the station are read from a topographical map, accurate to about 0′.01, and the Greenwich-time can be determined to about 0.1 sec. The accuracy of the astronomical north depends in the first place on the precision of the time-readings. It is further determined by the quality of the observation, that means, by the accuracy of the levelling during the observation. The quality of the determination will appear from the scattering of the values obtained by the series of determinations A and B, and from the difference $A - B$. The magnitude $(A - B) \cos h$ must have the same value at different stations, as long as the instrument remains unchanged. Finally a good measurement is accurate to 0′.1.

If the sky was cloudy, the direction of the astronomical north was determined by the help of triangulated points. The Governement's Triangulation (Rijksdriehoeksmeting) and the other survey services have determined the coordinates of a great number of church-steeples, triangulation stones and cadastral points, with respect to a system of coordinates with origin nearly coinciding with O. L. Vrouwe-tower at Amersfoort[1]). If the theodolite is placed above a triangulated point with the coordinates $x_1 y_1$ and is aimed at a spire with the coordinates $x_2 y_2$, then the telescope will make an angle arc tg $(x_1 - x_2)/(y_1 - y_2)$ with the direction of the ordinate through the place of observation. At the origin of the system of coordinates the direction of the y-axis coincides with the direction of the true north; at an arbitrary point with the coordinates xy an angle p exists between the two directions found by the formula[2])

$$p = 0{,}04155\, x + 1{,}1 \,.\, 10^{-8}\, xy + \ldots\ldots.$$

x and y must be expressed in meters, and p is found in seconds of arc.

The direction of the ordinate must be corrected for the angle p in order to find the astronomical north.

In cases where the triangulated point cannot be used directly, owing to the surroundings being magnetically disturbed, the theodolite can be placed on the line between this point and a tower.

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[1]) PH. C. P. HARTMANN, Thesis Utrecht 1945.

[1]) Rechthoekige coordinaten, Rijksdriehoeksmeting 1855—1928, Delft 1929. Militair register getrianguleerde punten, 1933.

[2]) HK. J. HEUVELINK, De stereografische kaartprojectie in hare toepassing, Delft, 1910.

It often happens, that no triangulated stone is present on the spot where the observation must be done. Then it is possible to determine the coordinates of the theodolite by aiming at three triangulated steeples. For this purpose we used a calculating-scheme, which gives results considerably quicker than the usual methods and is more comprehensible.

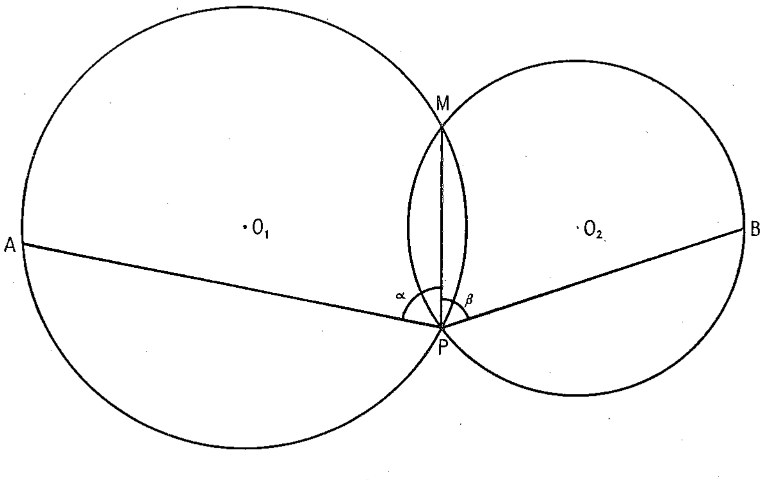


Fig. 2.

Let the triangulated points be A, M and B with coordinates $A(x_1y_1)$, $M(x_3y_3)$ and $B(x_2y_2)$. The angles α and β are measured and it is required to find the coordinates x_p and y_p of the point P. P must be found as the point of intersection of the circles through A, M, P and B, M, P with the angles α and β respectively.

The origin of the system of coordinates is translated to M. The coordinates of a point (xy) are transformed into (s, t) according to:

$$s = x - x_3$$
$$t = y - y_3$$

so that the new coordinates of A, M, B and P will be: $A(s_1t_1)$, $B(s_2t_2)$, $M(0, 0)$ and $P(s_pt_p)$.

The coordinates of the centres o_1 and o_2 are:

$$s(o_1) = \tfrac{1}{2}s_1 + \tfrac{1}{2}t_1 \operatorname{cotg} \alpha \qquad s(o_2) = \tfrac{1}{2}s_2 + \tfrac{1}{2}t_2 \operatorname{cotg} \beta$$
$$t(o_1) = \tfrac{1}{2}t_1 - \tfrac{1}{2}s_1 \operatorname{cotg} \alpha \qquad t(o_2) = \tfrac{1}{2}t_2 - \tfrac{1}{2}s_2 \operatorname{cotg} \beta$$

If A, M and B have arbitrary positions with respect to the point P the signs of α and β are determined by the arcs MA and MB, which must be taken positive if their sense is clockwise with respect to P.

The equation of MP is:

$$t = -s \, \frac{s(o_2) - s(o_1)}{t(o_2) - t(o_1)}$$

The point of intersection P of the circles o_1 and o_2 with the line PM is given by:

$$\tfrac{1}{2}s_p = \frac{\{s(o_1)t(o_2) - s(o_2)t(o_1)\}\{t(o_2) - t(o_1)\}}{\{s(o_2) - s(o_1)\}^2 + \{t(o_2) - t(o_1)\}^2}$$
$$\tfrac{1}{2}t_p = \frac{\{s(o_2)t(o_1) - s(o_1)t(o_2)\}\{s(o_2) - s(o_1)\}}{\{s(o_2) - s(o_1)\}^2 + \{t(o_2) - t(o_1)\}^2}$$

whereas the coordinates of P finally are derived from:

$$x_p = s_p + x_3$$
$$y_p = t_p + y_3$$

After determining the astronomical north, either with the help of the sun or by means of a triangulation, the direction of the magnetical north must be found. For this purpose a hollow magnet is suspended in the axis of the theodolite, one end provided with a little lens and the other with a divided scale, which is fitted at the focus of the lens. A silk thread for suspending the magnet is stretched by a weight equal to that of the magnet in order to remove the torsion. This being completed the magnet is attached to the thread and the theodolite is adjusted so that the centre of the scale division coincides with the vertical wire of the telescope.

About five readings are taken, each time just at the second at which a point record is made in the magnetic observatory at Witteveen. Then the magnet is removed from the thread, the tube with the thread is rotated through 180°; the magnet is turned upside down and attached again. Five other readings are taken, which may all differ some minutes of arc from the first series. If both series are averaged, the eccentricity of the suspending-point as well as the difference between the optical axis and the magnetical one of the telescope will be eliminated. Then the magnet is replaced by a torsion-weight and the angle of torsion of the thread if present can be determined. As the torsion-coefficient of the thread is known, a correction for the value of the astronomical north can be calculated from this angle.

Examples of declination-measurements by observation of the sun as well as by means of triangulation which are worked out completely, can be seen on pages 12 and 13.

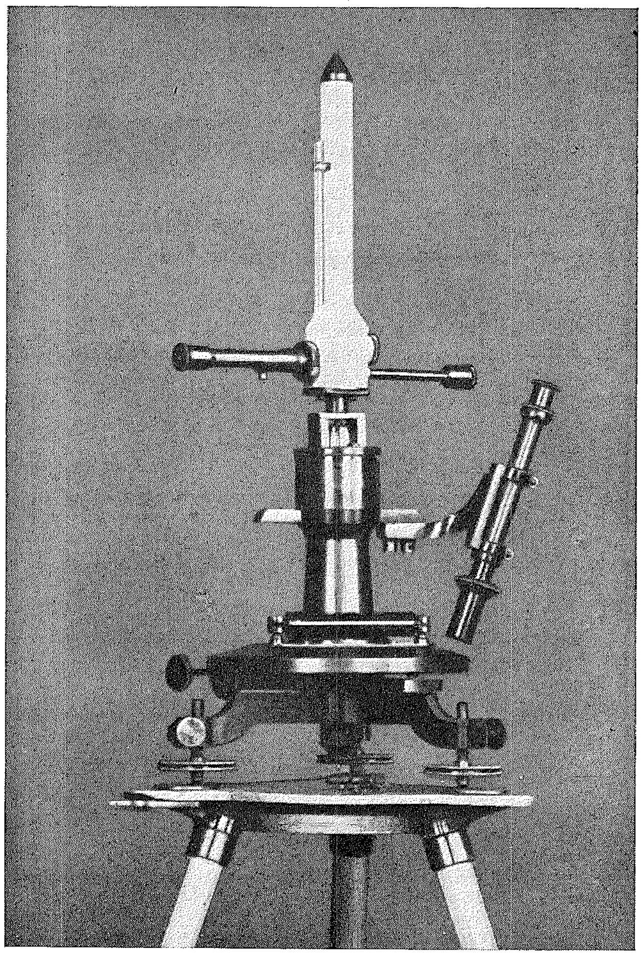


Fig. 3. QHM (quartz horizontal-intensity magnetometer).

Measuring the horizontal component. This component was determined by a QHM (quartz-horizontal-magnetometer) after the design of LA COUR (fig. 3). This instrument is fitted on a magnetic BAMBERG theodolite, left by VAN RIJCKEVORSEL. The QHM contains a little magnet 1.5 cm in length, which is suspended by a quartz-wire. A little mirror is attached to the magnet. The position of the magnet is read by means of a telescope, provided with a GAUSS ocular. When the magnet hangs with its axis in the direction of the axis of the telescope the image of the division scale coincides with the object in the ocular. This coincidence can be accurately adjusted whereupon the corresponding position of the theodolite is read.

Let the quartz-wire, with a torsion-coefficient T, be rotated through an angle β, and let this cause the magnet to make an angle δ with the magnetic meridian, then

$$MH \sin \delta = T\beta$$

In this equation M is the magnetic moment of the magnet, and H is the horizontal component of the earth's magnetic field.

Then the theodolite together with the telescope and the suspending-point of the quartz-wire is rotated through an angle $2\pi + \alpha_1$, till the reflection of the scale division coincides once more. In this case the little magnet, apart from a possible change of H, must have rotated over an angle of exactly 2π. The equation of equilibrium reads:

$$MH \sin (\delta + \alpha_1) = T(\beta + 2\pi)$$

The same process can be carried out by rotating the theodolite in the opposite sense. If this time a rotation of $2\pi + \alpha_2$ appears to be necessary for the coincidence of the reflected image and the scale division itself, it follows that:

$$MH \sin (\delta - \alpha_2) = T(\beta - 2\pi)$$

From this we get:

$$MH \cos \frac{2\delta + \alpha_1 - \alpha_2}{2} \sin \frac{\alpha_1 + \alpha_2}{2} = 2\pi T$$

The instrument is constructed in such a way that in the initial position the angle δ is very small. This angle can be derived from the first three equations.

One finds:

$$\operatorname{tg} \delta = \frac{\sin \alpha_1 - \sin \alpha_2}{2 - (\cos \alpha_1 + \cos \alpha_2)}$$

If δ is indeed small, the angles α_1 and α_2 are almost equal, and one can write:

$$H = \frac{2\pi T}{M \sin \varphi}, \text{ where } \varphi = \frac{\alpha_1 + \alpha_2}{2}$$

φ is the mean deviation of the magnet, caused by a torsion over an angle 2π.

The magnetic moment M and the torsion-coefficient T depend on the temperature t. Besides, the value of M depends on the induction of the magnet caused by the geomagnetic field. Consequently M and T must be written as:

$$T = T_0(1 - c_1 t)$$
$$M = M_0(1 - c_2 t)(1 + \mu H \cos \varphi)$$

where T_0 = the torsion coefficient of the quartz-wire at a temperature of 0 °C, M_0 = the moment of the magnet at 0 °C in the absence of an external field, c_1 = the temperature coefficient of the quartz-wire, c_2 = the temperature coefficient of the magnet, and μ = the induction coefficient of the magnet.

c_1, c_2 and μ are small constants. Therefore one can write approximately:

$$\log H = \log \frac{2\pi T_0}{M_0} - \log \sin \varphi + (c_2 - c_1)\, t \log e - \mu H \cos \varphi \,.\, \log e$$

The last term is practically constant over the whole region of the Netherlands. The equation can be simplified to:

$$\log H = c + \alpha t - \log \sin \varphi$$

The constant c depends almost entirely on the torsion coefficient of the quartz-wire and on the magnetic moment of the magnet. This constant, together with the temperature coefficient α, is determined in the Danish Meteorological Institute at Copenhagen, which furnished the instruments QHM 13 and QHM 14. During the measurements the constant c was regularly checked in the magnetic observatory at Witteveen; α was supposed to remain constant, this was not checked by us.

An example of a complete determination is shown on page 14. The reduction of the measurements and the outcome of the calibrations will be described in chapter II.

Measuring the vertical component.

This was done with a BMZ (magnometric zero balance), after the design of LA COUR (fig. 4). In principle the BMZ is a magnetic balance, constructed in such a way, that the centre of gravity is exactly under the centre of rotation when the magnetic axis of the balance-magnet is

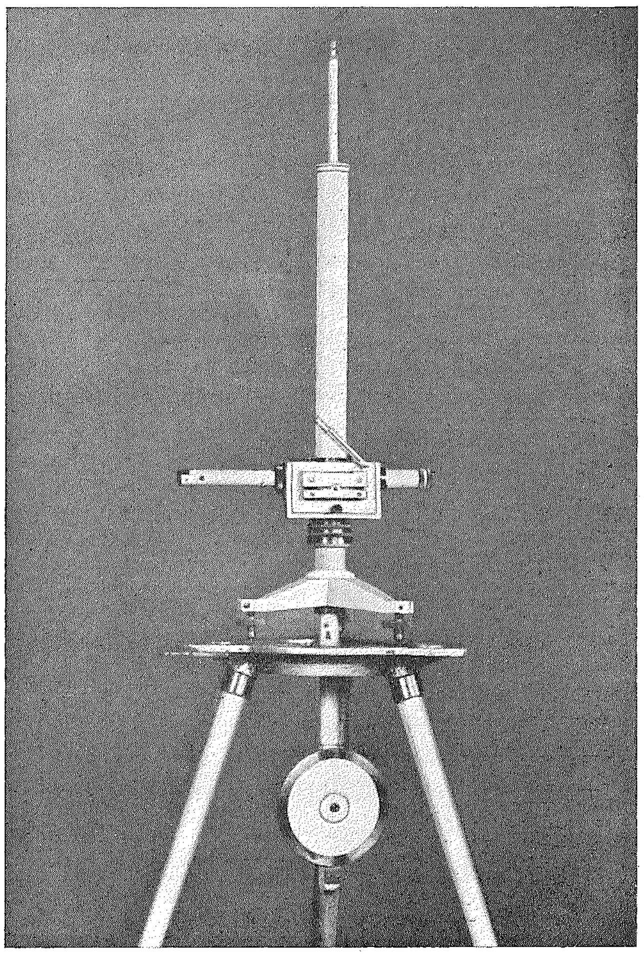


Fig. 4. BMZ (magnetometric zero balance).

horizontal. Over the balance a magnet is fitted, with a magnetic moment neutralizing the vertical component of the geomagnetic field at the place of the balance-magnet. At a distance of 30 cm below the balance a revolving auxiliary magnet is fixed for compensating completely the earth's magnetism. This once being the case, the balance-magnet will have a horizontal position, and this position will be independent of the azimuth of the balance. Whereas the position of the balance generally differs in various azimuths, the neutral position of the balance-magnet will be the same in any direction if the compensation of the vertical component is complete. This neutral position must be determined first of all.

Let the mass of the balance-magnet be P, the magnetic moment M, the distance between the centre of gravity and the rotation-axis a, the azimuth of the magnetic axis δ, the angle between the magnetic axis and the horizontal plane η, and the acceleration of gravity g, then the equation of equilibrium of the balance-magnet will be

$$ZM = (Pga + HM \cos \delta) \operatorname{tg} \eta.$$

The sensitivity of the balance measured in oersted per radian is

$$\frac{dZ}{d\eta} = \frac{Pga + HM \cos \delta}{M \cos^2 \eta}$$

Now P is about 2.5 gram, a is about 10^{-2} cm, M is about 100 c.g.s. units and in this country H is about 0.18 oersted.

Near the neutral position ($\eta = 0$) the sensitivity of the balance in the northern direction ($\delta = 0$) is

$$\frac{dZ}{d\eta} = 0.43 \text{ or } 12\gamma \text{ per minute}$$

and the sensitivity in the southern direction ($\delta = 180°$) is

$$\frac{dZ}{d\eta} = 0.07 \text{ or } 2\gamma \text{ per minute}$$

In the south-position the sensitivity is a maximum, and in this country it is 6 times greater than in the north-position. If the reading of the balance in the south-position is x_2, and in the north-position x_3, the unknown neutral position being x_1, it follows that

$$x_2 - x_1 = 6\,(x_3 - x_1)$$

from which

$$x_1 = x_3 + {}^1/_5\,(x_3 - x_2)$$

The neutral position is thus found by taking a fifth part of the difference between the readings in the north- and in the south-position, and by adding this to the reading in the north-position, in a direction opposite to the south-reading.

The neutral position being determined in this way, the vertical component Z can be derived directly from the field strenghts Z_1 and Z_2 due to the main magnet and the auxiliary magnet.

$$Z = Z_1 + Z_2$$

Let the magnetic moment of the main magnet be M' at a temperature of 0 °C, its temperature coefficient α_1, the distance between the centres of the main magnet and the balance magnet a, and the coefficient of expansion of the BMZ α_2, then at a temperature of t °C

$$Z_1 = \frac{2\,M'\,(1 - \alpha_1 t)}{a^3(1 + \alpha_2 t)^3}$$

Approximately Z_1 can be written as:

$$Z_1 = \frac{2M'}{a^3}\left\{1 - (\alpha_1 + 3\alpha_2)t\right\} = Z\,(1 - \beta t)$$

The field strength Z_2 depends on the angle between the magnetic axis of the auxiliary magnet and the horizontal plane in the first place, and moreover on the temperature. As the two magnets are made of the same magnetic steel

$$Z_2 = Z_p(1 - \beta t)$$

where Z_p can be derived from the dimensions of the auxiliary magnet, the magnetic moment of this magnet at a temperature of 0 °C, the distance to the balance magnet, and the angle between the auxiliary magnet and the horizontal plane, after the formulas of AD. SCHMIDT. We obtain then:

$$Z = Z_c + Z_p - (Z_c + Z_p)\beta t$$

which can be simplified to

$$Z = Z_c + Z_p - \alpha t$$

where α is a temperature coefficient, proportional to $Z_c + Z_p$. In this country the variations of the vertical component are small, and therefore α has practically the same value everywhere.

Finally the difference between the temperature of the thermometer and the main magnet must be taken into account, in case the temperature is rising or falling. Suppose that the temperature of the thermometer in the main magnet varies by an amount Δt per minute, a stream of heat will flow from the air via the main magnet to the thermometer or in the opposite sense, so that the temperature of the main magnet will be $t + \varepsilon\Delta t$, ε is a constant depending on the heat insulation of the main magnet. The vertical component is ultimately determined from

$$Z = Z_c + Z_p - \alpha t - \varepsilon\alpha\Delta t$$

We used the BMZ 26. The values of Z_c and a table of Z_p at different angles were determined in the Danish Meteorological Institute. The coefficients α and ε have also been determined there. At fixed times the BMZ was compared with the values of the vertical component in the magnetic observatory, which were derived from the absolute measurements of the horizontal component and the inclination. The coefficients α and ε were supposed to be invariable, and they were not checked. It will appear from the calibrations — see chapter II — that no large variations of Z_c or Z_p were observed.

In the northernmost part of the country, on the Wadden islands, the moment of the revolving auxiliary magnet was too small to compensate the field completely. In this region a fixed auxiliary magnet was used, fitted below the rotating-disc. The field strength was determined by means of the rotating-disc — see next chapter.

CHAPTER II

THE REDUCTION OF THE MEASUREMENTS

The reduction of a declination measurement depends entirely on whether the direction of the astronomical north was determined by observation of the sun or by means of triangulated points. An example of a sun's observation is printed on page 12. At the top to the right the astronomical longitude and latitude of the station are filled in, read from an accurate map. For this purpose we used the topographical map of the Netherlands, scale 1 : 50 000, issued by the Topographical Service. Moreover, the equation of time, valid during the sun's observation, is indicated and the longitude converted into time. The correction for the chronometer is given as well.

The first column of the astronomical part of the measurement contains 20 readings of the moment the sun touches the reticle-wire, with the right limb and with the left one alternately. After every four readings either the mirror or the whole theodolite has been turned. The read times and angles are checked graphically for possible errors. The average of each group of observation times is converted into mean local time (column 2), taking into account the correction to the chronometer and the geographical longitude of the station. The average of the circle readings is corrected in column 4 for errors in the division of the circle. In column 5 the true hour-angle of the sun is computed, belonging to the average of each group of observations. The right-hand part of the example contains the computation of the sun's azimuth α. Subtracting this from the circle reading when the measurement was carried out after true noon, and adding it to the circle reading for an observation before noon, the direction of the instrumental north is obtained. In this way we obtain six numbers, which are combined two by two to give A_1, B and A_2, being the values of the instrumental north with the sun in front of the observer, behind him and in front of him again. If the measurement has been carried out well A_1 and A_2 must be equal. By comparing them it can be seen immediately whether a large error has slipped into the data used for the computation. The average of A_1 and A_2 is now combined with B to obtain the value of the astronomical north, at the foot of the form to the right.

Below, the magnetical part of the measurement is shown. The columns 2 and 3 contain the times of observation with the corresponding circle readings. Column 4 contains the readings of the declination from the magnetogram in the magnetic observatory at Witteveen. It is supposed now, that the geomagnetic variations are synchronous and have the same amplitude at Witteveen as at any other place in the Netherlands. This hypothesis, a priori plausible on account of the small distances in our country compared with the distances at which the currents responsible for these variations, flow in general, has been tested by a comparison between the magnetograms of Witteveen and De Bilt. It appeared that the magnetograms are indeed identical for small variations, and that only in case of strong disturbances small differences occur.

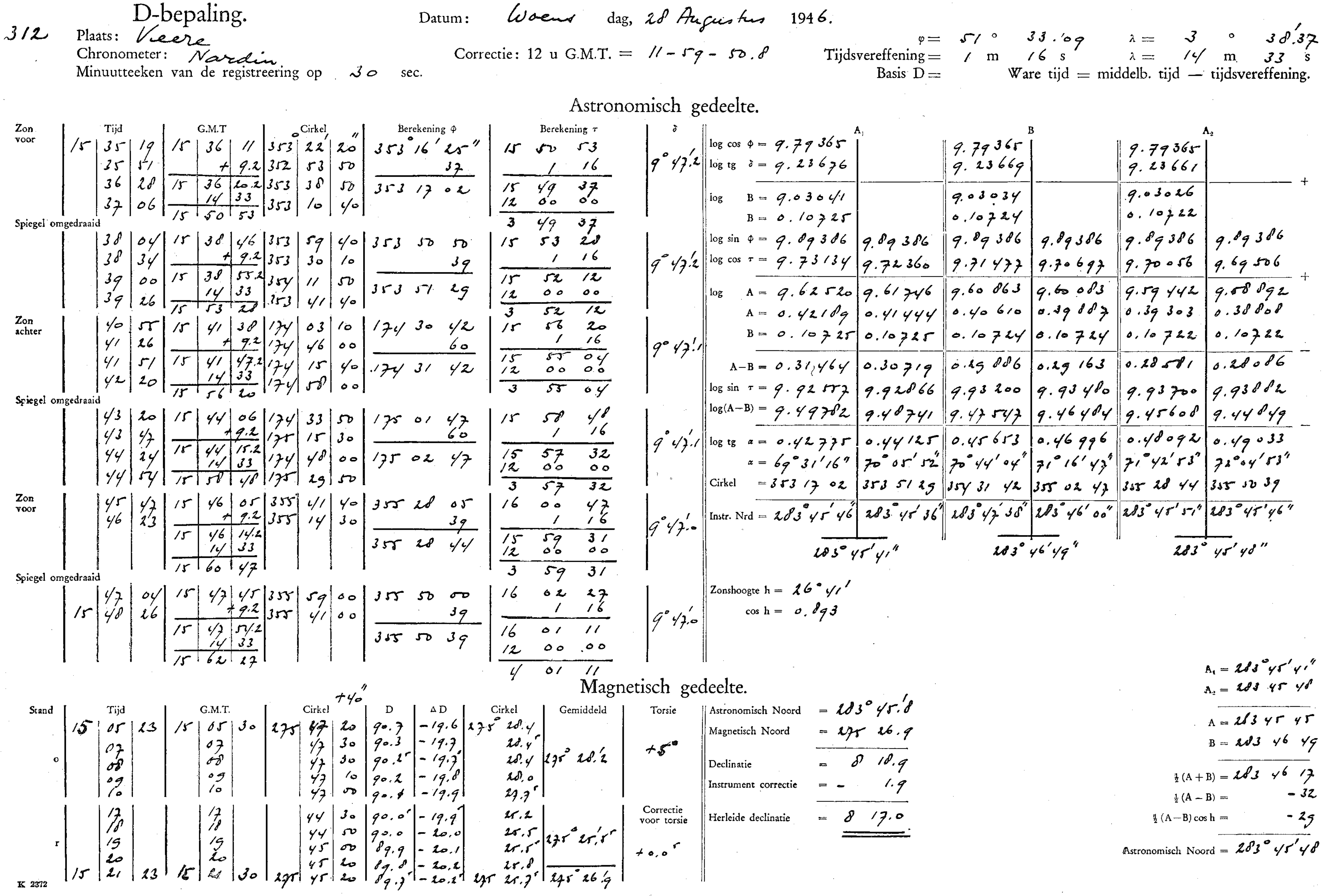
The read positions of the theodolite are now reduced to one definite value of the declination at Witteveen, indicated as base D. The corrections, that means the differences between the declination at the moment of the measurement and this basic value, are indicated in column 5 converted into minutes of arc. Column 6 contains the reduced circle readings. The scattering of the values gives an idea of the accuracy of each individual reading. Abnormal values can then be easily rejected. Column 7 gives the mean of the readings with the magnet upright and in the opposite position. Column 8 contains the value of the torsion of the thread, read after the observation was carried out. As the torsion amounted to 0° at the beginning of the observation, half of the torsion angle is applied as a correction to the obtained values of the magnetical meridian. This is done in the lower part of column 8. Finally, column 9 contains the computation of the declination, the instrumental correction determined by calibrations in the magnetic observatory, and the definite reduced declination.

In the second place fig. 6 shows an example of a declination measurement, the direction of the astronomical north being fixed with the help of triangulated points. In column 1 the six church-steeples are mentioned, visible at the station Wognum. Column 2 contains the corresponding readings of the theodolite, column 3 the corrected readings, column 4 and 5 the coordinates of the spires. The identification of the church-steeples often gave some trouble and could not always be carried out during the measurement. The coordinates of the station can be read approximately from a topographical map, so that the church-steeples can be identified afterwards by the read direction. From a number of six church-steeples three combinations of three steeples are given, which are favourable for the determination of the coordinates of the station. Applying the formulas derived in the last chapter, three values are obtained for these coordinates, which mostly differ a few dm. The average of them is used for the computation of the azimuth of the spires, seen from the station. By adding the value of the azimuth to the circle reading the direction of the y-axis of the coordinates used is obtained. This direction is shown in the last column. Each steeple used gives a value for it. The values for the direction of the y-axis may not differ too much, provided no errors in the coordinates or in the computations have slipped in. The mean value obtained on giving different weights to the azimuth of the various spires, is used for the computation of the astronomical north. For this purpose the correction-angle p is derived (see chapter I) and is added to the direction of the y-axis, giving the value of the astronomical north. The procedure for the magnetical part of the example is the same as in the case of the measurement by observation of the sun.

The reduction of the H-measurement.

In the example of a H-measurement (fig. 7) the instrument used is mentioned in the first column. The third column contains the readings of the theodolite, the fourth column the times read from the chronometer, the fifth column the times reduced to Greenwich-time. Column 6 contains the temperatures, column 7 and 8 the readings of the declination and the horizontal component from the magnetogram of the magnetic observatory at Witteveen. Heading these columns the basic values are given, to which the individual readings are reduced. Column 9 contains the deviations of H from the basic value, column 10 the correction which must be applied to the read position of the circle in order to reduce H to the basic value. It follows namely from the equation for the QHM

$$\log H = c + \alpha t - \log \sin \varphi$$



312 **D-bepaling.**

Datum: Woens dag, 28 Augustus 1946.

Plaats: Veere
Chronometer: Nardin
Minuutteeken van de registreering op 30 sec.

Correctie: 12 u G.M.T. = 11-59-50.8

φ = 51° 33.′09 λ = 3° 38.′37
Tijdsvereffening = 1 m 16 s λ = 14 m 33 s
Basis D = Ware tijd = middelb. tijd — tijdsvereffening.

Astronomisch gedeelte.

	Tijd			G.M.T			Cirkel °	′	″	Berekening φ	Berekening τ	δ
Zon voor	15	35	19	15	36	11	353	22	20	353°16′25″	15 50 53	
		35	51			+ 9.2	352	53	50	37	1 16	9°47′.2
		36	28	15	36	20.2	353	38	50	353 17 02	15 49 37	
		37	06		14	33	353	10	40		12 00 00	
				15	50	53					3 49 37	
Spiegel omgedraaid		38	04	15	38	46	353	59	40	353 50 50	15 53 28	
		38	34			+ 9.2	353	30	10	39	1 16	9°47′.2
		39	00	15	38	55.2	354	11	50	353 51 29	15 52 12	
		39	26		14	33	353	41	40		12 00 00	
				15	53	28					3 52 12	
Zon achter		40	55	15	41	38	174	03	10	174 30 42	15 56 20	
		41	26			+ 9.2	174	46	00	60	1 16	9°47′.1
		41	51	15	41	47.2	174	15	40	174 31 42	15 55 04	
		42	20		14	33	174	58	00		12 00 00	
				15	56	20					3 55 04	
Spiegel omgedraaid		43	20	15	44	06	174	33	50	175 01 47	15 58 48	
		43	47			+ 9.2	175	15	30	60	1 16	9°47′.1
		44	24	15	44	15.2	174	48	00	175 02 47	15 57 32	
		44	54		14	33	175	29	50		12 00 00	
				15	58	48					3 57 32	
Zon voor		45	47	15	46	05	355	41	40	355 28 05	16 00 47	
		46	23			+ 9.2	355	14	30	39	1 16	9°47′.0
				15	46	14.2				355 28 44	15 59 31	
					14	33					12 00 00	
				15	60	47					3 59 31	
Spiegel omgedraaid		47	04	15	47	45	355	59	00	355 50 00	16 02 27	
	15	48	26			+ 9.2	355	41	00	39	1 16	9°47′.0
				15	47	54.2				355 50 39	16 01 11	
					14	33					12 00 .00	
				15	62	27					4 01 11	

	A₁		B		A₂		
log cos φ =	9.79365		9.79365		9.79365		
log tg δ =	9.23676		9.23669		9.23661		+
log B =	9.03041		9.03034		9.03026		
B =	0.10725		0.10724		0.10722		
log sin φ =	9.89386	9.89386	9.89386	9.89386	9.89386	9.89386	
log cos τ =	9.73134	9.72360	9.71477	9.70697	9.70056	9.69506	+
log A =	9.62520	9.61746	9.60863	9.60083	9.59442	9.58892	
A =	0.42189	0.41444	0.40610	0.39887	0.39303	0.38808	
B =	0.10725	0.10725	0.10724	0.10724	0.10722	0.10722	−
A−B =	0.31464	0.30719	0.29886	0.29163	0.28581	0.28086	
log sin τ =	9.92557	9.92866	9.93200	9.93480	9.93700	9.93882	
log(A−B) =	9.49782	9.48741	9.47547	9.46484	9.45608	9.44849	−
log tg α =	0.42775	0.44125	0.45653	0.46996	0.48092	0.49033	
α =	69°31′16″	70°05′52″	70°44′04″	71°16′43″	71°42′53″	72°04′53″	
Cirkel =	353 17 02	353 51 29	354 31 42	355 02 47	355 28 44	355 50 39	
Instr. Nrd =	283°45′46″	283°45′36″	283°47′38″	283°46′00″	283°45′51″	283°45′46″	
	283°45′41″		283°46′49″		283°45′48″		

Zonshoogte h = 26°41′
cos h = 0.893

A₁ = 283°45′41″
A₂ = 283 45 48
A = 283 45 45
B = 283 46 49
½ (A + B) = 283 46 17
½ (A − B) = −32
½ (A − B) cos h = −29
Astronomisch Noord = 283°45′48″

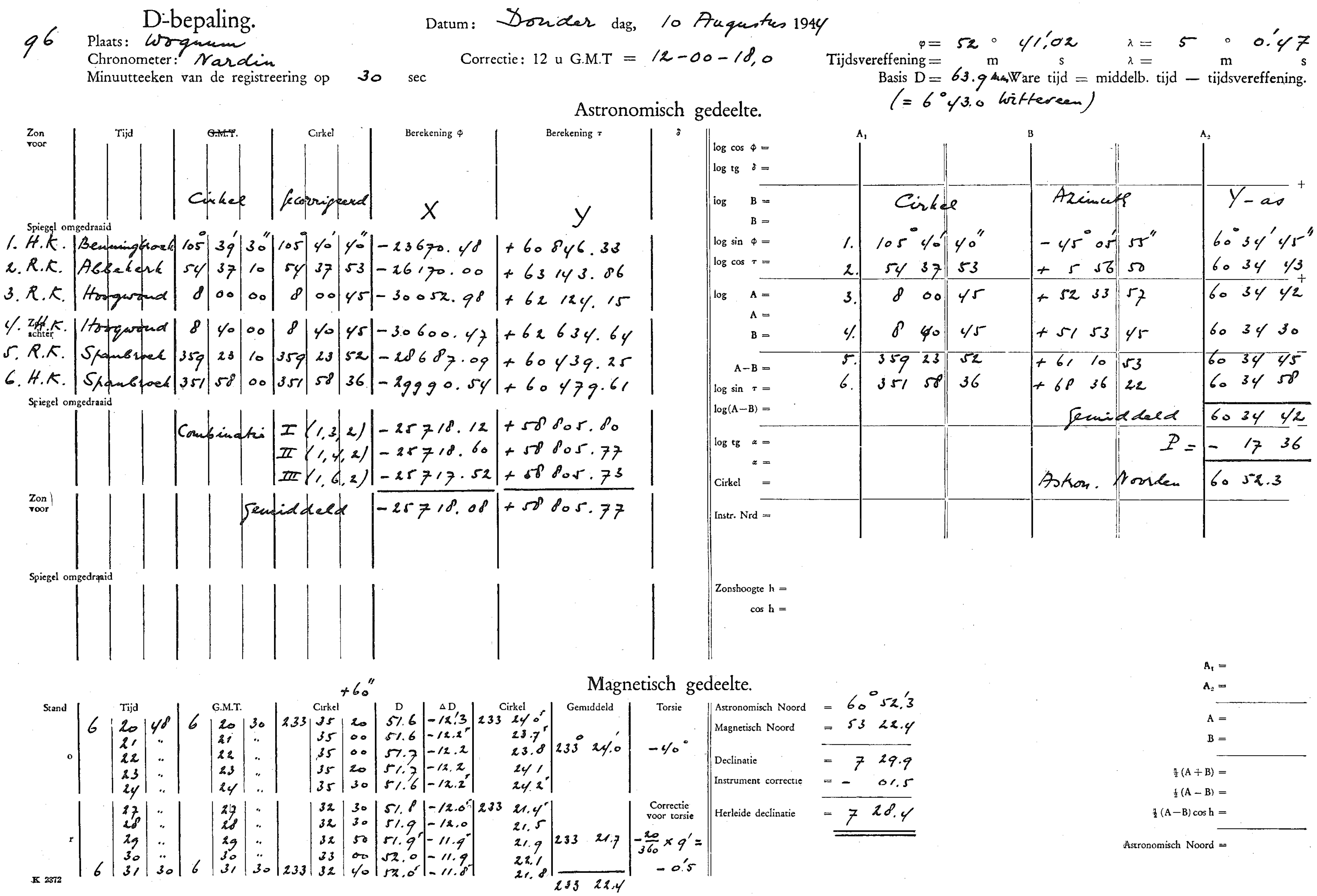
Magnetisch gedeelte.

Stand	Tijd			G.M.T.			Cirkel	+40″		D	ΔD	Cirkel	Gemiddeld	Torsie
	15	05	23	15	05	30	275	47	20	90.7	−19.6	275° 28.4		
		07			07			47	30	90.3	−19.7	28.45		
o		08			08			47	30	90.25	−19.75	28.4	275° 28′.2	+5°
		09			09			47	10	90.2	−19.8	28.0		
		10			10			47	00	90.4	−19.9	27.75		
		17			17			44	30	90.05	−19.9	25.2		Correctie voor torsie
		18			18			44	50	90.0	−20.0	25.5		
r		19			19			45	00	89.9	−20.1	25.55	275° 25′.5	+0.05
		20			20			45	20	89.8	−20.2	25.8		
	15	21	23	15	21	30	275	45	20	89.7	−20.25	275 25.75	275° 26′.9	

Astronomisch Noord = 283° 45′.8
Magnetisch Noord = 275 26.9
Declinatie = 8 18.9
Instrument correctie = − 1.9
Herleide declinatie = 8 17.0

K 2372

Fig. 5. Measurement of declination by sun's observation.



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D-bepaling.

Plaats: Wognum
Chronometer: Nardin
Minuutteeken van de registreering op 30 sec

Datum: Donder dag, 10 Augustus 1944
Correctie: 12 u G.M.T = 12-00-18,0

φ = 52 ° 41,′02 λ = 5 ° 0.′47
Tijdsvereffening = m s λ = m s
Basis D = 63.9 km. Ware tijd = middelb. tijd — tijdsvereffening.
(= 6°43.0 Witteveen)

Astronomisch gedeelte.

Zon voor	Tijd	~~G.M.T.~~	Cirkel	Berekening φ	Berekening τ	δ
		Cirkel	gecorrigeerd	X	Y	
Spiegel omgedraaid						
1. H.K.	Benningbroek	105° 39′ 30″	105° 40′ 40″	−23670.48	+60846.33	
2. R.K.	Abbekerk	54 37 10	54 37 53	−26170.00	+63143.86	
3. R.K.	Hoogwoud	8 00 00	8 00 45	−30052.98	+62124.15	
4. Z.H.K. achter	Hoogwoud	8 40 00	8 40 45	−30600.47	+62634.64	
5. R.K.	Spanbroek	359 23 10	359 23 52	−28687.09	+60439.25	
6. H.K.	Spanbroek	351 58 00	351 58 36	−29990.54	+60479.61	
Spiegel omgedraaid						
		Combinatie	I (1, 3, 2)	−25718.12	+58805.80	
			II (1, 4, 2)	−25718.60	+58805.77	
			III (1, 6, 2)	−25717.52	+58805.73	
Zon voor		Gemiddeld		−25718.08	+58805.77	
Spiegel omgedraaid						

		A₁	B	A₂
log cos φ =				
log tg δ =				
log B =		Cirkel	Azimuth	Y-as
B =				
log sin φ =	1.	105° 40′ 40″	−45° 05′ 55″	60° 34′ 45″
log cos τ =	2.	54 37 53	+5 56 50	60 34 43
log A =	3.	8 00 45	+52 33 57	60 34 42
A =				
B =	4.	8 40 45	+51 53 45	60 34 30
A−B =	5.	359 23 52	+61 10 53	60 34 45
log sin τ =	6.	351 58 36	+68 36 22	60 34 58
log(A−B) =			Gemiddeld	60 34 42
log tg α =			P =	− 17 36
α =				
Cirkel =			Astron. Noorden	60 52.3
Instr. Nrd =				

Zonshoogte h =
cos h =

Magnetisch gedeelte.

+60″

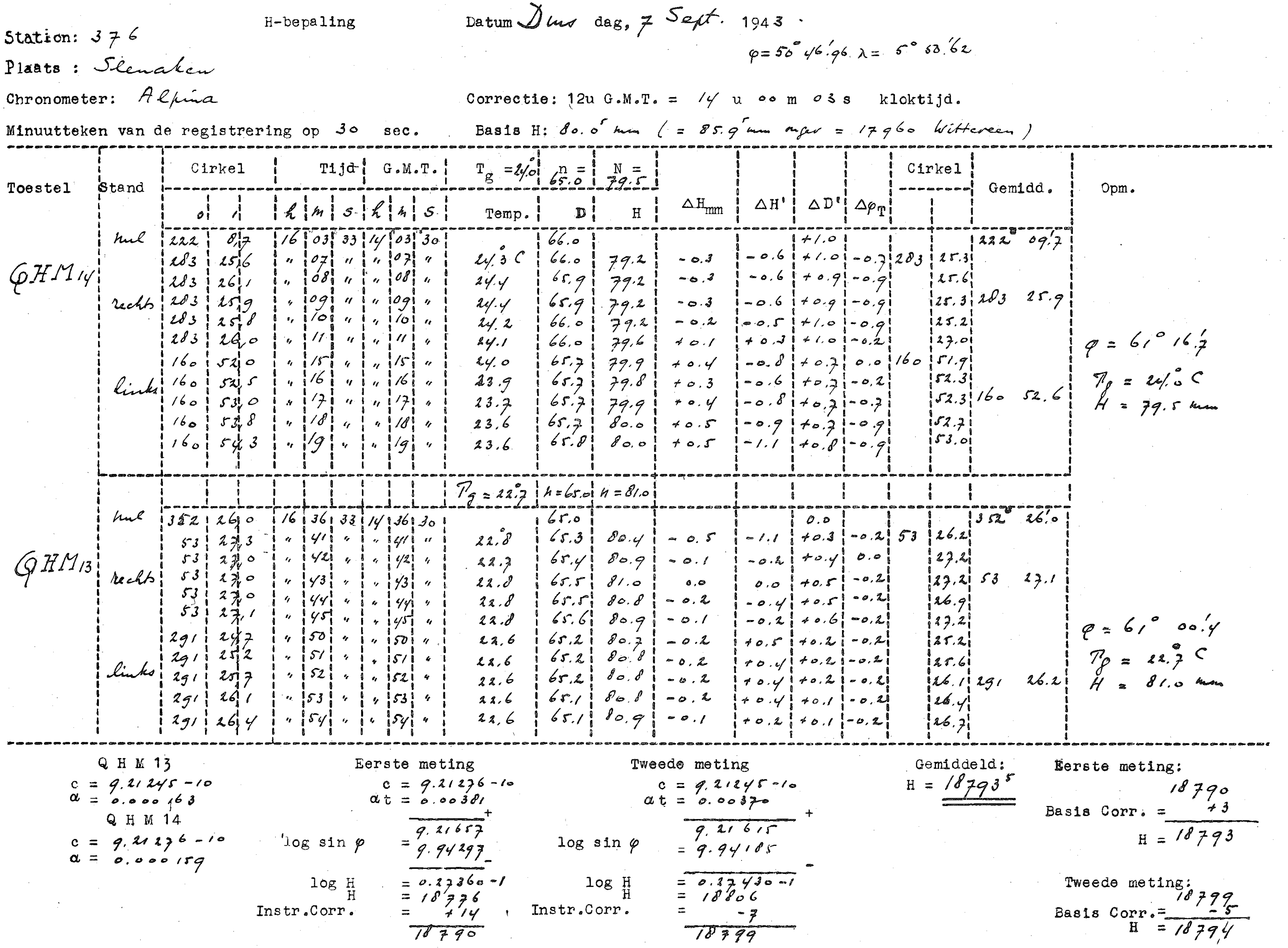
Stand	Tijd			G.M.T.			Cirkel			D	ΔD	Cirkel	Gemiddeld	Torsie
	6	20	48	6	20	30	233	35	20	51.6	−12.′3	233 24.0′		
		21	..		21	..		35	00	51.6	−12.2′	23.7′		
o		22	..		22	..		35	00	51.7	−12.2	23.8	233° 24.′0	−40°
		23	..		23	..		35	20	51.7	−12.2	24.1		
		24	..		24	..		35	30	51.6	−12.2′	24.2′		
		27	..		27	..		32	30	51.8	−12.0′	233 21.4′		Correctie voor torsie
		28	..		28	..		32	30	51.9	−12.0	21.5		
r		29	..		29	..		32	50	51.9′	−11.9′	21.9	233 21.7	$-\frac{20}{360} \times 9' =$
		30	..		30	..		33	00	52.0	−11.9	22.1		
	6	31	30	6	31	30	233	32	40	52.0′	−11.8′	21.8	233 22.4	−0.′5

Astronomisch Noord = 60° 52.′3
Magnetisch Noord = 53 22.4
Declinatie = 7 29.9
Instrument correctie = − 01.5
Herleide declinatie = 7 28.4

A₁ =
A₂ =
A =
B =
½ (A + B) =
½ (A − B) =
½ (A − B) cos h =
Astronomisch Noord =

K 2372

Fig. 6. Measurement of declination by means of triangulated points.



Station: 376　　H-bepaling　　Datum Dinsdag, 7 Sept. 1943.

$\varphi = 50° 46'.96$　$\lambda = 5° 53'.62$

Plaats : Slenaken

Chronometer: Alpina　　Correctie: 12u G.M.T. = 14 u 00 m 03 s kloktijd.

Minuutteken van de registrering op 30 sec.　　Basis H: 80.0^5 mm (= 85.9^5 mm ongev = 17960 Witteveen)

Toestel	Stand	Cirkel		Tijd			G.M.T.			$T_g = 24.0°$	n = 65.0	N = 79.5	ΔH_{mm}	$\Delta H'$	$\Delta D'$	$\Delta \varphi_T$	Cirkel		Gemidd.	Opm.
		°	'	h	m	s	h	m	s	Temp.	D	H								
QHM14	nul	222	8.7	16	03	33	14	03	30		66.0				+1.0				222° 09'.7	
	rechts	283	25.6	"	07	"	"	07	"	24.3° C	66.0	79.2	−0.3	−0.6	+1.0	−0.7	283	25.3		
		283	26.1	"	08	"	"	08	"	24.4	65.9	79.2	−0.3	−0.6	+0.9	−0.9		25.6		
		283	25.9	"	09	"	"	09	"	24.4	65.9	79.2	−0.3	−0.6	+0.9	−0.9		25.3	283 25.9	
		283	25.8	"	10	"	"	10	"	24.2	66.0	79.2	−0.2	−0.5	+1.0	−0.9		25.2		
		283	26.0	"	11	"	"	11	"	24.1	66.0	79.6	+0.1	+0.3	+1.0	−0.2		27.0		$\varphi = 61° 16'.7$
	links	160	52.0	"	15	"	"	15	"	24.0	65.7	79.9	+0.4	−0.8	+0.7	0.0	160	51.9		
		160	52.5	"	16	"	"	16	"	23.9	65.7	79.8	+0.3	−0.6	+0.7	−0.2		52.3		$T_g = 24.0°$ C
		160	53.0	"	17	"	"	17	"	23.7	65.7	79.9	+0.4	−0.8	+0.7	−0.7		52.3	160 52.6	H = 79.5 mm
		160	53.8	"	18	"	"	18	"	23.6	65.7	80.0	+0.5	−0.9	+0.7	−0.9		52.7		
		160	54.3	"	19	"	"	19	"	23.6	65.8	80.0	+0.5	−1.1	+0.8	−0.9		53.0		
										$T_g = 22.7°$	n = 65.0	N = 81.0								
QHM13	nul	352	26.0	16	36	33	14	36	30		65.0				0.0				352° 26'.0	
	rechts	53	27.3	"	41	"	"	41	"	22.8°	65.3	80.4	−0.5	−1.1	+0.3	−0.2	53	26.2		
		53	27.0	"	42	"	"	42	"	22.7	65.4	80.9	−0.1	−0.2	+0.4	0.0		27.2		
		53	27.0	"	43	"	"	43	"	22.8	65.5	81.0	0.0	0.0	+0.5	−0.2		27.2	53 27.1	
		53	27.0	"	44	"	"	44	"	22.8	65.5	80.8	−0.2	−0.4	+0.5	−0.2		26.9		
		53	27.1	"	45	"	"	45	"	22.8	65.6	80.9	−0.1	−0.2	+0.6	−0.2		27.2		
	links	291	24.7	"	50	"	"	50	"	22.6	65.2	80.7	−0.2	+0.5	+0.2	−0.2		25.2		$\varphi = 61° 00'.4$
		291	25.2	"	51	"	"	51	"	22.6	65.2	80.8	−0.2	+0.4	+0.2	−0.2		25.6		$T_g = 22.7°$ C
		291	25.7	"	52	"	"	52	"	22.6	65.2	80.8	−0.2	+0.4	+0.2	−0.2		26.1	291 26.2	H = 81.0 mm
		291	26.1	"	53	"	"	53	"	22.6	65.1	80.8	−0.2	+0.4	+0.1	−0.2		26.4		
		291	26.4	"	54	"	"	54	"	22.6	65.1	80.9	−0.1	+0.2	+0.1	−0.2		26.7		

Q H M 13
c = 9.21245 −10
α = 0.000163
Q H M 14
c = 9.21276 −10
α = 0.000159

Eerste meting
c = 9.21276 −10
αt = 0.00381 +
9.21657
log sin φ = 9.94297 −
log H = 0.27360 −1
H = 18776
Instr.Corr. = +14
18790

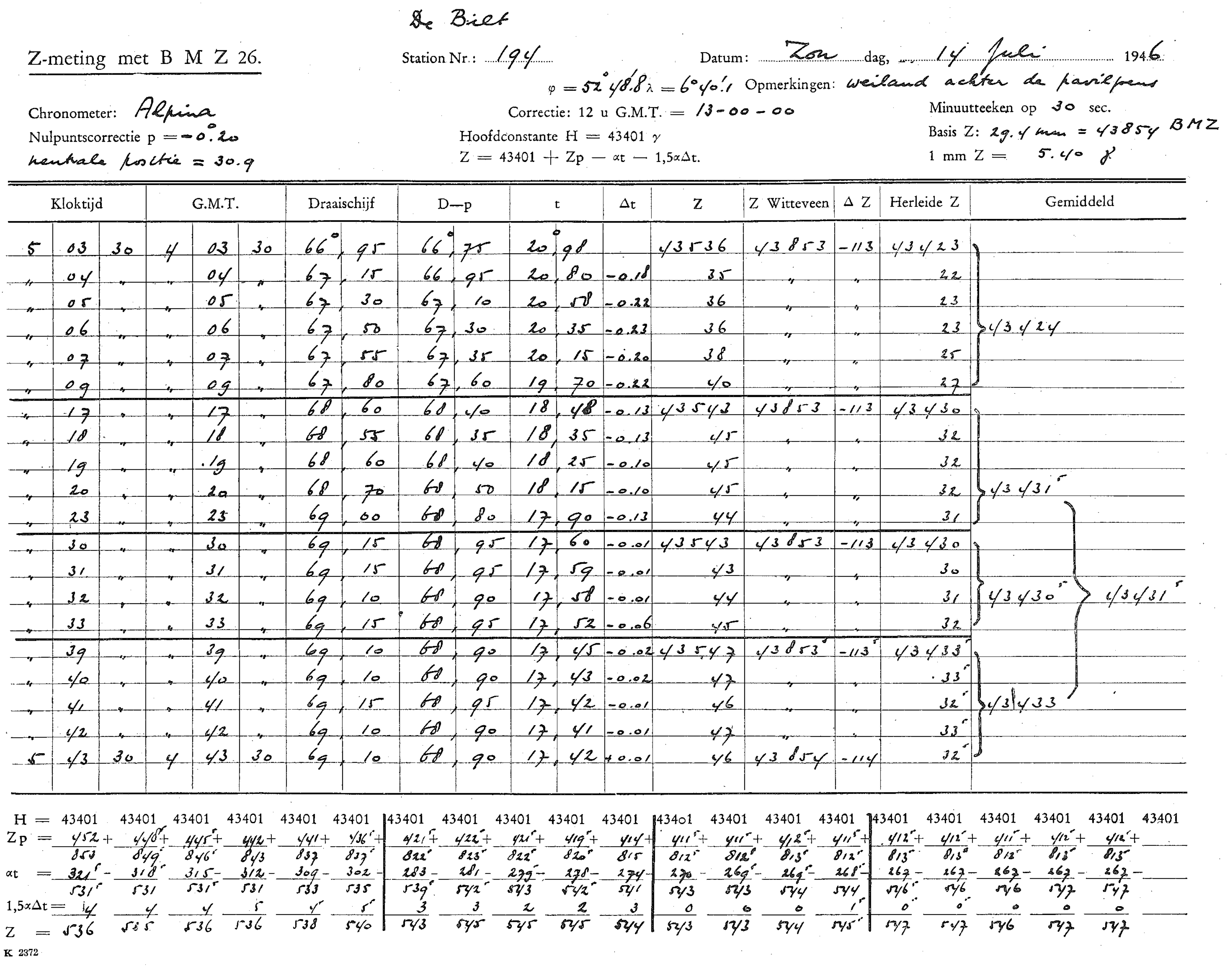
Tweede meting
c = 9.21245 −10
αt = 0.00370 +
9.21615
log sin φ = 9.94185 −
log H = 0.27430 −1
H = 18806
Instr.Corr. = −7
18799

Gemiddeld:
H = 18793^5

Eerste meting:
18790
Basis Corr. = +3
H = 18793

Tweede meting:
18799
Basis Corr. = −5
H = 18794

Fig. 7. Measurement of the horizontal component by means of QHM 13 and 14.



De Bilt

Z-meting met B M Z 26.

Station Nr.: 194

Datum: Zon dag, 14 Juli 1946

φ = 52°48.8 λ = 6°40.1 Opmerkingen: weiland achter de paviljoens

Chronometer: Alpina

Nulpuntscorrectie p = -0°.20

kentrale positie = 30.9

Correctie: 12 u G.M.T. = 13-00-00

Hoofdconstante H = 43401 γ

Z = 43401 + Zp — αt — 1,5αΔt.

Minuutteeken op 30 sec.

Basis Z: 29.4 mm = 43854 BMZ

1 mm Z = 5.40 γ

Kloktijd			G.M.T.			Draaischijf		D—p		t		Δt	Z	Z Witteveen	Δ Z	Herleide Z	Gemiddeld
5	03	30	4	03	30	66°	95	66°	75	20°	98		43536	43853	-113	43423	43424
„	04	„	„	04	„	67	15	66	95	20	80	-0.18	35	„	„	22	
„	05	„	„	05	„	67	30	67	10	20	58	-0.22	36	„	„	23	
„	06	„	„	06	„	67	50	67	30	20	35	-0.23	36	„	„	23	
„	07	„	„	07	„	67	55	67	35	20	15	-0.20	38	„	„	25	
„	09	„	„	09	„	67	80	67	60	19	70	-0.22	40	„	„	27	
„	17	„	„	17	„	68	60	68	40	18	48	-0.13	43543	43853	-113	43430	43431^5
„	18	„	„	18	„	68	55	68	35	18	35	-0.13	45	„	„	32	
„	19	„	„	19	„	68	60	68	40	18	25	-0.10	45	„	„	32	
„	20	„	„	20	„	68	70	68	50	18	15	-0.10	45	„	„	32	
„	23	„	„	23	„	69	00	68	80	17	90	-0.13	44	„	„	31	
„	30	„	„	30	„	69	15	68	95	17	60	-0.01	43543	43853	-113	43430	43430^5 43431^5
„	31	„	„	31	„	69	15	68	95	17	59	-0.01	43	„	„	30	
„	32	„	„	32	„	69	10	68	90	17	58	-0.01	44	„	„	31	
„	33	„	„	33	„	69	15	68	95	17	52	-0.06	45	„	„	32	
„	39	„	„	39	„	69	10	68	90	17	45	-0.02	43547	43853^5	-113^5	43433^5	43433
„	40	„	„	40	„	69	10	68	90	17	43	-0.02	47	„	„	33^5	
„	41	„	„	41	„	69	15	68	95	17	42	-0.01	46	„	„	32^5	
„	42	„	„	42	„	69	10	68	90	17	41	-0.01	47	„	„	33^5	
5	43	30	4	43	30	69	10	68	90	17	42	+0.01	46	43854	-114	32^5	

H =	43401	43401	43401	43401	43401	43401	43401	43401	43401	43401	43401
Zp =	452 +	448^5 +	445^5 +	442 +	441 +	436^5 +	421^5 +	422^5 +	421^5 +	419^5 +	414 +
	853	849^5	846^5	843	837	837^5	822^5	823^5	822^5	820^5	815
αt =	321^5 -	318^5 -	315 -	312 -	309 -	302 -	283 -	281 -	279^5 -	278 -	274 -
	531^5	531	531^5	531	533	535	539^5	542^5	543	542^5	541
1,5αΔt =	4	4	4	5	4^5	5^5	3	3	2	2	3
Z =	536	535	536	536	538	540	543	545	545	545	544

H =	43401	43401	43401	43401	43401	43401	43401	43401	43401	43401
Zp =	411^5 +	411^5 +	412^5 +	411^5 +	412^5 +	412^5 +	411^5 +	412^5 +	412^5 +	
	812^5	812^5	813^5	812^5	813^5	813^5	812^5	813^5	813^5	
αt =	270 -	269^5 -	269^5 -	268^5 -	267 -	267 -	267 -	267 -	267 -	
	543	543	544	544	546^5	546	546	547	547	
1,5αΔt =	0	0	0	1^5	0	0	0	0	0	
Z =	543	543	544	545^5	547	547	546	547	547	

K 2372

Fig. 8. Measurement of the vertical component by means of BMZ 26.

that with a variation of H a variation of φ is related according to

$$dH = -H \cot \varphi \, d\varphi$$

Column 11 contains the deviations of D from the basic value. The amounts of these deviations are applied as corrections to the readings, since the magnet, even in its deflected position, will follow the slight rotations of the geomagnetic field during the measurement. Column 12 contains corrections for the reduction of the temperatures to a basic temperature, by means of the relation

$$dH = H\alpha dt$$

Column 13 contains the circle readings reduced to definite values of t, D and H. The mean values of each group of readings are given in column 14. The mean angle of deflection caused by a torsion over an angle 2π is shown in column 15. At the bottom of the example the values of H have been computed. An instrumental correction is added to them, which is determined by calibrating the instrument in the magnetic observatory viz. — 7γ for QHM 13 and + 14γ for QHM 14. Finally a basic correction is given, obtained by reducing a provisional basic correction H in column 8 to the definitive basic value, written at the head of the example. The final results of the two measurements, which were carried out at a distance of 50 m, lead to figures differing only by 1γ.

The reduction of the Z-measurement.

Fig. 8 shows a complete Z-measurement. In the first place a few constants are given viz. the zero point correction of the rotating-disc, determined by calibration in the magnetic observatory, the neutral position determined during the measurement, the temperature coefficient α given by the Danish Meteorological Institute, and the basic value to which all readings are reduced. Column 1 contains the time of each reading, column 2 the Greenwich time, column 3 the reading of the rotating-disc with the auxiliary magnet, column 4 the corrected reading of this disc, column 5 the temperature of the main magnet, column 6 the temperature gradient per minute, column 7 the value of the vertical component derived from the preceding data, column 8 the value of Z at Witteveen, column 9 the difference between this value and the basic value to which all measurements were reduced, column 10 the reduced Z-values, column 11 the average of the series of Z-values. The BMZ was used at four different places some tens of meters apart, so that four different values of Z are obtained. The last three of them are in good agreement with each other, whereas the first one is different. For that reason only the last three values have been used for the determination of the definitive mean value, the first one being rejected.

The determination of the time.

For reading the time during the astronomical measurements the chronometer Nardin No. 10658 was mostly used. This chronometer was compared with a radio time signal once a day at least. In the years 1942 and 1943 we used the time signals of the Deutsche Seewarte, later on mostly the six pips of the BBC.

Fig. 9 shows the rate of the Nardin No. 10658 during five successive days. It turns out that the rate is constant or nearly constant for a rather long period, so that the time correction between the time signals could be determined by interpolation, with an accuracy of 0.1 sec.

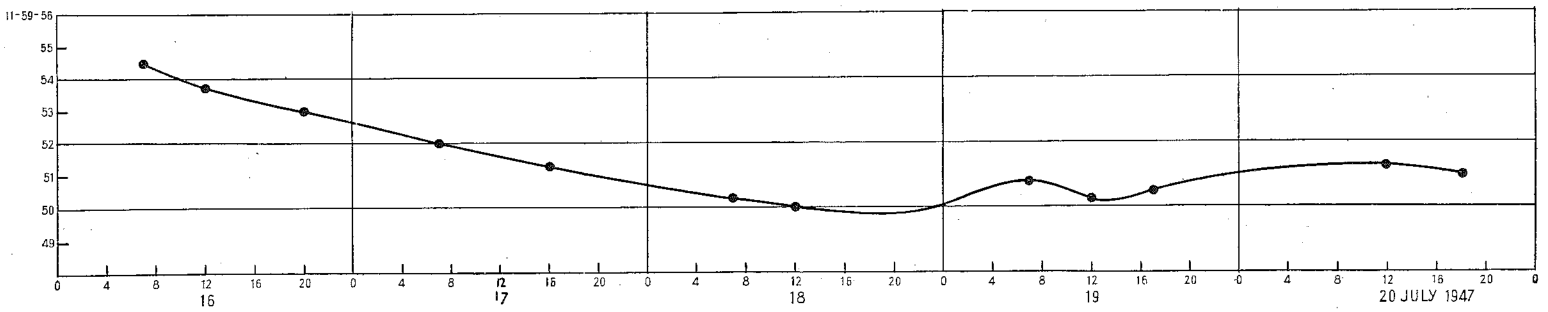


Fig. 9. Rate of the chronometer Nardin 10658 during five successive days.

The calibration of the instruments.

All measurements were reduced to the annual means for the epoch 1945.0, as determined with the absolute instruments in the magnetic observatory at Witteveen. Consequently the instruments for the field work were compared from time to time with these instruments and with the outcome of the absolute measurements performed by the officer-in-charge, who is responsible for the magnetic observatory.

In the years before 1945 the absolute measurements have been performed regularly, and therefore the calibration of the instruments, used for the magnetic survey, is known quite accurately.

The same does not hold however for the years 1945—1948. After the completion of the present publication it has become evident that the absolute measurements made by the former officer-in-charge of the Witteveen magnetic observatory cannot be considered as trustworthy during these years [1]. Without going into details of this regrettable matter it can be said that the reduction of the measurements was based upon a more or less fictitious value, which was chosen in such a manner that the outcome of the measurements fitted the results of the years 1942—1945.

Whereas it is a matter for regret that accurate calibrations are lacking for the years 1945—1948, the method followed by the former officer-in-charge implies that the field measurements of these years are reasonably trustworthy, as part of them overlapped the measurements of former years. Moreover the greater part of the country was surveyed during the first three years, so that only the measure-

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[1] See Preface of Yearbook B, Geomagnetism, 1947, Royal Netherlands Meteorological Institute, De Bilt.

ments of Zeeland, Zeeuws-Vlaanderen, the Zuid-Hollandse islands and the Wadden Sea, fall into the less accurate period.

In order to clear up the uncertainty a couple of measurements was repeated in the above mentioned regions during the fall of 1949 and the spring of 1950, with the result that in the writer's opinion all values in these regions have an accuracy better than 1′ and 10 γ for D, H and Z resp.

The D-instrument was compared with the DOVER instrument of the Witteveen observatory. The difference between both instruments was fairly constant. Corrections ranging from — 1′.3 to — 1′.7 were applied to all declination values found by means of the field instruments.

For the instruments QHM 13 and QHM 14 the following formulas were used:

QHM 13 : $\log H = 9.21245 - 10 + 0.000163\, t - \log \sin \varphi$
QHM 14 : $\log H = 9.21276 - 10 + 0.000159\, t - \log \sin \varphi$

By comparing the QHM's with the H-instrument DOVER in the magnetic observatory Witteveen corrections of $+3\ \gamma$ and $+2\ \gamma$ were found for QHM 13 and QHM 14 respectively in the year 1942. In the beginning of 1943 the quartz-wire of QHM 14 broke during transport. After that the correction was $+14\ \gamma$, whereas QHM 13 remained practically constant. In the year 1944 the quartz-wire of QHM 13 broke, and after the repair the correction was $-1\ \gamma$. After the end of 1944 QHM 13 was no longer used for field work but was kept as a reserve instrument in the magnetic observatory at Witteveen. Calibrations during the summer of 1949 led to a correction of $-12\ \gamma$ for QHM 14.

The formula used for BMZ 26 was

$$Z = 43401 + Z_p - \alpha\, t - 1.5\, \alpha \Delta t$$

Z_p is the field-strength of the turning magnet, varying between 0 and 1160 γ.

The values of Z_p depend on the position of the turning magnet, and had been calibrated at the Meteorological Institute, Charlottenlund, Denmark. The calibration of BMZ 26 consisted of comparing the instrument with the basic values, which were derived for the vertical component of the geomagnetic field at the Witteveen observatory calculated from the H-measurement with the DOVER-instrument and from the I-measurements with the earth-inductor TOEPFER. The correction in the year 1942 and in the beginning of 1943 was $-9\ \gamma$. After this date the behaviour of BMZ 26 was very irregular. The scattering between the individual readings was very large, the corrections amounted from $-20\ \gamma$ to $-60\ \gamma$. The error appeared to be caused by the balance magnet touching the damping. The magnet moves between copper plates whose purpose is to damp the motion considerably. It turned out that slight displacements of the balance were possible when clamped, from which this touching now and then resulted.

In 1943 the clamping of the balance was corrected, so that it rests now in four forks. When the balance is lowered, it comes in the right position with respect to the damping. After these repairs the behaviour of the BMZ was completely regular and the corrections had once more the former value of $-9\ \gamma$.

New calibrations were made in the year 1949. The whole instrument was placed in a Helmholtz field, generated by three coils, diameter 100 cm, with distances of 40 cm. The outer coils had 50 windings, the middle coil 31, so that the field had a constant value of 90.56 γ per mA along the major part of the axis of the instrument.

It turned out that the magnetic moment of the rotating magnet had increased since 1942 so that all Z_p values had to be corrected by an increase of 1.5 %. The correction for the whole instrument appeared to be $-25\ \gamma$, which can be ascribed to a small change of the magnetic moment of the upper magnet.

The zero point correction of the rotating-disc amounted constantly to +0°,20 during these years. It was determined from a comparison of the readings of the rotating-disc in the two positions of the rotating magnet in which the same angle is made with the vertical.

During the measurement in the northernmost part of the country it was necessary to use supplementary magnets for augmenting the compensating field strength. They can be screwed on below the rotating magnet. Their influence upon the balance was determined in 1947 and amounted

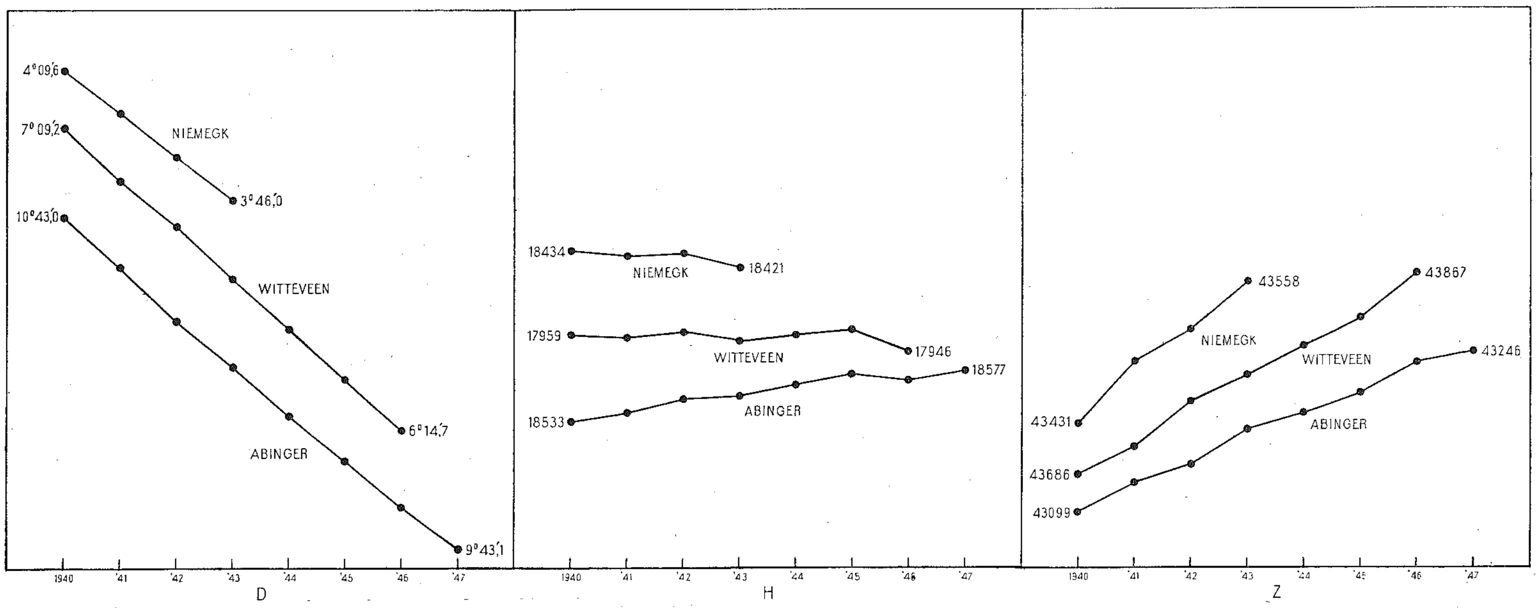

Fig. 10. Secular changes at Witteveen, Abinger and Niemegk.

to 1983 γ for the auxiliary magnet 26-1, to 1988 γ for 26-2, and to 1987 γ for 26-3.

New determinations in 1949 and 1950 gave the values 2005 γ for the auxiliary magnet 26-1 and 2020 γ for 26-3. The magnet 26-2 appeared to be loose in the casing, so that no accurate values could be obtained.

The secular change.

All determinations were reduced to the epoch 1945.0 by applying the secular changes at Witteveen. It was supposed that the secular change has the same value at Witteveen as at any place in the Netherlands. This is certainly allowed as regards the declination. The secular change of D is practically the same everywhere in NW-Europe. However the secular changes of H and Z at De Bilt—Witteveen, Greenwich—Abinger and Potsdam—Niemegk are different.

Below, the annual means of the magnetic elements at the observatories Witteveen, Abinger and Niemegk are given for the recent years. The secular changes are represented graphically in fig. 10.

Annual means of the magnetic elements at Witteveen

$(\varphi = +52^\circ 48'.8; \lambda = +6^\circ 40'.1)$

Year	D	H	Z
1940	7° 09.2	17959	43686
1941	6° 59.8	956	711
1942	51.2	962	750
1943	42.2	954	776
1944	33.0	961	800
1945	24.3	966	827
1946	14.7	946	867

Annual means of the magnetic elements at Abinger

$(\varphi = +51^\circ 11'.1; \lambda = +0^\circ 23'.2)$

Year	D	H	Z
1940	10° 43.0	18533	43099
1941	33.8	539	128
1942	24.8	554	146
1943	16.2	556	172
1944	07.8	566	189
1945	9° 59.5	573	207
1946	51.1	569	235
1947	43.1	577	246

Annual means of the magnetic elements at Niemegk

$(\varphi = +52^\circ 04'.3; \lambda = +12^\circ 40'.5)$

Year	D	H	Z
1940	4° 09.6	18434	43431
1941	01.4	430	484
1942	3° 53.8	433	516
1943	46.0	421	558

To reduce the measurements to 1945.0 the correction for the secular change was applied over a maximum period of 2 years. During this time the difference in the secular change between Potsdam and Witteveen and between Witteveen and Abinger amounted to about 15γ for H and to about 20γ for Z. Supposing a linear change of the secular variation with the distance to Witteveen, it appears that in the extreme regions of this country the elements H and Z showed a variation during the mentioned period, which differs at most 6γ and 8γ resp. from the variation at Witteveen.

It is not possible, however, to determine this correction exactly because the annual means at Potsdam are missing after 1943. Besides, for the greater part of the stations this correction is smaller than a few γ, so that it is not taken into account for the present.

The reduced results.

The results of the measurements at 392 stations, reduced to the epoch 1945.0, are tabulated on page 26 till page 30. They contain number, name and coordinates of the stations, together with the values of D, H and Z. In addition, the components in northward direction X and in eastward direction Y are given. These were computed from the formulas

$$X = H \cos D \quad \text{and} \quad Y = H \sin D$$

All Y-values are negative owing to the fact that in the whole country the declination is westerly.

The last columns contain the values ΔX, ΔY and ΔZ, the deviations of X, Y and Z from a normal field, which is derived in the next chapter. The formulas are:

$$\begin{aligned} X_n &= 18120 - 470\Delta\varphi + 45\Delta\lambda \\ Y_n &= -2315 + 30\Delta\varphi + 150\Delta\lambda \\ Z_n &= 43448 + 500\Delta\varphi \end{aligned}$$

$$\Delta X = X - X_n; \quad \Delta Y = Y - Y_n; \quad \Delta Z = Z - Z_n.$$

The last 14 measurements (A—N) were carried out after a great part of this publication had already been completed. It was not possible to insert them in the tables; therefore they are printed at the end of the list. At these stations only H and Z have been determined. The values of D, necessary for the calculation of X and Y, were read from the D-chart. These values are therefore given in parentheses.

CHAPTER III

THE CONSTRUCTION OF THE CHARTS

Charts have been constructed of the magnetic elements D, H, Z, X, Y, and of the anomalies ΔX, ΔY, ΔZ. Each chart has been printed in three colours: the numbers of the stations are grey, the values of the magnetic elements are black, and the isolines drawn through them are red.

Although some 240 years have elapsed since Halley published his famous isogonic chart, no clear principles for the construction of magnetic charts have been laid down. The tracing of contours is still a matter of individual judgment. A survey of methods of constructing magnetic charts has been given by Bernstein [1]).

Two general procedures have been employed in the tracing of contours. They may be termed the analytic method, by which the contours are approximated by a mathematical expression, and the graphical method, consisting of free-hand smoothing. As the network of our stations is dense, and the quality of the measurements is good in general, it was possible to use the graphical method, interpolating the isomagnetic lines between the measured values.

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[1]) A. Bernstein, A survey of methods of constructing magnetic charts, Terr. Mag. 49, 169, 1944.

Fitting the isolines to the Belgian and German charts.

We have tried to continue the isolines over Belgium and Germany. For Belgium the maps of Dehalu and Marie Merken and Hoge [1]) were used, which are reduced to 1913.0. In applying the magnetic difference [2]) between De Bilt and Witteveen to the mean values of the magnetic elements in the years 1912 and 1913 at De Bilt [3]), one finds for the magnetic elements at Witteveen for the epoch 1913.0: $D = 12° 01'.9$, $H = 18266\gamma$, $Z = 43485\gamma$. The secular changes from 1913.0 to 1945.0 are: $D = -5° 33'.2$, $H = -303\gamma$, $Z = +328\gamma$. After applying these values to the Belgian maps the connection between the isogonics is good. Around South-Limburg, however, the network of the Belgian measurements is not dense enough, so that the isogonics could not be continued with sufficient certainty. The connection of the H-isodynamics is good, provided a reduction of -250γ in stead of -303γ is applied. Considering that the Belgian H-measurements as well as the Z-measurements are apparently only accurate to about 10γ, the agreement can not be called bad. The Z-isodynamics too can be connected properly, taking into account the smaller accuracy of the Belgian values.

For the fitting in of the German declination-measurements Burmeister's chart [4]) for the epoch 1940.0 was used. According to the annual means at Witteveen the correction for the secular change of the declination from 1940.0 to 1945.0 amounts to $-45'$. After application of this correction the agreement between Burmeister's isogonics and ours is rather bad, however. Apparently the borderland of Burmeister's chart is based on van Rijckevorsel's measurements, which in this region are $5'$ or $10'$ too small. The isolines of our D-chart are therefore traced as well as possible according to the general shape of the German isogonics. Extrapolating the H- and Z-isodynamics was not possible, because the results of the German survey of the second order [5]), which was begun in 1937, were not available.

The construction of the isanomalic chart.

For drawing the chart of anomalies of the magnetic field the knowledge of the normal field is necessary. This normal field is in a certain sense an arbitrary conception, the definition depends entirely on what one wishes to see. If one wants to investigate the continental anomalies over the whole world, one has to assume for a normal field, the field of a magnetic dipole situated in or about the centre of the earth. If, however, one intends to study the regional anomalies in a limited region, the normal field must be chosen in such a way, that it corresponds to the field in the undisturbed parts of this region. One attempts then to write down the components of this normal field as functions of latitude and longitude in an expression of the form

$$F = F_0 + a\varphi + b\lambda + c\varphi^2 + d\lambda^2 + e\varphi\lambda + \ldots\ldots\ldots\ldots$$

F_0 and the coefficients $a, b, c, d, e \ldots\ldots\ldots$ are to be determined so that the undisturbed field is represented by this expression. It would be possible to calculate these coefficients from the values of the true magnetic field by the method of least squares, if the deviations of the true field from the normal field were distributed according to the laws of chance. This method has indeed been used by Schott [6]) and Hazard [7]) in constructing the magnetic maps of the United States.

As however was remarked by Rücker en Thorpe [8]), the anomalies are usually not distributed according to chance. The latter authors followed therefore a much simpler procedure. In the first place they chose for the normal field the expression

$$F = F_0 + a\varphi + b\lambda + e\varphi\lambda + f \cos d(\varphi - g)$$

with a, b, d, e, f and g as unknown factors, as this function was nearly in harmony with the mean course of the isolines. The 205 stations were grouped into a number of districts, and for every district the arithmetical average of the values of latitude, longitude and magnetic element was determined. The unknown coefficients were finally determined from a number of equations, equal to the number of unknowns. This method was also used by van Rijckevorsel [9]). He was rightly of opinion, that for a small country as the Netherlands a linear approximation of the normal field must be sufficient. A magnetic centre was determined by taking for all the stations the arithmetical means of the longitude, the latitude and the magnetic components. In each place the deviation of the normal field from that magnetic centre is given by

$$\Delta F = a\Delta\varphi + b\Delta\lambda$$

where for ΔF is successively taken ΔX, ΔY and ΔZ; $\Delta\varphi$ and $\Delta\lambda$ are the differences between the latitude and longitude of the place in question and the coordinates of the magnetic centre. For each component van Rijckevorsel obtained two equations by summing up the equations for all the stations north of the magnetic centre and by doing the same for all the stations east of this centre. The stations in the southwestern quadrant were thus left out of consideration, because the disturbances here were greater than in the rest of the country. The ultimate equations were:

$$\begin{aligned} \Delta X &= -354.1\Delta\varphi + 116.0\Delta\lambda \\ \Delta Y &= -73.0\Delta\varphi - 143.4\Delta\lambda \\ \Delta Z &= +429.8\Delta\varphi - 73.5\Delta\lambda \end{aligned}$$

with the magnetic centre: $\varphi = 52° 16' 41''$ N.L., $\lambda = 5° 30' 43''$ E.L., and $X = 17706\gamma$, $Y = -4611\gamma$, $Z = 43994\gamma$.

A still simpler method for the construction of the normal field consists of drawing smooth isolines in one way or another, for example, by drawing by free hand or by

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[1]) M. Dehalu et Marie Merken, Nouvelle carte magnétique de la Belgique, 1913; E. Hoge, Nouvelle contribution à la carte magnétique de la Belgique, 1934.

[2]) Yearbook B, Geomagnetism 1945, De Bilt.

[3]) Annuaire B, Magnétisme Terrestre 1938, De Bilt.

[4]) F. Burmeister, Karte der Erdmagnetischen Missweisung für die Epoche 1940.0.

[5]) R. Bock, Über die magnetische Reichsvermessung II. Ordnung und ihre ersten vorläufigen Ergebnisse, Z.f. Geophysik, 15, 66, 1939.

[6]) C. A. Schott, Distribution of the magnetic declination in Alaska and adjacent waters for the year 1895, U. S. Coast and Geodetic Survey Bull. 34, 129, 1895.

[7]) D. L. Hazard, United States magnetic tables and charts for 1925, U. S. Coast and Geodetic Survey, Serial 453, 1929.

[8]) A. W. Rücker and T. E. Thorpe, Magnetic survey of Great Britain and Ireland, Phil. Trans. 190 A, 53, 1890.

[9]) E. van Rijkevorsel l.c.

averaging groups of observations, the isolines being approximated by a linear or quadratic equation. This method is followed by LEWIS [1]) in constructing an isogonic map of South-Africa. A combination of the above described methods was used by LJUNGDAHL [2]). From the measurements of a number as relatively undisturbed selected stations he derived by the method of least squares a set of linear equations for all the magnetic elements.

The formulas for the normal field in the Netherlands, used by HARTMANN [3]), are based on the geomagnetic field at the observatories at Abinger, Eskdalemuir, Witteveen, Chambon-la-Forêt, Rude Skov and Niemegk. It is supposed that the field at these observatories is determined by the dipole-field plus the continental European anomaly and that, therefore, the regional disturbances are small. This is an arbitrary supposition, though it may be expected that a magnetic observatory is generally built in a magnetically undisturbed region. HARTMANN finds:

$$\begin{aligned} X_n &= 18105 - 470\Delta\varphi + 45\Delta\lambda \\ Y_n &= -2430 + 30\Delta\varphi + 150\Delta\lambda \\ Z_n &= 43375 + 500\Delta\varphi \end{aligned}$$

where $\Delta\varphi = \varphi - 52°$ and $\Delta\lambda = \lambda - 5°$. It turned out, that these formulas gave a reasonable distribution of positive and negative regions for ΔZ, but that the horizontal disturbance-components deviated systematically from the direction, which could result from the vertical disturbance-field. A much better result was obtained by slightly altering the constant term in the formulas for X_n and Y_n. Finally HARTMANN used the following formulas:

$$\begin{aligned} X_n &= 18115 - 470\Delta\varphi + 45\Delta\lambda \\ Y_n &= -2380 + 30\Delta\varphi + 150\Delta\lambda \\ Z_n &= 43775 + 500\Delta\varphi \end{aligned}$$

In this report the anomalies, which are reproduced in the Δ-chart, are computed from HARTMANN's formulas, reduced to 1945.0. They are:

$$\boxed{\begin{aligned} X_n &= 18120 - 470\Delta\varphi + 45\Delta\lambda \\ Y_n &= -2315 + 30\Delta\varphi + 150\Delta\lambda \\ Z_n &= 43448 + 500\Delta\varphi \end{aligned}}$$

with $\Delta\varphi = \varphi - 52°$ and $\Delta\lambda = \lambda - 5°$.

The differences $X - X_n$, $Y - Y_n$ and $Z - Z_n$ between the measured values X, Y and Z and the normal values X_n, Y_n and Z_n are used for drawing the chart of anomalies. The values $X - X_n$ and $Y - Y_n$ are compounded into a resultant horizontal disturbance vector, the values of $Z - Z_n$ given in γ are printed below the stations.

On the Belgian territory the isanomalics are copied from HARTMANN's chart, they have been computed from a normal equation valid for 1913.0 viz.

$$Z_n = 43156 + 530\Delta\varphi - 85\Delta\lambda$$

this formula being derived by a method analogous to that used for the formulas for the Netherlands.

For Germany a formula for the normal Z-field is given by RÖSSIGER [4]). This reads:

$$\begin{aligned} Z_n = 43460 + 499.9\Delta\varphi + 19.28\Delta\lambda + 0.952\Delta\varphi\Delta\lambda + \\ - 10.95\,(\Delta\varphi)^2 + 2.21\,(\Delta\lambda)^2 \end{aligned}$$

with $\Delta\varphi = \varphi - 52°.07$, $\Delta\lambda = \lambda - 12°.68$ valid,for 1941.5. This normal field is constructed from the yearly means at the magnetic observatories Niemegk, San Fernando, Eskdalemuir, Lovö, Kasan and Helwan and is, therefore, applicable for the whole of Europe. The annual changes of the coefficients are: for the term with $\Delta\varphi$: -0.60, for the term with $\Delta\lambda$: $+1.61$, for the term with $\Delta\varphi\Delta\lambda$: -0.058, for the term with $(\Delta\varphi)^2$: $+0.42$, for the term with $(\Delta\lambda)^2$: -0.206. Neglecting the terms of higher order, and reducing this formula to $\varphi = 52°$, $\lambda = 5°$ as a magnetic centre, the approximation for the epoch 1945.0 becomes:

$$Z_n = 43470 + 499\Delta\varphi + 21\Delta\lambda$$

This formula differs only slightly from the one used in this publication, apart from the term with $\Delta\lambda$, which is of little importance.

For the northeastern borderland REICH's [5]) charts of the anomalies of the vertical component were available. Moreover, the isanomals of the disturbed region of Lingen have already been published by REICH [6]). These isanomals show a close correspondence with ours and have been drawn in the northeastern borderland of the Δ-map. For the southeastern region no German maps were available.

CHAPTER IV

DISCUSSION OF THE CHARTS

The D-chart.

The isogonics of the declination chart have been drawn at mutual distances of 5′. As the uncertainty is greater on Belgian territory than on Dutch, they have there been drawn for every 10′. It was not possible to continue the isogonics around the province of South-Limburg. Over the North Sea the isogonics have been drawn in accordance with the general direction in NW-Europe; the accuracy of the lines is here much smaller than on land. We see that the declination varies from 6° 15′ to 8° 0′ between the east frontier of the Netherlands and the isle of Walcheren. A disturbed region extends from South-Limburg to Utrecht. The disturbances of the Belgian region turn out to be continued in the province of Zeeland and the west part of North Brabant. Some other important disturbances are found in the neighbourhood of the Dollart and in the Wadden Sea.

The H-chart.

The horizontal component varies from 17600γ over the Wadden islands in the north to 18800γ over South-Limburg. The disturbed region over the Wadden Sea and in West-Friesland is very striking. The disturbance over the Dollart becomes evident by an abnormally steep gradient of the horizontal component. The central part of the Netherlands

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[1]) A. D. LEWIS, Magnetic declination in South Africa (1936), Department of Irrigation, Pretoria.

[2]) G. S. LJUNGDAHL, A magnetic survey of Sweden, Kungl. Sjökarteverket, Jordmagnetische Publikationer No. 9, Stockholm 1934.

[3]) PH. C. P. HARTMANN, l.c.

[4]) M. RÖSSIGER, Beitrage der angewandten Geophysik, 9, 121, 1941.

[5]) Thanks are due to Prof Dr. H. REICH for furnishing the maps.

[6]) H. REICH, Zeitschr. der deutschen geologischen Gesellschaft 85, 935, 1933.

is only slightly disturbed. The Belgian region together with South-Limburg and Zeeland show a strong irregularity as is also the case on the D-chart.

The Z-chart.

The vertical component increases between South-Limburg and the Wadden islands from 42850γ to 44200γ. The chart shows remarkable disturbances in the Wadden Sea and in the area of the Dollart. The disturbed region from South-Limburg to Utrecht is characterized by a downward bulging of the isolines, which means an abnormally large value of the vertical component or a positive anomaly. Just as in the case of the D-chart and the H-chart the south part of the Z-chart is strongly disturbed.

The X-chart.

The chart of the northerly component is naturally very much like the H-chart and, therefore, does not give rise to special remarks. The accuracy of the X-chart is determined by the formula

$X = H \cos D$, from which: $dX = \cos D.dH - H \sin D.dD$

Over the whole country this formula can be simplified to

$$dX = dH - 0{,}5\, dD$$

(dX and dH in γ, dD in minutes of arc) from which it follows that the accuracies of X and of H are practically the same.

The Y-chart.

The isodynamics of the easterly component have a nearly north-south direction. In the neighbourhood of the east frontier the value is -1950γ, over Walcheren it amounts to -3000γ. The disturbed regions of the Y-chart are essentially the same as of the other charts. The accuracy of the Y-values follows from

$Y = H \sin D$, from which: $dY = \sin D.dH + H \cos D.dD$

This can be reduced approximately to:

$$dY = 0{,}1\, dH + 5\, dD$$

(dY and dH are expressed in γ, dD in minutes of arc). The accuracy of Y is in the first place determined by that of D, an error of $1'$ has an influence of 5γ upon Y.

The air-earth current.

In a publication "Notes on isomagnetic charts: VI Earth-air electric currents, and the mutual consistency of the H and D isomagnetic charts "CHAPMAN[1]) concludes that a non-potential part of the geomagnetic field must be attributed to errors in the values of D and H. This means, that the value of the vertical downward electric current I from the air into the earth, derived from the line integral of H along a closed curve

$$\int H\, ds = 4\pi I$$

must be very small or even zero. In order to investigate this three trapezia 1, 2 and 3 of 5435, 5100 and 8325 km^2 resp. have been drawn with their sides parallel to the circles of longitude and latitude. Along the parallel sides of these trapezia the mean value of Y was determined over intervals of 5 km and also the value of X along the slanting sides. The integral of H along these trapezia, taken in clockwise direction, gives for 1 the value $+ 1045$ oersted cm, for 2 : -1550 oersted cm and for 3: $+1415$ oersted cm. From these values the following currents are calculated: in 1: $+0.15$ A/km^2, in 2: -0.24 A/km^2, in 3: $+0.14$ A/km^2 (+ means a downward current).

After SCHMIDT's map [2]) the intensity of the air-earth current is -0.2 A/km^2 in NW-Europe. CHAPMAN's [3]) values differ considerably from SCHMIDT's map.

The difference between the directions of the currents in the adjoining regions 1 and 2 raises the surmise that these currents are not real. In order to investigate this in more detail each trapezium is subdivided into four parts and in each part the strength of the current is calculated separately. The result is:

1*a*: -0.43 A/km^2, 1*b*: $+ 0.02$ A/km^2, 1*c*: $+0.48$ A/km^2, 1*d*: $+0.64$ A/km^2.

In 2*a*: -0.73 A/km^2, 2*b*: $+1.75$ A/km^2, 2*c*: -0.84 A/km^2, 2*d*: -0.90 A/km^2.

In 3*a*: $+3.78$ A/km^2, 3*b*: -2.56 A/km^2, 3*c*: -0.23 A/km^2, 3*d*: -0.22 A/km^2.

It turns out that the currents per km^2 become stronger according as the integrals enclose a smaller area, and that there is not any regularity in the direction of the currents. This points evidently to the influence of the accidental errors in X and Y, which get more important according as a smaller region is considered.

We will conclude with the remark that a periodically variable air-earth current cannot be detected by the above mentioned method. The measurements have been carried out on various days and times, and have been reduced without taking onto consideration an eventual local current. This local current could be found from simultaneous measurements along a closed line. The only statement that can be made is that a permanent air-earth current does not exist.

The Δ-chart.

The deviations from the normal field, ΔX, ΔY and ΔZ, have been collected in one chart. The horizontal anomalies ΔX and ΔY have been composed to form one vector, the value ΔZ is printed in γ. The isanomals of ΔZ are drawn for every 20γ. The regions with positive values of ΔZ are dotted red, the negative regions are white. Only a few lines have been drawn over Belgian territory, but in part of the German borderland we were able to complete the chart.

The G-chart.

The last chart is the chart of the gravity anomalies in the Netherlands, based on measurements of the Government's Commission for Geodesy, the Bataafsche Petroleum Maatschappij and the Government's Mines. This chart was kindly put at our disposal by the Bataafsche Petroleum Maatschappij. The isogams have been drawn for every 5 mgal. The regions with an abnormally large value of the gravity are dotted red, the negative regions are white.

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[1]) S. CHAPMAN, Notes on isomagnetic charts, Terr. Mag. 47, 1, 1942.

[2]) J. BARTELS and S. CHAPMAN, Geomagnetism, page 665.

[3]) S. CHAPMAN, l. c.

The magnetic and gravimetric anomalies.

The magnetic anomalies are caused by irregular deviations from a horizontally homogeneous magnetization in the earth's crust. Our knowledge of the details and quantitative values for magnetization of rocks is still in a rather unsatisfactory state owing to the lack of experimental determinations of the magnetic properties of rocks in low magnetic fields. A factor of primary importance is the magnetic susceptibility, but this factor depends highly on the strength of the magnetic field in which it is measured. Many values given in the literature refer to a field-strength larger than that of the earth's magnetism.

A great many values of the susceptibility of various rocks are given by Haalck [1]), Heiland [2]) and Nettleton [3]). It is probable that the magnetic properties of most rocks are determined by magnetite (Fe_3O_4) which is present almost everywhere in the form of an admixture.

The susceptibility and also the residual magnetism of the crystalline rocks are much larger than the corresponding values for sedimentary rocks. The ratio of the susceptibilities is of the order of 100 to 1000. This convinced Reich [4]) that at least in North Germany the archaic crystalline massifs and the crystalline rocks of the Palaeozoicum cause the extensive positive regional disturbances of the magnetic field, whereas the sedimentary rocks are accompanied by negative anomalies, because the small value of the susceptibility of the sediments is compensated by the greater depths of the crystalline rocks. Nettleton concludes that the measurements may be considered as being made on a plane (i.e. the surface of the ground) which is supported on a nonmagnetic medium (i.e. the sediments) and that the effects measured are caused by undulations of the magnetic surface (i.e. the surface of the igneous rocks) and polarization-contrasts below that surface. Generally speaking, the magnetic anomalies in sedimentary regions give an image of the tectonics of the crystalline substructure. Where the basement rock in the form of a horst or a massif is higher than in its neighbourhood, it will usually cause a positive disturbance. The magnitude of this disturbance depends on the susceptibility of the rock and on its depth.

The interpretation of magnetic anomalies is not unique. As not only the susceptibilities of the rocks but also their dimensions and depths exert an influence, a given anomaly can be explained by a variety of causes. The right interpretation can, therefore, only be obtained from additional dates (geological, gravimetric and seismic).

In fig. 11 taken from Nettleton (page 221), the calculated profile has been drawn of a magnetic anomaly, caused by a long ridge with vertical sides, representing an uplift of one-fourth of the depth and with a width equal to the thickness of the sediment. The polarizing field is taken vertical and the susceptibilities of sediment and basement are supposed to be $k = 0$ and $k = 6.10^{-3}$ respectively, so that the magnetic polarization I

$$I = kZ$$

with a field strength $Z = 0.5$ oersted is equal to 0 for the sediment and to 0.003 c.g.s. for the basement. The calculation of the magnetic influence of the horst is carried out in the simplest way by replacing the volume-magnetization by a uniform distribution of magnetic poles with a density of I per cm^2 along the upper and lower sides of the horst. It turns out that the positive disturbance over the horst with a value of 150γ is accompanied on both sides by weak negative disturbances, so that the value integrated over an infinitely extended horizontal surface is zero.

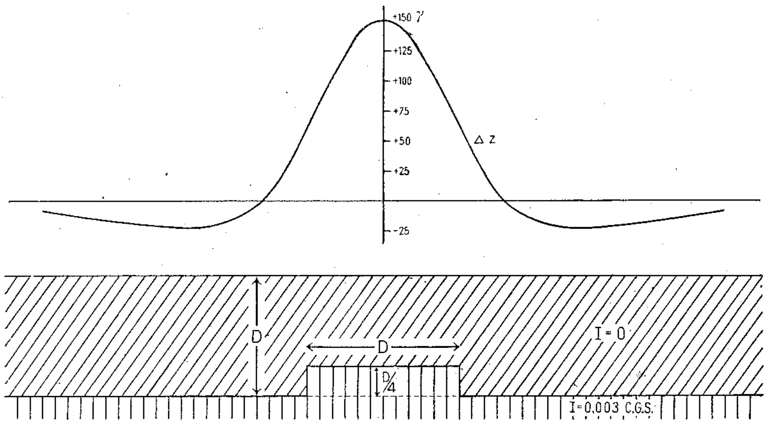

Fig. 11. Vertical magnetic anomaly caused by a long ridge (after Nettleton.)

The geological interpretation of the magnetic anomalies is given for the greater part by Hartmann [5]) in his doctoral thesis. We borrow from it: "The old crystalline massifs of Brabant, Stavelot, Hohe Venn and Rocroy stand out with positive anomalies against the negatively disturbed surroundings. A zone with positive maxima extends from the Yser to Maastricht. The upward curving of the Axe d'Ostende is evident from the northward deflection of the isanomals. The nose of the massif of Brabant causes a positive anomaly in ΔZ of 225γ near Maastricht in accordance with the small depth at which the Cambro-Silur is here found

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[1]) H. Haalck, Der Gesteinsmagnetismus, 1942.

[2]) C. A. Heiland, Geophysical Exploration, 1946.

[3]) L. L. Nettleton, Geophysical prospecting for oil, 1940.

[4]) H. Reich, Zur Frage der regionalen, magnetischen Anomalien Deutschlands, ins besondere derjenigen Norddeutschlands, Z.f. Geophysik, IV, 84, 1928.

[5]) Ph. C. P. Hartmann, Thesis.

directly under the Senon. The "Sillon du Rupel-Demer" is marked by a strip of negative anomalies from Hasselt to the West. North of this strip we find a positive maximum near Antwerp. The massif of Stavelot-Hohe Venn causes a strong positive disturbance. To the north of this massif the crystalline rock is covered by devon, carbon and chalk. We see therefore a strong decrease of the anomaly to the north so that even a negative value of -14γ is found near Eysden. The influence of the massif of Brabant is furthermore expressed on Dutch territory in the strong positive anomaly of Woensdrecht".

The measurements carried out later on in Zeeland show that the greater part of Zeeland is strongly disturbed by positive anomalies, from which we infer that the limit of the massif of Brabant presumably follows a line from the South-Holland islands to South-Limburg. In this region all disturbance vectors of the horizontal field are directed perpendicularly to this line.

About the magnetic anomalies on Dutch territory HARTMANN tells us: "Most striking is the Netherlands direction which dominates the tectonics of our country. Regions of positive and negative anomalies alternate and show very clearly the NW-SE direction. The Swabian direction can also clearly be seen on the chart, namely from the shifting of the isanomals along WSW-ENE directed lines.

The Central Graben can be clearly seen as a negatively disturbed region. We find the minimum in the province of North Brabant south of Eindhoven. More to the NW the zone, which is magnetically negative, seems to shift to the NE. The Peelhorst and its continuation, the horst of Erkelenz, cause a positive anomaly. To the north this anomaly is bordered by a negative disturbance, by which the troughs of Venlo and Venray are represented. The horst of Viersen deflects the isanomal of $+20\gamma$ to the NW again, where upon it curves round the horst of Mill, which is shifted to the NE with regard to the Peelhorst even in its magnetic anomaly."

Comparing now the Δ-chart with the G-chart we see that the gravimetric chart too gives a clear image of the Central Graben; the gravimetric minimum, however, is situated more to the north than the magnetic one. The strip of positive magnetic anomalies which borders the Central Graben to the east, coincides with the region of horsts, as published in the Mijnbouwkundig Jaarboek 1947 ¹), but is found at the limit of the gravimetric negative region. The gravimetrically deep trough of the Roer can be found on the magnetic chart too as a shallow between the maxima, but does not lead to negative values. As regards the region west of the Central Graben the two charts agree well with each other.

HARTMANN continues: "One gets the impression from the magnetic anomalies that a region of grabens extending over the Rhine is situated between the horst of Mill with its continuation to the north, and the high region of the Achterhoek. A partly broad region of horsts is sharply outlined by the magnetic anomalies in the continuation of the zone Erkelenz—Peel—Mill over "het Gooi", the Utrecht ridge, an important part of the Gelderse Vallei and even of the Neder Veluwe to Voorthuizen. Over the horst of the Utrecht ridge the disturbance values are highest and this horst seems to extend farthest to the NW and the SE. The geomagnetic anomalies in this region support the hypothesis that the existence of the Utrecht ridge is not primarily due to the pushing of the land-ice, but that a tectonically caused higher structure accounts for the formation of a push-moraine. The horst of the Utrecht ridge is shifted to the NE relative to the horst of Mill. The same was found for the situation of the horst of Mill in relation to the Peelhorst, where the shift took place along the fault-lines of the transverse graben of Venray. It is therefore possible to suppose the existence of a transverse graben following the line Tiel—Dieren. The sudden deflection of the rivers is perhaps partly caused by this graben."

We can remark in this connection that this transverse graben is still better visible in the Δ-chart than in HARTMANN's chart. The magnetic maximum near the Utrecht ridge is not visible on the G-chart, the spur to the Neder-Veluwe, however, coincides with a slight gravimetric maximum of $+5$ mgal.

HARTMANN continues:

"To the east of the magnetically positive disturbed region of the Utrecht ridge lies a negative region. Probably the Rhine Graben which could be followed to the Ysel east of Arnhem is continued in the NW direction, slightly shifted to the NE. The east border of this graben may be supposed to lie near Apeldoorn. East of it the high ground of the east part of the Netherlands begin probably to rise stepwise. The west border of the graben is supposed to follow a line drawn over Voorthuizen".

The graben, supposed to exist by HARTMANN, is very clear from a gravimetric viewpoint. Besides, we see that on the G-chart a minimum region in the province of North-Holland is visible as a continuation of this Rhine graben. Also from a magnetic viewpoint this continuation in NW-direction through the centre of North-Holland is quite evident. HARTMANN remarks about the magnetic anomalies in the province of South-Holland:

"Parallel to the zone with positive magnetic anomalies in "het Gooi" and Utrecht, a zone with negative values runs SW of it through Nieuw Vennep and Vreeswijk. Further to the SW the anomalies increase first, but soon they decrease again so that a second zone of minima seems to run from Leidschendam over Zevenhuizen in the direction of Gorinchem. It is obvious to suppose a secondary horst to lie between these two more negatively disturbed regions".

Further, according to HARTMANN a graben can faintly be perceived near the Nieuwe Waterweg and he attempts to connect it with the bed of the original Rhine, as constructed from the location of fossils of *Viviparus glacialis*. This graben is not visible on the complete Δ-chart; however, we see a strongly curved minimum region over the South-Holland islands, bordered in the north by a small maximum over the Waterweg. The corresponding gravimetrically negative region is situated more northward and its axis coincides with Nieuwe Waterweg. Further we see on the G-chart a maximum extending from The Hague

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¹) W. J. VAN RIEL, Geophysische metingen ten behoeve van de Kolenmijnbouw, Mijnbouwkundig Jaarboek 1947.

in SE-direction to the Lek. This sustains HARTMANN's supposition of a secondary horst in the graben: the complete Δ-chart shows a positive strip between the Hague and Haarlem.

HARTMANN remarks about the province of North-Holland: "The whole of the province is negatively disturbed in a magnetic sence. Nearly the whole province shows negative anomalies of the gravity as well. We find the minimum of the magnetic anomaly near Alkmaar and Hoorn. FABER's geological profile which indicates a broad graben, is in accordance with this minimum. This whole province belonged to the small region, which was flooded by the Eemsea. On the other hand the sea of the High-terrace did not penetrate here, but did so into the graben south of the town of The Hague, which remained dry during the irruption of the Eemsea.

To the northeast the value of the anomaly of the vertical component increases again and near Staveren (station 74) a positive anomaly of $+15\gamma$ is found. The basement rock probably rises stepwise in that direction.

The NW-SE line, drawn SW along the isles of Texel and Wieringen, formed the shore of the sea of the High-terrace, the Eemsea and the sea of the Boreal-Atlanticum. In the first case the isles of Texel and Wieringen were flooded, in the two other cases they remained dry, whereas the sea flooded the province of North-Holland (TESCH 1939).

It is obvious, therefore, to suppose the existence of a faultline sowewhere near here, wich borders the Alkmaar graben to the northeast. The diluvium is situated higher in the isles of Texel and Wieringen than elsewhere in the province of North-Holland. The tectonically higher structure of Texel may at the same time explain the fact that the coast-line juts out in a northwest direction, a phenomenon which appeared on a larger scale in the situation of the original reefs. Probably Gaasterland forms also part of this zone of horsts."

Let us now have a look at the centre of East Netherland. Beyond the German frontier we see a strong magnetical and gravimetrical maximum, the maximum of Lingen, which makes its influence felt within the Netherlands. This is part of the crystalline massif of Bramsche, situated more towards the east. The high grounds of the Achterhoek are magnetically as well as gravimetrically disturbed by positive variations. The magnetic minimum in the centre of the Achterhoek nearly coincides with a saddle-region between two positive regions in the *G*-chart. It is obvious therefore, to suppose here the existence of a graben, as indicated already by VAN WATERSCHOOT VAN DER GRACHT between Buurse and Rekken. Northwest of it a magnetically negative strip extends through West-Overijsel and South-west Friesland, in which all isanomals are stretched out in a northwest direction. The corresponding region in the gravimetric chart is positive and points to a maximum over South Friesland and the head of Overijsel. Here the gravimetric and the magnetic maps are contradictory. HARTMANN writes about this:

"Since the Jura the high grounds of the Achterhoek and Twente have sunk considerably less than the region north of it, where very thick mesozoic and tertiary layers were deposited. If we assume that the gravimetric horst (here the maximum over the nortwestern part of Overijsel is meant) is relatively young, its abnormal magnetic field can be explained by the great thickness of the calcareous mesozoic sediments. The susceptibility of limestone and marl is verry small, much smaller than the susceptibility of other sediments. Their density, however, is greater than the density of sands and clays. Owing to the rising of the horst these very thick mesozoic layers have come to lie higher than in their surroundings. By their greater density they cause a positive gravity anomaly. However, by their smaller susceptibility these layers can cause a negative magnetic disturbance. The crystalline basement, which is situated at a rather great depth notwithstanding the rising, has a smaller influence upon the magnetic field, so that a negative anomaly may be the result of the elevation".

It is also possible to conceive the presence of a graben in the crystalline basement, filled with sediments of great density, which are responsible for the gravity maximum. This interpretation is simpler than HARTMANN's. A decision between the two is not possible for the time being, through lack of knowledge of the deeper substructure. A negative strip runs through the provinces of Drente and Groningen in the Netherlands direction SE-NW, which it is possible to follow in the Wadden Sea north of Groningen. The *G*-chart too shows a negative region getting deeper in the NW direction. At the northeast side this strip is bordered by an extensive magnetic maximum, the oblong centre of which is situated over the Eems and the Dollart. Presumably a crystalline ridge can be found here, which follows the graben through the province of Groningen. HARTMANN remarks about this graben that the Eemsea-transgression has been able to penetrate here only along a narrow bay from the Lauwersea to the Lake of Zuidlaren. The region west of this graben, the greater part of the province of Friesland and the Wadden Sea show a positive magnetic anomaly. The gravity anomaly is negative here though an increase of the gravity must exist from NW-Friesland to the isles of Vlieland and Terschelling. Just as in South-Friesland a contradiction is also present in North-Friesland between the magnetic and the gravimetric maps. Most remarkable is the narrow tongue of positive magnetic anomalies penetrating from the Wadden Sea in an eastward direction into Friesland. A narrow ridge in the crystalline basement may be responsible for it. The isolated negative anomaly on the isle of Ameland is not quite certain, it may be caused by an error.

Finally we see in the Wadden Sea between the isles of Texel, Vlieland, Terschelling and the Friesian coast a very strong and steep magnetic maximum, the anomaly in the centre situated at the Inschot fairway reaching a value of more than 200γ. The cause of this strong disturbance, visible in all magnetic charts, is completely unknown. Up to now neither gravimetric nor seismic investigations have been carried out in this region, but it will be very interesting to compare the results of these investigations, which we hope will not be postponed much longer, with the magnetic anomalies. The limited area of this disturbance, the steep gradient and the high value of its maximum are only comparable with the disturbances near the south frontier of our country, where the crystalline rocks with a considerable magnetite content are found close under the surface.

Magnetic anomalies and seismicity.

By J. P. Rothé [1]) attention is drawn to the fact, that in some cases a relation can be found between the epicenters of earthquakes and magnetic anomalies. It was found in Japan that the epicenters of some recent heavy earthquakes were situated in magnetically strongly disturbed regions, where moreover the geomagnetism showed an abnormally strong secular change. In France, too, centres of earthquakes are found on the axis of the magnetically Basin of Paris and here also important changes of the anomalies occurred from the year 1896 to 1924. Rothé ascribes this fact to magmatic displacements which at the same time cause the earthquakes and the changes of the geomagnetic field.

In the Netherlands earthquakes are very rare phenomena. We borrow from the surveys of Visser [2]) and van Rummelen [3]) the following. In the years 1833, 1850 and 1883 shocks have been felt in the provincies of North- and South-Holland with epicenters in the neighbourhood of Haarlem. Quakes are also mentioned near Harderwijk in the years 1781, 1824, 1859 and 1906. Furthermore in the year 1829 a shock was observed in Zwolle and in the year 1843 in Blokzijl. In the southern part of our country earthquakes are more numerous than in the northern part. Several epicenters were found on the eastern border of the Central Graben: Tiel (1928, 1932), Uden and Veghel (1843, 1848, 1932), Dinter (1848), Vught (1932), Asten (1932), Gratem (1906), Roermond (1851). The town of Sittard situated on the western border of the Central Graben experienced a very slight earthquake in the years 1918 and 1931. Several times shocks have been observed related with movements along the Feldbiss, an important tectonical disturbance in the region of the Limburg mines: Herzogenrath (1873, 1874, 1877) and Rolduc (1928). Also related to faults are the quakes of Heerlen (1914) and Voerendaal (1930). It is evident therefore that even in recent years movements occur along the fault planes in the South of the Netherlands. The most important shocks are connected with shifts in the fault-region between the Central Graben and the Peelhorst. The epicentres, however, are not found in the axis of the magnetic anomaly as in France, but along the western border of the related magnetic maximum. To what extent sudden changes in the magnetic anomalies are caused by the tectonical movements is a question which cannot be answered as the surveys of 1892 and 1945 differ too much in accuracy. Probably, the shocks in the northern part of the Netherlands are also of tectonical origin. The epicenters of Harderwijk, Zwolle and Blokzijl are indeed situated in transition-regions between magnetic maxima and magnetic minima and are perhaps related to movements along the borders of the Alkmaar graben. The Δ-chart and the G-chart give the impression that this graben extends via the Veluwe through the province of North-Holland as a continuation of the Rhine graben, which from a seismic viewpoint is still active. It is not possible to relate the shocks in the neighbourhood of Haarlem to a gravimetric or magnetic structure.

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[1]) J. P. Rothé, Tremblements de terre et anomalies magnétiques, Geofisica pura et applicata, 12, 1, 1948; Thèses, Paris, 1937.

[2]) S. W. Visser, Aardbevingen in Nederland, Tijdschrift Ned. Aardr. Genootschap, 59, 494, 1942; Seismologie, Gorinchem, 1949.

[3]) F. H. van Rummelen, Overzicht van aardbevingen enz. Mededelingen Jaarverslag Geologisch Bureau te Heerlen, 1945.

VALUES OF THE GEOMAGNETIC ELEMENTS AT EPOCH 1945.0

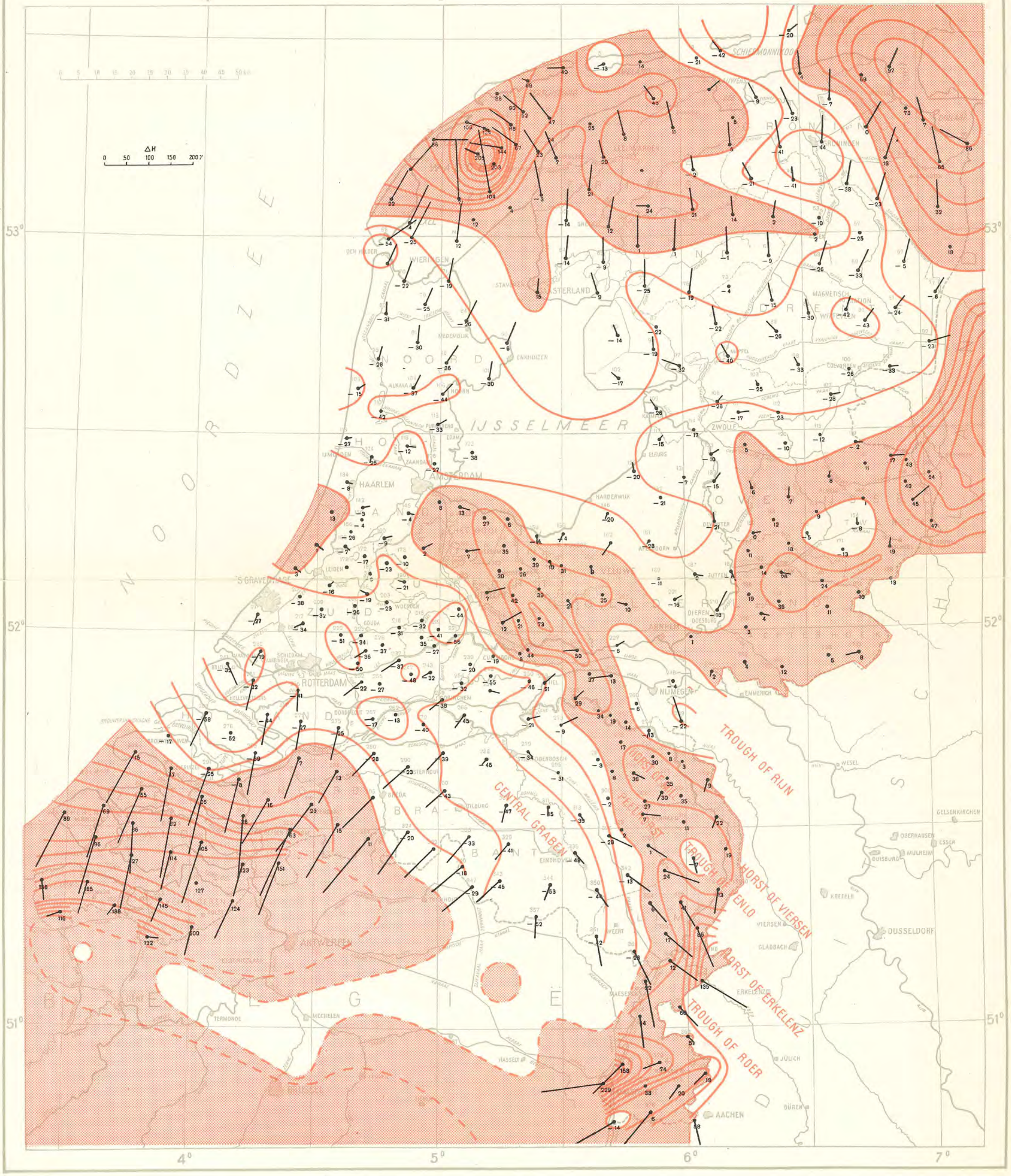
	Name of station	φ	λ	—D	H	X	—Y	Z	ΔX	ΔY	ΔZ
1	Boschplaat	53° 31′.59	6° 26′.85	6° 37′.6	17600γ	17482γ	2031γ	44191γ	+ 14γ	+ 21γ	— 20γ
2	Schiermonnikoog	53° 28′.52	6° 09′.74	6° 53′.3	17627γ	17500γ	2114γ	44144γ	+ 21γ	— 17γ	— 42γ
3	Engelsmanplaat	53° 27′.75	6° 03′.43	6° 21′.4	17637γ	17529γ	1953γ	44158γ	+ 48γ	+159γ	— 21γ
4	Burum	53° 27′.02	5° 49′.12	7° 00′.9	17604γ	17472γ	2150γ	44187γ	— 3γ	— 2γ	+ 14γ
5	Hollum	53° 26′.83	5° 39′.70	7° 08′.1	17598γ	17462γ	2186γ	44158γ	— 7γ	— 13γ	— 13γ
6	Oost-Terschelling	53° 26′.63	5° 29′.43	7° 18′.0	17604γ	17462γ	2237γ	44210γ	— 1γ	— 39γ	+ 40γ
7	Spijk	53° 25′.64	6° 52′.26	6° 24′.2	17684γ	17574γ	1972γ	44258γ	+ 42γ	+ 20γ	+ 97γ
8	Westernieland	53° 25′.14	6° 29′.65	6° 38′.7	17695γ	17576γ	2048γ	44162γ	+ 57γ	0γ	+ 4γ
9	Oosternieland	53° 24′.40	6° 44′.55					44220γ			+ 69γ
10	Den Hoorn	53° 24′.25	5° 20′.50	7° 16′.2	17618γ	17477γ	2230γ	44218γ	+ 3γ	— 8γ	+ 68γ
11	Anjum	53° 22′.36	6° 06′.16	6° 46′.0	17668γ	17545γ	2082γ		+ 20γ	+ 27γ	
12	West-Terschelling	53° 22′.22	5° 12′.63	7° 55′.9	17613γ	17444γ	2430γ	44222γ	— 41γ	—188γ	+ 88γ
13	Blija	53° 21′.42	5° 52′.36	7° 02′.5	17686γ	17552γ	2168γ	44169γ	+ 31γ	— 25γ	+ 43γ
14	Zoutkamp	53° 21′.36	6° 18′.40	6° 47′.9	17700γ	17575γ	2095γ	44117γ	+ 34γ	— 17γ	— 9γ
15	Middelstum	53° 20′.87	6° 36′.77	6° 33′.9	17745γ	17629γ	2029γ	44115γ	+ 70γ	+ 4γ	— 7γ
16	Oostmeep	53° 19′.57	5° 19′.40	7° 22′.4	17694γ	17548γ	2271γ	44163γ	+ 37γ	— 44γ	+ 52γ
17	Farmsum	53° 19′.22	6° 56′.32					44181γ			+ 73γ
18	Ezinge	53° 18′.77	6° 27′.30	6° 43′.6	17754γ	17632γ	2080γ	44081γ	+ 63γ	— 23γ	— 23γ
19	Kollumerpomp	53° 18′.29	6° 12′.40		17723γ			44108γ			+ 8γ
20	Oost-Vlieland	53° 17′.91	5° 05′.30	7° 12′.3	17630γ	17494γ	2211γ	44203γ	— 19γ	+ 56γ	+ 80γ
21	St. Jacobi-Parochie	53° 17′.64	5° 36′.15					44120γ			+ 25γ
22	Borgsweer	53° 17′.25	7° 00′.43	6° 25′.4	17773γ	17661γ	1988γ	44098γ	+ 56γ	— 13γ	+ 7γ
23	Rinsumageest	53° 16′.90	5° 57′.28	6° 56′.3	17753γ	17622γ	2145γ	44100γ	+ 62γ	— 11γ	+ 11γ
24	Woltersum	53° 16′.48	6° 45′.74	6° 22′.7	17770γ	17660γ	1974γ	44085γ	+ 60γ	+ 39γ	0γ
25	Stiens	53° 16′.00	5° 44′.63	7° 03′.2	17748γ	17613γ	2179γ	44089γ	+ 55γ	— 14γ	+ 8γ
26	West-Vlieland	53° 15′.31	4° 56′.79	7° 10′.9	17661γ	17523γ	2208γ	44162γ	— 5γ	+ 77γ	+ 86γ
27	Groningen	53° 14′.37	6° 34′.35	6° 34′.9	17785γ	17668γ	2039γ	44023γ	+ 59γ	+ 3γ	— 44γ
28	Gerkesklooster	53° 14′.25	6° 11′.44	6° 48′.3	17768γ	17643γ	2105γ	44072γ	+ 51γ	— 6γ	+ 5γ
29	Griend	53° 14′.15	5° 13′.90	7° 30′.9	17715γ	17563γ	2317γ	44210γ	+ 14γ	— 74γ	+144γ
30	Nieuw-Statenzijl	53° 14′.06	7° 11′.71	6° 30′.2	17786γ	17672γ	2014γ	44151γ	+ 33γ	— 65γ	+ 86γ
31	Zuidhorn	53° 13′.73	6° 24′.11	6° 42′.3	17791γ	17669γ	2077γ	44020γ	+ 64γ	— 9γ	— 41γ
32	Menaldum	53° 12′.58	5° 39′.56	7° 05′.1	17758γ	17622γ	2190γ	44073γ	+ 40γ	— 10γ	+ 20γ
33	Wijnaldum	53° 12′.35	5° 27′.59	7° 13′.9	17778γ	17637γ	2238γ	44058γ	+ 63γ	— 28γ	+ 7γ
34	Noordbroek	53° 11′.65	6° 50′.51	6° 22′.2	17818γ	17708γ	1977γ	44061γ	+ 67γ	+ 26γ	+ 16γ
35	De Cocksdorp	53° 11′.02	4° 50′.86	7° 16′.0	17759γ	17616γ	2246γ		+ 60γ	+ 56γ	
36	Beerta	53° 10′.74	7° 04′.35	6° 22′.7	17848γ	17738γ	1983γ	44103γ	+ 80γ	— 14γ	+ 65γ
37	Leeuwarden	53° 10′.41	5° 49′.25	7° 00′.3							
38	Oostermeer	53° 10′.39	6° 02′.18	6° 53′.0	17779γ	17651γ	2131γ	44033γ	+ 36γ	— 6γ	— 2γ
39	Marum	53° 09′.08	6° 16′.47	6° 47′.7	17798γ	17673γ	2106γ	44003γ	+ 38γ	— 17γ	— 21γ
40	Roden	53° 08′.60	6° 27′.06	6° 39′.5	17798γ	17678γ	2064γ	43979γ	+ 30γ	— 1γ	— 41γ
41	Noordlaren	53° 07′.85	6° 40′.72	6° 29′.2	17829γ	17715γ	2014γ	43975γ	+ 52γ	+ 15γ	— 38γ
42	Wommels	53° 07′.42	5° 35′.89	7° 02′.1	17809γ	17675γ	2181γ	44031γ	+ 56γ	+ 10γ	+ 21γ
43	Paardenhoek	53° 07′.35	5° 11′.07	7° 19′.3	17890γ	17744γ	2280γ	44113γ	+144γ	— 27γ	+104γ
44	Zurich	53° 06′.90	5° 24′.30	7° 12′.7	17834γ	17692γ	2239γ	44003γ	+ 78γ	— 18γ	— 3γ
45	De Koog	53° 06′.29	4° 46′.09	7° 17′.4	17827γ	17683γ	2262γ	44022γ	+ 92γ	+ 55γ	+ 22γ
46	Wildervank	53° 05′.50	6° 48′.36	6° 24′.1	17858γ	17746γ	1991γ	43971γ	+ 58γ	+ 20γ	— 23γ
47	Grouw	53° 04′.98	5° 50′.78	7° 03′.5	17784γ	17650γ	2185γ	44014γ	+ 1γ	— 29γ	+ 24γ
48	Nieuw-Beets	53° 04′.31	6° 01′.90	6° 52′.0	17840γ	17712γ	2133γ	44005γ	+ 50γ	— 5γ	+ 21γ
49	Wedde	53° 04′.02	7° 03′.55	6° 20′.2	17880γ	17771γ	1973γ	44013γ	+ 60γ	+ 1γ	+ 32γ
50	Duurswoude	53° 03′.66	6° 12′.12	6° 47′.1	17842γ	17717γ	2108γ	43993γ	+ 41γ	— 5γ	+ 14γ
51	Veenhuizen	53° 02′.98	6° 21′.98	6° 40′.7	17841γ	17720γ	2075γ	43975γ	+ 32γ	+ 4γ	+ 2γ
52	Tjerkwerd	53° 02′.92	5° 30′.03	7° 04′.6	17860γ	17724γ	2200γ	43959γ	+ 74γ	+ 9γ	— 14γ
53	Zeijen	53° 02′.75	6° 33′.71					43960γ			— 10γ
54	Oudeschild	53° 02′.63	4° 51′.01	7° 17′.3	17857γ	17712γ	2265γ	43967γ	+ 90γ	+ 41γ	— 4γ
55	Sneek	53° 02′.13	5° 40′.96	6° 57′.8	17866γ	17733γ	2166γ	43978γ	+ 69γ	+ 16γ	+ 12γ
56	Assen	53° 00′.37	6° 32′.82		17895γ			43953γ			+ 2γ
57	Eext	53° 00′.32	6° 43′.87		17885γ			43926γ			— 25γ
58	De Mok	53° 00′.16	4° 45′.46	7° 16′.2	17830γ	17687γ	2256γ	43895γ	+ 49γ	+ 65γ	— 54γ
59	Joure	52° 58′.96	5° 48′.27	6° 56′.4	17895γ	17764γ	2162γ	43940γ	+ 70γ	+ 3γ	+ 1γ
60	Heerenveen	52° 58′.35	5° 57′.27	6° 51′.5	17905γ	17777γ	2138γ	43936γ	+ 71γ	+ 5γ	+ 1γ
61	Sellingen	52° 57′.84	7° 06′.33		17913γ			43948γ			+ 18γ
62	Nijeberkoop	52° 57′.81	6° 10′.60	6° 45′.5	17906γ	17782γ	2107γ	43929γ	+ 62γ	+ 2γ	— 1γ
63	Appelsga	52° 57′.22	6° 20′.87	6° 41′.5	17911γ	17789γ	2087γ	43916γ	+ 55γ	— 3γ	— 9γ
64	Brandeburen	52° 57′.08	5° 30′.22	7° 04′.7	17883γ	17747γ	2204γ	43910γ	+ 51γ	+ 6γ	— 14γ
65	Woudsend	52° 56′.44	5° 39′.47	7° 01′.7	17899γ	17765γ	2190γ	43909γ	+ 57γ	— 2γ	— 9γ
66	Den Helder	52° 56′.43	4° 45′.45	7° 24′.4	17863γ	17714γ	2303γ		+ 47γ	+ 20γ	
67	Buinerveen	52° 55′.95	6° 55′.28	6° 21′.8	17925γ	17814γ	1987γ	43910γ	+ 46γ	+ 12γ	— 5γ
68	Hooghalen	52° 55′.74	6° 33′.72	6° 31′.0	17924γ	17808γ	2034γ	43886γ	+ 55γ	+ 19γ	— 26γ
69	Schoonlo	52° 54′.53	6° 43′.70	6° 25′.2	17930γ	17818γ	2005γ	43869γ	+ 47γ	+ 24γ	— 33γ
70	Breezand	52° 54′.01	4° 49′.71	7° 21′.9	17885γ	17738γ	2293γ	43876γ	+ 49γ	+ 21γ	— 22γ
71	Den Oever	52° 53′.70	5° 00′.80	7° 18′.0	17900γ	17755γ	2274γ	43876γ	+ 55γ	+ 12γ	— 19γ
72	Delfstrahuizen	52° 52′.77	5° 49′.93	6° 55′.8	17936γ	17804γ	2164γ	43862γ	+ 60γ	0γ	— 25γ
73	Wilhelminaoord	52° 52′.70	6° 10′.90		17929γ			43883γ			— 4γ
74	Stavoren	52° 52′.02	5° 23′.09	7° 08′.6	17904γ	17766γ	2226γ	43896γ	+ 36γ	+ 5γ	+ 15γ
75	Wolvega	52° 51′.83	6° 01′.06	6° 48′.6	17945γ	17818γ	2128γ	43861γ	+ 58γ	+ 8γ	— 19γ
76	Takozijl	52° 51′.71	5° 38′.35	7° 04′.4	17930γ	17794γ	2208γ	43871γ	+ 50γ	— 15γ	— 9γ
77	Roswinkel	52° 51′.19	7° 02′.30	6° 15′.9	17951γ	17844γ	1959γ	43869γ	+ 33γ	+ 24γ	— 6γ
78	Dwingelo	52° 50′.47	6° 21′.66	6° 41′.9	17955γ	17832γ	2094γ	43854γ	+ 46γ	— 8γ	— 15γ
79	Oostwaard	52° 50′.07	4° 54′.88	7° 19′.4	17912γ	17766γ	2283γ	43840γ	+ 42γ	+ 20γ	— 25γ
80	Witteveen	52° 48′.79	6° 40′.09	6° 28′.7	17963γ	17848γ	2027γ	43813γ	+ 36γ	+ 14γ	— 42γ
81	Emmen	52° 48′.75	6° 52′.27	6° 21′.0	17960γ	17850γ	1986γ	43831γ	+ 28γ	+ 25γ	— 24γ
82	Schagen	52° 48′.67	4° 45′.09	7° 27′.4	17910γ	17759γ	2324γ	43823γ	+ 31γ	+ 4γ	— 31γ
83	Wijster	52° 48′.01	6° 30′.73	6° 37′.2	17976γ	17856γ	2072γ	43818γ	+ 44γ	— 8γ	— 30γ

	Name of station	φ	λ	—D	H	X	—Y	Z	ΔX	ΔY	ΔZ
84	Medemblik	52° 47′.70	5° 05′.32	7° 13′.5	17937γ	17794γ	2256γ	43819γ	+ 44γ	+ 22γ	— 26γ
85	Steenwijk	52° 46′.90	6° 07′.79	6° 48′.6	17969γ	17843γ	2131γ	43817γ	+ 40γ	— 9γ	— 22γ
86	Benneveld	52° 46′.88	6° 44′.51	6° 25′.4	17971γ	17858γ	2010γ	43796γ	+ 28γ	+ 21γ	— 43γ
87	Blankenham	52° 46′.45	5° 52′.93	7° 18′.4	17969γ	17823γ	2285γ	43813γ	+ 27γ	—125γ	— 22γ
88	Ruinen	52° 44′.48	6° 22′.71	6° 44′.2	17980γ	17856γ	2109γ	43793γ	+ 23γ	— 23γ	— 26γ
89	Rutten	52° 45′.18	5° 43′.12	7° 01′.3	17956γ	17822γ	2195γ	43810γ	+ 24γ	— 11γ	— 14γ
90	Andijk	52° 44′.64	5° 15′.67	7° 07′.7	17973γ	17834γ	2230γ	43814γ	+ 52γ	+ 24γ	— 6γ
91	Nieuwe Niedorp	52° 44′.20	4° 53′.08	7° 23′.0	17954γ	17805γ	2307γ	43786γ	+ 36γ	+ 3γ	— 30γ
92	Klazienaveen	52° 43′.55	7° 00′.63	6° 11′.3	17986γ	17881γ	1939γ	43788γ	+ 12γ	+ 53γ	— 23γ
93	Marknesse	52° 42′.95	5° 52′.05	6° 55′.1	17983γ	17852γ	2166γ	43787γ	+ 30γ	— 2γ	— 19γ
94	Meppel	52° 41′.92	6° 10′.53	6° 48′.6	17999γ	17872γ	2134γ	43758γ	+ 28γ	— 16γ	— 40γ
95	Koedijk	52° 41′.70	4° 43′.73	7° 26′.8	17958γ	17807γ	2327γ	43767γ	+ 26γ	+ 8γ	— 28γ
96	Wognum	52° 41′.02	5° 00′.47	7° 14′.2	17980γ	17837γ	2265γ	43754γ	+ 38γ	+ 28γ	— 36γ
97	Vollenhove	52° 40′.50	5° 58′.39	6° 59′.3	17998γ	17864γ	2190γ	43753γ	+ 17γ	— 41γ	— 32γ
98	Kerkenbosch	52° 40′.47	6° 28′.03	6° 38′.9	18010γ	17889γ	2085γ	43752γ	+ 20γ	— 10γ	— 33γ
99	Oud-Schoonebeek	52° 39′.82	6° 50′.64	6° 22′.5	18004γ	17893γ	1999γ	43747γ	+ 2γ	+ 20γ	— 33γ
100	Coevorden	52° 39′.67	6° 40′.59		18008γ			43753γ			— 26γ
101	Oosterleek	52° 38′.66	5° 10′.89	7° 12′.7	18008γ	17866γ	2261γ	43740γ	+ 41γ	+ 8γ	— 30γ
102	Nagele	52° 38′.49	5° 43′.33	7° 02′.2	18001γ	17866γ	2205γ	43752γ	+ 15γ	— 17γ	— 17γ
103	Oud-Avereest	52° 37′.62	6° 17′.82	6° 42′.6	18017γ	17894γ	2105γ	43736γ	+ 11γ	— 4γ	— 25γ
104	Ursem	52° 37′.31	4° 52′.23	7° 20′.4	17995γ	17847γ	2299γ	43722γ	+ 25γ	+ 16γ	— 37γ
105	Egmond aan Zee	52° 37′.17	4° 38′.47	7° 27′.1	17978γ	17826γ	2332γ	43743γ	+ 13γ	+ 18γ	— 15γ
106	Schardam	52° 36′.20	4° 59′.81	7° 16′.1	18003γ	17858γ	2278γ	43706γ	+ 22γ	+ 19γ	— 44γ
107	Collendoorn	52° 35′.74	6° 36′.04	6° 28′.8	18030γ	17914γ	2035γ	43718γ	+ 2γ	+ 22γ	— 28γ
108	Hasselt	52° 35′.14	6° 07′.82	6° 44′.1	18036γ	17911γ	2115γ	43713γ	+ 15γ	+ 13γ	— 28γ
109	Kampen	52° 34′.41	5° 52′.76	6° 56′.5	18042γ	17910γ	2181γ	43709γ	+ 20γ	— 15γ	— 26γ
110	Akersloot	52° 33′.76	4° 44′.33	7° 26′.2	18002γ	17850γ	2330γ	43687γ	+ 7γ	+ 7γ	— 42γ
111	Nieuw-Leuzen	52° 33′.22	6° 13′.10	6° 39′.4	18036γ	17914γ	2091γ	43708γ	0γ	+ 24γ	— 17γ
112	Ommen	52° 33′.20	6° 22′.72	6° 38′.9	18045γ	17924γ	2089γ	43702γ	+ 2γ	+ 2γ	— 23γ
113	Kwadijk	52° 31′.75	4° 58′.23	7° 16′.4	18025γ	17880γ	2282γ	43680γ	+ 10γ	+ 21γ	— 33γ
114	Zwolle	52° 30′.71	6° 01′.98	6° 47′.8	18059γ	17932γ	2137γ	43686γ	+ 7γ	+ 8γ	— 17γ
115	Mariënberg	52° 29′.61	6° 33′.40	6° 33′.9	18067γ	17949γ	2066γ	43683γ	— 9γ	+ 1γ	— 12γ
116	Wijk aan Zee	52° 29′.55	4° 35′.90	7° 29′.0	18025γ	17872γ	2347γ	43667γ	+ 2γ	+ 13γ	— 27γ
117	Oosterwolde	52° 29′.22	5° 53′.65	6° 51′.9	18070γ	17940γ	2160γ	43676γ	+ 9γ	+ 6γ	— 15γ
118	Zaandijk	52° 28′.55	4° 50′.67	7° 20′.5	18033γ	17885γ	2304γ	43674γ	— 4γ	+ 20γ	— 12γ
119	Bruinehaar	52° 28′.49	6° 42′.23	6° 25′.4	18086γ	17972γ	2023γ	43683γ	— 2γ	+ 22γ	— 2γ
120	Lemelerberg	52° 28′.39	6° 24′.48	6° 38′.8	18077γ	17956γ	2092γ	43675γ	— 5γ	— 2γ	— 10γ
121	Hoonhorst	52° 28′.23	6° 14′.70	6° 43′.4	18079γ	17955γ	2117γ	43688γ	0γ	— 3γ	+ 5γ
122	Marken	52° 27′.68	5° 06′.20	7° 16′.2	18051γ	17906γ	2284γ	43641γ	— 2γ	+ 1γ	— 38γ
123	Wapenvelde	52° 26′.92	6° 06′.08	6° 44′.1	18098γ	17973γ	2122γ	43662γ	+ 14γ	+ 15γ	— 10γ
124	Beverwijk	52° 26′.73	4° 42′.02	7° 29′.0	18035γ	17882γ	2349γ	43645γ	— 16γ	— 2γ	— 26γ
125	Vasse	52° 26′.18	6° 50′.91	6° 17′.4	18109γ	18000γ	1984γ	43683γ	+ 2γ	+ 41γ	+ 17γ
126	Broek in Waterland	52° 25′.75	4° 57′.71	7° 20′.5	18055γ	17907γ	2307γ	43636γ	— 9γ	+ 1γ	— 27γ
127	Oud-Ootmarsum	52° 25′.55	6° 55′.01					43709γ			+ 48γ
128	Geesteren	52° 25′.23	6° 44′.51					43669γ			+ 11γ
129	Nunspeet	52° 24′.63	5° 46′.82	6° 56′.6	18110γ	17977γ	2189γ	43633γ	+ 15γ	— 3γ	— 20γ
130	Denekamp	52° 23′.56	7° 00′.13		18149γ			43708γ			+ 64γ
131	Heerde	52° 23′.46	5° 59′.54	6° 51′.9	18113γ	17983γ	2165γ	43636γ	+ 2γ	— 11γ	— 7γ
132	Wierden	52° 23′.20	6° 35′.47	6° 31′.4	18140γ	18023γ	2060γ	43649γ	+ 13γ	+ 4γ	+ 8γ
133	Veesen	52° 22′.85	6° 07′.07	6° 43′.4	18132γ	18008γ	2123γ	43623γ	+ 17γ	+ 13γ	— 15γ
134	Overveen	52° 22′.81	4° 36′.26	7° 28′.3	18074γ	17920γ	2350γ	43630γ	— 4γ	+ 13γ	— 8γ
135	Siemerink	52° 22′.26	6° 54′.71					43683γ			+ 49γ
136	Raalte	52° 21′.79	6° 15′.88	6° 42′.7	18146γ	18022γ	2121γ	43635γ	+ 16γ	— 7γ	+ 6γ
137	Tepelberg	52° 20′.36	5° 53′.62		18136γ			43597γ			— 21γ
138	Holterberg	52° 20′.18	6° 25′.07	6° 37′.0	18166γ	18045γ	2093γ	43623γ	+ 19γ	— 1γ	+ 7γ
139	Waveren	52° 19′.82	4° 58′.96					43621γ			+ 8γ
140	Zenderen	52° 19′.71	6° 43′.63					43613γ			+ 1γ
141	Oldenzaal	52° 19′.40	6° 56′.30	6°13′.7	18193γ	18086γ	1974γ	43655γ	+ 31γ	+ 40γ	+ 45γ
142	Muiden	52° 19′.21	5° 04′.10	7° 12′.4	18108γ	17964γ	2272γ	43621γ	— 8γ	+ 23γ	+ 13γ
143	Hoofddorp	52° 18′.92	4° 40′.35	7° 24′.3	18113γ	17962γ	2334γ	43603γ	+ 5γ	+ 21γ	— 3γ
144	Hillegom	52° 18′.26	4° 32′.52		18104γ			43613γ			+ 13γ
145	Amstelveen	52° 18′.22	4° 51′.38	7° 20′.8	18116γ	17967γ	2316γ	43596γ	— 4γ	+ 12γ	— 4γ
146	Ermelo	52° 18′.10	5° 40′.69	7° 00′.2	18129γ	17994γ	2210γ	43579γ	— 15γ	— 6γ	— 20γ
147	Rijssen	52° 17′.98	6° 31′.90					43607γ			+ 9γ
148	Naarden	52° 17′.48	5° 10′.30					43621γ			+ 27γ
149	Blaricum	52° 17′.31	5° 16′.02	7° 10′.6	18130γ	17988γ	2265γ	43598γ	— 8γ	+ 1γ	+ 6γ
150	Nieuw Vennep I	52° 17′.18	4° 39′.74					43587γ			— 4γ
151	Bofink	52° 16′.68	6° 21′.27					43599γ			+ 12γ
152	Deventer	52° 16′.60	6° 06′.75	6° 45′.2	18177γ	18051γ	2138γ	43565γ	+ 11γ	+ 2γ	— 21γ
153	Losser	52° 15′.98	7° 00′.86					43628γ			+ 47γ
154	Delden	52° 15′.97	6° 42′.30	6° 28′.4	18197γ	18081γ	2052γ	43573γ	+ 9γ	— 1γ	— 8γ
155	Nijkerk	52° 15′.62	5° 29′.75	7° 06′.1	18133γ	17994γ	2242γ	43574γ	— 25γ	— 9γ	— 4γ
156	Nieuw Vennep II	52° 15′.33	4° 37′.07					43550γ			— 26γ
157	Bathmen	52° 15′.03	6° 16′.03	6° 38′.4	18183γ	18061γ	2102γ	43573γ	+ 2γ	+ 15γ	0γ
158	Markelo	52° 14′.78	6° 29′.99	6° 33′.9	18182γ	18062γ	2079γ	43566γ	— 9γ	+ 4γ	— 5γ
159	Bunschoten	52° 14′.88	5° 23′.49	7° 07′.3	18140γ	18000γ	2249γ	43568γ	— 21γ	0γ	— 4γ
160	Kudelstaart	52° 14′.38	5° 45′.38	7° 22′.6	18150γ	18000γ	2330γ	43559γ	+ 4γ	+ 15γ	— 9γ
161	Apeldoorn	52° 13′.97	5° 50′.73	6° 55′.4	18170γ	18037γ	2190γ	43536γ	— 11γ	— 9γ	— 28γ
162	Garderen	52° 13′.55	5° 41′.39	7° 02′.4	18152γ	18016γ	2225γ		— 30γ	— 20γ	
163	Voorhout	52° 13′.40	4° 28′.38	7° 30′.6	18141γ	17986γ	2371γ	43561γ	— 5γ	+ 16γ	+ 1γ
164	Baarn	52° 13′.28	5° 15′.21					43594γ			+ 35γ
165	Verwolde	52° 13′.06	6° 25′.00					43575γ			+ 18γ
166	Abbenes	52° 13′.04	4° 36′.08	7° 27′.2	18143γ	17990γ	2353γ	43549γ	— 10γ	+ 15γ	— 7γ
167	Vinkeveen	52° 12′.97	4° 55′.00	7° 16′.9	18172γ	18025γ	2303γ	43558γ	+ 11γ	+ 18γ	+ 2γ
168	Loosdrecht	52° 12′.50	5° 05′.85	7° 10′.2	18172γ	18030γ	2268γ	43559γ	+ 4γ	+ 26γ	+ 7γ

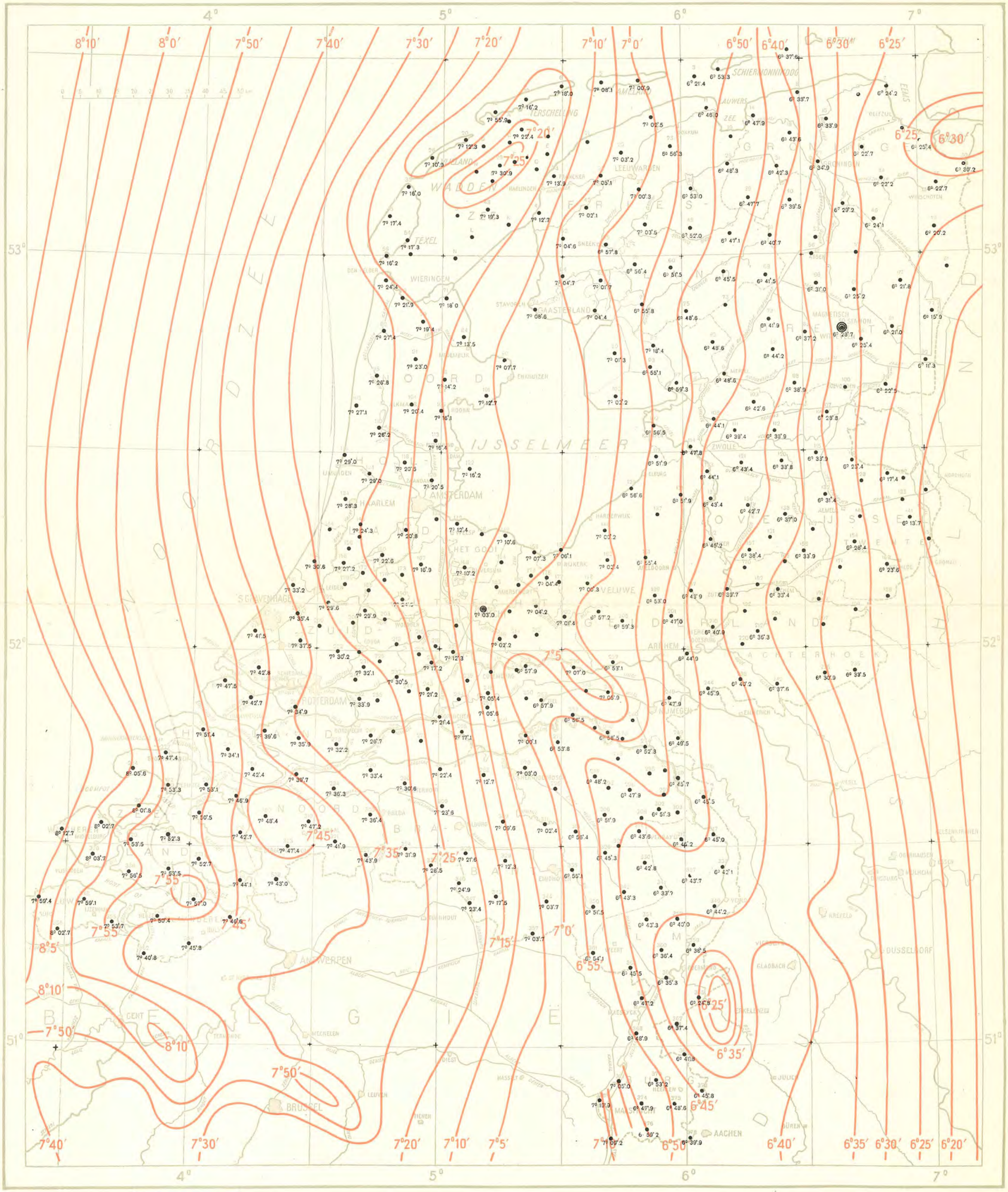
	Name of station	φ	λ	—D	H	X	—Y	Z	ΔX	ΔY	ΔZ
169	Usselo	52° 12′.43	6° 50′.38	6° 23′.6	18240γ	18126γ	2031γ	43570γ	+ 20γ	+ 2γ	+ 19γ
170	Eesterhold	52° 12′.29	6° 15′.27					43562γ			+ 11γ
171	Wegdam	52° 11′.98	6° 38′.70					43535γ			— 13γ
172	Rijnsaterwoude	52° 11′.63	4° 40′.68		18161γ			43528γ			— 17γ
173	Mijdrecht	52° 11′.43	4° 50′.42		18169γ			43533γ			— 10γ
174	Ham	52° 11′.02	5° 22′.27					43579γ			+ 39γ
175	Hoevelaken	52° 10′.98	5° 26′.16	7° 04′.4	18178γ	18039γ	2238γ	43550γ	— 15γ	+ 7γ	+ 10γ
176	Zevenhoven	52° 10′.56	4° 46′.16		18178γ			43513γ			— 23γ
177	Klaarwater	52° 10′.22	5° 29′.29					43564γ			+ 31γ
178	Voorthuizen	52° 10′.14	5° 36′.34	7° 00′.3	18185γ	18049γ	2218γ	43541γ	— 19γ	+ 1γ	+ 9γ
179	Hoogmade	52° 10′.05	4° 36′.25		18183γ						
180	Bunt	52° 09′.74	5° 19′.20					43555γ			+ 26γ
181	Wassenaar	52° 09′.68	4° 23′.64	7° 33′.2	18167γ	18010γ	2388γ	43532γ	— 7γ	+ 13γ	+ 3γ
182	Almen	52° 09′.57	6° 18′.12					43542γ			+ 14γ
183	Pijnenburg	52° 09′.51	5° 13′.94					43557γ			+ 30γ
184	Zutfen	52° 09′.06	6° 10′.75	6° 39′.7	18182γ	18059γ	2109γ	43518γ	— 43γ	+ 24γ	— 6γ
185	Aarlanderveen	52° 08′.96	4° 42′.16		18193γ			43514γ			— 9γ
186	Lochem	52° 08′.92	6° 23′.15	6° 33′.4	18226γ	18107γ	2081γ	43548γ	— 5γ	+ 22γ	+ 26γ
187	Loenen	52° 08′.84	6° 01′.80	6° 43′.9	18219γ	18093γ	2136γ	43519γ	— 4γ	+ 20γ	— 2γ
188	Buurse	52° 08′.57	6° 50′.66					43533γ			+ 13γ
189	Hoenderloo	52° 08′.11	5° 53′.13	6° 53′.0	18221γ	18090γ	2184γ	43505γ	— 6γ	— 6γ	— 11γ
190	Zegveld	52° 07′.68	4° 50′.52	7° 24′.5	18208γ	18056γ	2348γ	43491γ	+ 3γ	— 13γ	— 21γ
191	Borculo	52° 07′.33	6° 33′.40					43533γ			+ 24γ
192	Leiden	52° 07′.00	4° 32′.20	7° 29′.6	18207γ	18052γ	2374γ	43490γ	+ 8γ	+ 7γ	— 16γ
193	Woudenberg	52° 06′.23	5° 23′.42	7° 04′.2	18211γ	18072γ	2241γ	43539γ	— 17γ	+ 12γ	+ 39γ
194	De Bilt	52° 06′.06	5° 10′.62	7° 03′.0	18231γ	18093γ	2238γ	43505γ	+ 12γ	+ 47γ	+ 7γ
195	Boskoop	52° 05′.87	4° 41′.20	7° 29′.9	18226γ	18070γ	2378γ	43478γ	+ 10γ	— 19γ	— 19γ
196	Zeist	52° 05′.66	5° 16′.85					43537γ			+ 42γ
197	Lunteren	52° 05′.65	5° 39′.03	6° 57′.2	18240γ	18106γ	2208γ	43520γ	+ 1γ	+ 7γ	+ 25γ
198	Wichmond	52° 05′.60	6° 15′.18					43514γ			+ 19γ
199	Rekken	52° 05′.51	6° 42′.46		18292γ			43504γ			+ 10γ
200	Leidschendam	52° 05′.22	4° 24′.46	7° 35′.4	18196γ	18036γ	2403γ	43454γ	— 17γ	— 2γ	— 38γ
201	Woeste Hoeve	52° 04′.95	5° 56′.94	6° 47′.0	18259γ	18131γ	2157γ	43475γ	+ 7γ	+ 14γ	— 16γ
202	Scherpenzeel	52° 04′.66	5° 30′.60	7° 01′.4	18233γ	18096γ	2229γ	43508γ	— 10γ	+ 7γ	+ 21γ
203	Bodegraven	52° 04′.59	4° 45′.95		18220γ			43463γ			— 23γ
204	Stapelbroek	52° 04.′23	6° 22′.28					43519γ			+ 36γ
205	Ede	52° 04′.08	5° 44′.94	6° 59′.3	18262γ	18126γ	2222γ	43492γ	+ 4γ	— 21γ	+ 10γ
206	Waddinxveen	52° 03′.82	4° 38′.20		18225γ			43454γ			— 26γ
207	Beltrum	52° 03′.38	6° 34′.53		18287γ			43487γ			+ 11γ
208	Oudenrijn	52° 03′.34	5° 03′.94		18251γ			43432γ			— 44γ
209	Zegwaard	52° 03′.30	4° 30′.22					43444γ			— 32γ
210	Dieren	52° 03′.22	6° 07′.18	6° 40′.9	18262γ	18138γ	2125γ	43457γ	+ 43γ	+ 20γ	— 18γ
211	Loosduinen	52° 02′.62	4° 14′.48	7° 41′.5	18202γ	18038γ	2436γ	43444γ	— 27γ	— 9γ	— 27γ
212	Hengelo (Gld.)	52° 02′.43	6° 18′.05	6° 36′.3	18277γ	18156γ	2102γ	43472γ	— 4γ	+ 16γ	+ 4γ
213	Remse	52° 01′.98	5° 23′.76					43537γ			+ 73γ
214	Doorn	52° 01′.76	5° 18′.42		18272γ			43484γ			+ 21γ
215	Snelrewaard	52° 01′.64	4° 54′.79		18245γ			43430γ			— 32γ
216	Werkhoven	52° 01′.60	5° 14′.87	7° 02′.2	18278γ	18140γ	2239γ	43473γ	+ 22γ	+ 38γ	+ 12γ
217	Pijnacker	52° 01′.12	4° 25′.17	7° 37′.5	18235γ	18074γ	2420γ	43423γ	— 11γ	— 19γ	— 34γ
218	Boven-Haastrecht	52° 00′.77	4° 49′.00					43423γ			— 31γ
219	Benschop	52° 00′.50	4° 58′.78		18265γ			43411γ			— 41γ
220	Hummelo	52° 00′.44	6° 14′.26		18303γ			43454γ			+ 3γ
221	Vreeswijk	51° 59′.62	5° 03′.67	7° 12′.3	18270γ	18126γ	2291γ	43389γ	0γ	+ 15γ	— 56γ
222	Zevenhuizen	51° 59′.50	4° 35′.02	7° 30′.2	18266γ	18110γ	2385γ	43393γ	+ 5γ	— 8γ	— 51γ
223	Moordrecht	51° 59′.50	4° 40′.31					43410γ			— 34γ
224	Westervoort	51° 59′.25	6° 00′.40	6° 44′.9	18300γ	18173γ	2150γ	43443γ	+ 2γ	+ 14γ	+ 1γ
225	Polsbroek	51° 59′.22	4° 54′.81		18264γ			43407γ			— 35γ
226	Stolwijk	51° 58′.00	4° 45′.19		18270γ			43394γ			— 37γ
227	Renkum	51° 57′.90	5° 42′.59	6° 53′.1	18309γ	18178γ	2195γ	43425γ	+ 10γ	+ 15γ	— 6γ
228	Jaarsveld	51° 57′.84	4° 58′.28	7° 17′.2	18279γ	18132γ	2318γ	43393γ	— 4γ	+ 2γ	— 27γ
229	Rijswijk	51° 57′.60	5° 21′.10	6° 57′.9	18276γ	18141γ	2216γ	43472γ	— 14γ	+ 47γ	+ 44γ
230	Rhenen	51° 57′.40	5° 33′.25	7° 07′.0	18305γ	18164γ	2268γ	43476γ	— 1γ	— 35γ	+ 50γ
231	Berkenwoude	51° 57′.30	4° 41′.52	7° 32′.1	18264γ	18107γ	2395γ	43390γ	— 20γ	— 33γ	— 36γ
232	Gaag	51° 57′.25	4° 15′.46	7° 42′.8	18237γ	18072γ	2448γ	43406γ	— 37γ	— 21γ	— 19γ
233	Zoelmond	51° 56′.87	5° 19′.09					43430γ			+ 8γ
234	Culemborg	51° 56′.79	5° 12′.78					43402γ			— 19γ
235	Woold	51° 56′.39	6° 42′.25	6° 33′.5	18353γ	18233γ	2096γ	43426γ	— 8γ	— 32γ	+ 8γ
236	Aalten	51° 55′.97	6° 34′.68	6° 30′.9	18347γ	18228γ	2082γ	43419γ	+ 5γ	— 2γ	+ 5γ
237	Schoonhoven	51° 55′.81	4° 49′.24	7° 30′.5	18272γ	18116γ	2388γ	43377γ	— 29γ	— 44γ	— 37γ
238	Hettenheuvel	51° 55′.28	6° 14′.10	6° 40′.2	18327γ	18203γ	2129γ	43413γ	— 10γ	+ 3γ	+ 4γ
239	Schoonrewoerd	51° 55′.26	5° 06′.74					43389γ			— 20γ
240	Ouderkerk	51° 55′.22	4° 39′.52		18264γ			43359γ			— 50γ
241	Oostvoorne	51° 54′.91	4° 07′.15	7° 47′.5	18241γ	18072γ	2473γ	43374γ	— 49γ	— 23γ	— 32γ
242	Silvolde	51° 54′.35	6° 22′.92	6° 37′.6	18350γ	18228γ	2118γ	43413γ	+ 2γ	— 7γ	+ 12γ
243	Noordeloos	51° 53′.97	4° 57′.37	7° 21′.2	18306γ	18156γ	2343γ	43366γ	— 9γ	— 18γ	— 32γ
244	Aerdt	51° 53′.70	6° 05′.97	6° 45′.9	18331γ	18203γ	2159γ	43398γ	— 15γ	— 6γ	+ 2γ
245	Druten	51° 53′.60	5° 36′.20					43432γ			+ 37γ
246	Winsum	51° 53′.57	5° 41′.28	7° 05.′9	18334γ	18194γ	2266γ	43407γ	— 7γ	— 51γ	+ 13γ
247	Ottoland	51° 53′.54	4° 52′.47					43346γ			— 48γ
248	Beesd I	51° 53′.24	5° 12′.10	7° 05′.4				43337γ			— 55γ
249	Gent	51° 52′.60	5° 56′.29	6° 47′.9	18360γ	18230γ	2173γ	43382γ	+ 10γ	+ 5γ	— 4γ
250	Wadenoijen	51° 52′.52	5° 21′.28					43340γ			— 46γ
251	Zwartewaal	51° 52′.50	4° 13′.70	7° 42′.7	18240γ	18076γ	2448γ	43364γ	— 68γ	— 13γ	— 22γ
252	Alblasserdam	51° 52′.39	4° 40′.48	7° 33′.9	18291γ	18131γ	2408γ	43363γ	— 34γ	— 40γ	— 22γ
253	Tiel	51° 52′.32	5° 25′.12	6° 57′.9	18361γ	18225γ	2226γ	43363γ	+ 26γ	+ 30γ	— 21γ

	Name of station	φ	λ	—D	H	X	—Y	Z	ΔX	ΔY	ΔZ
254	Heukelum	51° 52′.28	5° 04′.81					43352γ			— 32γ
255	Bleskensgraaf	51° 52′.20	4° 45′.09		18287γ			43356γ			— 27γ
256	Rhoon	51° 51′.10	4° 24′.58	7° 34′.9	18269γ	18109γ	2410γ	43333γ	— 54γ	— 2γ	— 41γ
257	Beesd II	51° 51′.05	5° 11′.79	7° 05′.6	18334γ	18194γ	2264γ		— 5γ	+ 26γ	
258	Appeltern	51° 50′.05	5° 32′.99	6° 56′.5	18374γ	18240γ	2221γ	43394γ	+ 17γ	+ 17γ	+ 29γ
259	Dalem	51° 49′.62	5° 00′.00	7° 21′.4	18327γ	18176γ	2347γ	43324γ	— 25γ	— 27γ	— 38γ
260	Hoogbroek	51° 49′.03	5° 47′.36					43351γ			— 6γ
261	Dennenburg	51° 48′.16	5° 38′.30					43384γ			+ 34γ
262	Biesbosch	51° 47′.66	4° 49′.24					43332γ			— 13γ
263	Stellendam	51° 47′.55	4° 02′.34	7° 51′.4	18270γ	18098γ	2497γ	43286γ	— 76γ	— 32γ	— 58γ
264	Goudswaard	51° 47′.50	4° 17′.24	7° 39′.6	18278γ	18115γ	2436γ	43300γ	— 71γ	— 8γ	— 44γ
265	Aalst	51° 47′.47	5° 05′.66	7° 17′.1	18341γ	18193γ	2326γ	43299γ	— 29γ	— 19γ	— 45γ
266	Neerloon	51° 47′.27	5° 41′.45	6° 58′.5	18392γ	18256γ	2233γ	43361γ	+ 5γ	— 16γ	+ 19γ
267	Kop van het Land	51° 46′.84	4° 43′.43	7° 26′.7	18363γ	18208γ	2379γ	43322γ	— 3γ	— 16γ	— 17γ
268	Alem	51° 46′.74	5° 21′.33	7° 00′.1	18384γ	18247γ	2241γ	43317γ	+ 7γ	+ 28γ	— 21γ
269	Groesbeek	51° 46′.52	5° 58′.91	6° 49′.5	18449γ	18318γ	2192γ	43314γ	+ 48γ	— 17γ	— 22γ
270	Nederasselt	51° 46′.46	5° 45′ 16					43349γ			+ 14γ
271	Klaaswaal	51° 46′.34	4° 25′.48	7° 35′.9	18291γ	18130γ	2418γ	43307γ	— 71γ	— 10γ	— 27γ
272	Nieuwendijk	51° 46′.08	4° 55′.57					43293γ			— 40γ
273	Oss	51° 45′.96	5° 29′.13	6° 53′.8	18407γ	18273γ	2210γ	43322γ	+ 21γ	+ 39γ	— 9γ
274	Heumen	51° 45′.52	5° 50′.55	6° 52′.3	18378γ	18246γ	2199γ	43315γ	— 26γ	— 3γ	— 13γ
275	Strijen	51° 45′.33	4° 35′.08	7° 32′.2	18302γ	18143γ	2400γ	43301γ	— 73γ	— 16γ	— 25γ
276	Sommelsdijk	51° 44′.67	4° 08′.49	7° 34′.1	18294γ	18134γ	2409γ	43268γ	— 67γ	+ 43γ	— 52γ
277	Brouwershaven	51° 43′.85	3° 53′.42	7° 47′.4	18273γ	18104γ	2477γ	43297γ	— 93γ	+ 12γ	— 17γ
278	Lageheide	51° 43′.24	5° 44′.11					43325γ			+ 17γ
279	Hintham	51° 41′.85	5° 21′.29	7° 03′.0	18405γ	18266γ	2259γ	43263γ	— 12γ	+ 12γ	— 34γ
280	Hooge Zwaluwe	51° 41′.59	4° 43′.70	7° 33′.4	18357γ	18198γ	2414γ	43267γ	— 54γ	— 49γ	— 28γ
281	Capelle	51° 41′.54	5° 00′.56	7° 22′.4	18377γ	18225γ	2358γ	43255γ	— 40γ	— 35γ	— 39γ
282	Oeffelt	51° 41′.53	5° 55′ 40					43302γ			+ 8γ
283	Zuidzijde	51° 41′.53	4° 14′.56	7° 42′.4	18298γ	18132γ	2454γ	43255γ	— 99γ	— 16γ	— 39γ
284	Haamstede	51° 41′.46	3° 45′.83	8° 05′.6	18266γ	18084γ	2572γ	43309γ	—125γ	— 62γ	+ 15γ
285	Haps	51° 41′.06	5° 51′.33					43320γ			+ 30γ
286	Willemstad	51° 40′.79	4° 25′.27	7° 39′.7	18317γ	18154γ	2442γ	43295γ	— 90γ	— 30γ	+ 7γ
287	Uden	51° 40′.70	5° 38′.51	6° 48′.2	18431γ	18301γ	2183γ	43284γ	— 1γ	+ 46γ	— 3γ
288	Nieuwkuik	51° 40′.68	5° 11′.11	7° 12′.7	18408γ	18262γ	2311γ	43242γ	— 17γ	— 14γ	— 45γ
289	Gennep	51° 40′.26	5° 58′.35	6° 45′.7	18421γ	18293γ	2169γ	43287γ	— 26γ	+ 10γ	+ 3γ
290	Oosterhout	51° 39′.76	4° 51′.90	7° 30′.6	18381γ	18223γ	2402γ	43257γ	— 50γ	— 57γ	— 23γ
291	Oosterland	51° 39′.24	4° 03′.43	7° 53′.1	18285γ	18112γ	2508γ	43250γ	—129γ	— 42γ	— 25γ
292	Zierikzee	51° 38′.93	3° 54′.29	7° 53′.3	18290γ	18117γ	2510γ	43289γ	—119γ	— 20γ	+ 17γ
293	Oosterheide	51° 38′.82	5° 41′.85					43280γ			+ 8γ
294	Zevenbergen	51° 38′.71	4° 34′.78	7° 36′.3	18357γ	18196γ	2429γ	43283γ	— 72γ	— 40γ	+ 13γ
295	Dinther	51° 38′.63	5° 28′.66		18438γ			43239γ			— 31γ
296	Wanroy	51° 38′.54	5° 46′,88	6° 47′.9	18440γ	18310γ	2183γ	43305γ	— 13γ	+ 26γ	+ 36γ
297	St. Anthonis	51° 37′.82	5° 55′.12					43299γ			+ 35γ
298	Eckel	51° 37′.53	6° 05′.02	6° 45′.5	18445γ	18317γ	2171γ	43270γ	— 28γ	— 8γ	+ 9γ
299	St. Philipsland	51° 37′ 36	4° 10′.84	7° 46′.9	18307γ	18138γ	2479γ	43251γ	—122γ	— 30γ	— 8γ
300	Tilburg	51° 35′.81	5° 01′.28	7° 23′.6	18418γ	18265γ	2370γ	43203γ	— 45γ	— 46γ	— 43γ
301	Wissekerke	51° 35′.69	3° 47′.54	8° 01′.8	18310γ	18131γ	2558γ	43301γ	—125γ	— 50γ	+ 55γ
302	Oploo	51° 35′.65	5° 53′.82	6° 51′.3	18461γ	18329γ	2203γ	43276γ	— 22γ	— 11γ	+ 30γ
303	Overloon	51° 35′.04	5° 58′.41					43275γ			+ 35γ
304	Stavenisse	51° 34′.88	4° 02′.06	7° 50′.5	18314γ	18143γ	2499γ	43265γ	—131γ	— 26γ	+ 26γ
305	Princenhage	51° 34′.79	4° 43′.56	7° 36′.4	18397γ	18235γ	2435γ		— 71γ	— 66γ	
306	Gemert	51° 34′.70	5° 40′.78	6° 51′.9	18467γ	18334γ	2207γ	43235γ	— 15γ	+ 19γ	— 2γ
307	Steenbergen	51° 34′.62	4° 18′.10	7° 48′.4	18354γ	18184γ	2493γ	43253γ	—104γ	— 60γ	+ 16γ
308	Bunthorst	51° 34′.38	5° 49′.37					43262γ			+ 27γ
309	Boxtel	51° 33′.82	5° 16′.12	7° 09′.6	18442γ	18298γ	2299γ	43183γ	— 39γ	— 11γ	— 47γ
310	Roosendaal	51° 33′.80	4° 28′.52	7° 47′.2	18358γ	18189γ	2487γ	43253γ	—112γ	— 80γ	+ 23γ
311	St. Oedenrode	51° 33′.28	5° 26′.04	7° 02′.4	18465γ	18326γ	2263γ	43180γ	— 23γ	0γ	— 45γ
312	Veere	51° 33′.09	3° 38′.37	8° 02′.7	18325γ	18145γ	2565γ	43293γ	—124γ	— 33γ	+ 69γ
313	Mariahout	51° 32′.24	5° 33′.72	6° 56′.4	18482γ	18346γ	2233γ	43178γ	— 17γ	+ 12γ	— 39γ
314	De Rips	51° 32′.13	5° 49′.07	6° 43′.6	18498γ	18370γ	2167γ	43222γ	— 5γ	+ 39γ	+ 7γ
315	West-Kapelle	51° 31′.88	3° 29′.13	8° 12′.7	18331γ	18143γ	2618γ	43303γ	—129γ	— 62γ	+ 89γ
316	Tholen	51° 31′.86	4° 12′.09	7° 42′.7	18314γ	18148γ	2457γ	43239γ	—156γ	— 8γ	+ 26γ
317	Blitterswijk	51° 31′.81	6° 07′.18	6° 45′.0	18490γ	18362γ	2173γ	43235γ	— 29γ	— 12γ	+ 22γ
318	Goes	51° 31′.32	3° 54′.56	7° 52′.3	18339γ	18166γ	2512γ	43291γ	—130γ	— 20γ	+ 82γ
319	Venray	51° 31′.08	5° 59′.49	6° 45′.2	18506γ	18378γ	2176γ	43219γ	— 14γ	+ 4γ	+ 11γ
320	Arendskerke	51° 30′.54	3° 45′.53	7° 53′.5	18350γ	18177γ	2519γ	43288γ	—117γ	— 3γ	+ 86γ
321	Schijf	51° 30′.58	4° 35′.31	7° 41′.9	18372γ	18207γ	2461γ	43218γ	—125γ	— 69γ	+ 15γ
322	Bakel	51° 30′.05	5° 44′.49					43200γ			+ 2γ
323	Wouw	51° 29′.93	4° 23′.70	7° 47′.4	18342γ	18173γ	2486γ	43261γ	—156γ	— 65γ	+ 63γ
324	Chaam	51° 29′.50	4° 52′.34	7° 31′.9	18414γ	18256γ	2414γ	43174γ	— 97γ	— 65γ	— 20γ
325	Hilvarenbeek	51° 29′.01	5° 06′.98	7° 21′.6	18463γ	18311γ	2365γ	43157γ	— 57γ	— 52γ	— 33γ
326	Helmond	51° 28′.96	5° 40′.56	6° 45′.3	18493γ	18364γ	2175γ	43161γ	— 29γ	+ 55γ	— 28γ
327	Waaijenberg	51° 28′.42	4° 42′.79	7° 43′.9	18397γ	18230γ	2475γ	43195γ	—124γ	—101γ	+ 11γ
328	Oost-Souburg	51° 28′.25	3° 36′.69	8° 03′.7	18358γ	18177γ	2574γ	43279γ	—130γ	— 35γ	+ 96γ
329	Oostelbeers	51° 27′.84	5° 16′.54	7° 12′.3	18494γ	18348γ	2320γ	43139γ	— 36γ	— 30γ	— 41γ
330	Deurne	51° 27′.54	5° 50′.36	6° 42′.8	18513γ	18386γ	2164γ	43179γ	— 26γ	+ 41γ	+ 1γ
331	Kruiningen	51° 27′.48	4° 02′.15	7° 52′.7	18364γ	18191γ	2517γ	43282γ	—141γ	— 41γ	+105γ
332	Baarle Nassau	51° 27′.05	4° 58′.73	7° 28′.5	18467γ	18310γ	2402γ		— 67γ	— 68γ	
333	Houthuizen	51° 26′.69	6° 09′.23	6° 42′.1	18520γ	18393γ	2161γ	43189γ	— 40γ	— 2γ	+ 19γ
334	Hoedekenskerke	51° 26′.24	3° 54′.89	7° 53′.5	18381γ	18207γ	2524γ	43282γ	—129γ	— 29γ	+114γ
335	Geldrop	51° 26′.21	5° 32′.54	6° 55′.1	18518γ	18383γ	2231γ	43119γ	— 26γ	+ 20γ	— 48γ
336	Borselen	51° 25′.65	3° 45′.56	7° 56′.5	18386γ	18210γ	2540γ	43289γ	—123γ	— 22γ	+127γ
337	Sevenum	51° 25′.43	6° 01′.43	6° 43′.7	18526γ	18398γ	2171γ	43153γ	— 34γ	+ 7γ	— 7γ
338	Woensdrecht	51° 24′.68	4° 21′.03	7° 43′.0	18409γ	18242γ	2472γ	43305γ	—126γ	— 42γ	+151γ

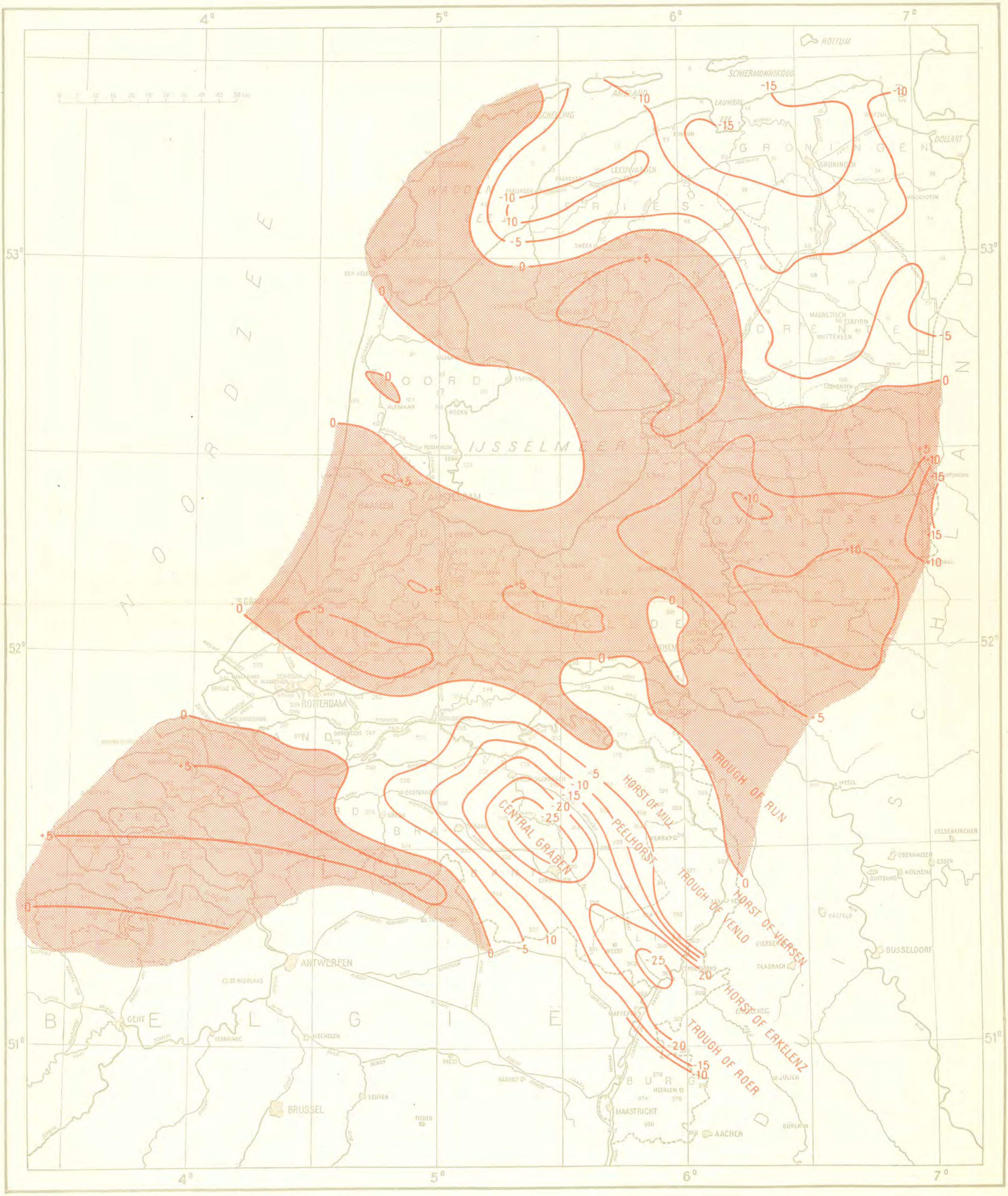
	Name of station	φ	λ	—D	H	X	—Y	Z	ΔX	ΔY	ΔZ
339	Rilland-Bath	51° 24′.58	4° 12′.48	7° 44′.1	18419γ	18252γ	2479γ	43279γ	—110γ	— 27γ	+123γ
340	De Utrecht	51° 24′.31	5° 05′.22	7° 24′.9	18501γ	18346γ	2388γ	43133γ	— 58γ	— 68γ	— 18γ
341	Helenaveen	51° 23′.52	5° 54′.23	6° 33′.7	18537γ	18416γ	2118γ	43168γ	— 31γ	+ 79γ	+ 24γ
342	Heusden	51° 22′.97	5° 45′.38	6° 43′.3	18533γ	18406γ	2169γ	43126γ	— 38γ	+ 52γ	— 13γ
343	Bladel	51° 22′.31	5° 14′.27	7° 17′.5	18530γ	18380γ	2352γ	43089γ	— 47γ	— 54γ	— 45γ
344	Valkenswaard	51° 21′.68	5° 26′.73	7° 03′.7	18545γ	18405γ	2280γ	43074γ	— 35γ	— 13γ	— 53γ
345	Cadzand	51° 21′.62	3° 24′.05	7° 59′.4	18482γ	18303γ	2569γ	43286γ	— 46γ	+ 5γ	+158γ
346	Hengstdijk	51° 21′.62	4° 01′.18	7° 57′.0				43255γ			+127γ
347	Reusel	51° 21′.22	5° 07′.88	7° 23′.4	18528γ	18374γ	2383γ	43096γ	— 56γ	— 69γ	— 29γ
348	Schoondijke	51° 21′.18	3° 34′.79	7° 59′.1	18463γ	18284γ	2565γ	43309γ	— 76γ	— 18γ	+185γ
349	Tegelen	51° 20′.77	6° 07′.28	6° 44′.2	18547γ	18419γ	2176γ	43134γ	— 58γ	+ 9γ	+ 13γ
350	Sterksel	51° 20′.70	5° 37′.65	6° 51′.5	18546γ	18413γ	2215γ	43076γ	— 43γ	+ 26γ	— 44γ
351	Nieuw-Namen	51° 18′.96	4° 10′.18	7° 46′.6	18486γ	18316γ	2501γ	43230γ	— 88γ	— 40γ	+124γ
352	Helden	15° 18′.84	5° 58′.24	6° 40′.0	18553γ	18427γ	2154γ	43144γ	— 59γ	+ 36γ	+ 41γ
353	Zaamslag	51° 18′.70	3° 52′.38	7° 50′.4	18516γ	18342γ	2526γ	43249γ	— 51γ	— 21γ	+145γ
354	Nederweert	51° 18′.65	5° 50′.83	6° 43′.3	18565γ	18438γ	2173γ	43110γ	— 44γ	+ 36γ	+ 6γ
355	Biervliet	51° 17′.92	3° 41′.39	7° 53′.7	18551γ	18375γ	2548γ	43285γ	— 16γ	— 15γ	+188γ
356	Aardenburg	51° 16′.62	3° 28′.80	8° 02′.7	18567γ	18384γ	2598γ	43203γ	— 8γ	— 33γ	+116γ
357	Schaft	51° 16′.36	5° 23′.51	7° 03′.7	18572γ	18431γ	2283γ	43033γ	— 49γ	— 5γ	— 52γ
358	Hulst	51° 15′.06	4° 00′.20	7° 45′.8	18531γ	18361γ	2503γ	43274γ	— 66γ	— 16γ	+200γ
359	Swalmen	51° 15′.05	6° 02′.52	6° 38′.5	18560γ	18436γ	2147γ	43160γ	— 83γ	+ 33γ	+ 86γ
360	Heythuizen	51° 14′.49	5° 54′.23	6° 36′.4	18586γ	18462γ	2138γ	43086γ	— 56γ	+ 64γ	+ 17γ
361	Dorplein	51° 13′.88	5° 37′.57	6° 54′.1	18575γ	18440γ	2232γ	43022γ	— 69γ	+ 12γ	— 42γ
362	Sas van Gent	51° 13′.52	3° 49′.76	7° 40′.8	18594γ	18427γ	2485γ	43193γ	— 4γ	+ 29γ	+132γ
363	Hunsel	51° 11′.73	5° 47′.13	6° 45′.5	18579γ	18450γ	2186γ	43019γ	— 83γ	+ 35γ	— 26γ
364	Luine	51° 10′.00	5° 55′ 39	6° 35′.3	18633γ	18510γ	2138γ	43043γ	— 44γ	+ 64γ	+ 12γ
365	Posterholt	51° 06′.96	6° 03′.40	6° 24′.8	18639γ	18522γ	2082γ	43141γ	— 62γ	+101γ	+135γ
366	Ohé	51° 06′.86	5° 49′.16	6° 47′.2	18598γ	18468γ	2198γ	43027γ	—106γ	+ 21γ	+ 22γ
367	Koningsbosch	51° 03′.04	5° 57′.72	6° 37′.4	18687γ	18562γ	2155γ	43034γ	— 47γ	+ 44γ	+ 60γ
368	Born	51° 01′.70	5° 47′.82	6° 48′.9	18668γ	18536γ	2215γ	43006γ	— 77γ	+ 9γ	+ 44γ
369	Schinveld	50° 58′.60	5° 59′.62	6° 41′.8	18762γ	18634γ	2188γ	42988γ	— 12γ	+ 9γ	+ 51γ
370	Nuth	50° 54′.54	5° 53′.03	6° 53′.2	18795γ	18660γ	2254γ	42977γ	— 13γ	— 39γ	+ 74γ
371	Geulle	50° 54′.51	5° 43′.95	7° 05′.0	18740γ	18597γ	2311γ	43061γ	— 69γ	— 73γ	+158γ
372	Kerkrade	50° 52′.82	6° 03′.67	6° 45′.8	18798γ	18667γ	2214γ	42908γ	— 27γ	— 24γ	+ 19γ
373	Maastricht	50° 51′.52	5° 38′.63	7° 19′.9	18822γ	18668γ	2402γ	43106γ	— 18γ	—150γ	+229γ
374	Valkenburg	50° 51′.03	5° 49′.50	6° 47′.9	18834γ	18701γ	2229γ	42909γ	+ 3γ	— 4γ	+ 38γ
375	Ubachsberg	50° 50′.78	5° 57′.21	6° 48′.6	18805γ	18673γ	2230γ	42892γ	— 32γ	— 23γ	+ 20γ
376	Slenaken	50° 46′.96	5° 50′.62	6° 59′.2	18790γ	18651γ	2286γ	42845γ	— 79γ	— 62γ	+ 6γ
377	Eijsden	50° 45′.87	5° 41′.54	7° 09′.2	18826γ	18680γ	2344γ	42817γ	— 52γ	— 96γ	— 14γ
378	Vaals	50° 45′.84	6° 00′.74	6° 39′.9	18801γ	18674γ	2182γ	42887γ	— 73γ	+ 18γ	+ 58γ
A	Oosterom	53° 20′.70	5° 16′.20	(7° 18′)	17651γ	17508γ	2243γ	44211γ	+ 8γ	— 9γ	+ 90γ
B	N. O. Meep	53° 18′.50	5° 26′.30	(7° 18′)	17722γ	17578γ	2252γ	44149γ	+ 53γ	— 42γ	+ 47γ
C	Franekergat	53° 17′.40	5° 16′.30	(7° 25′)	17701γ	17552γ	2285γ	44181γ	+ 26γ	— 50γ	+ 88γ
D	Schieringhals	53° 16′.80	5° 09′.70	(7° 18′)	17662γ	17519γ	2244γ	44213γ	— 6γ	+ 9γ	+124γ
E	N. O. Ballastplaat	53° 15′.75	5° 26′.20	(7° 17′)	17755γ	17612γ	2251γ	44104γ	+ 66γ	— 40γ	+ 24γ
F	Oost v. Griend	53° 14′.50	5° 17′.50	(7° 26′)	17743γ	17594γ	2295γ	44136γ	+ 44γ	— 61γ	+ 67γ
G	Z. Ballastplaat	53° 13′.40	5° 23′.10	(7° 17′)	17757γ	17614γ	2254γ	44083γ	+ 52γ	— 34γ	+ 23γ
H	W. v. Inschot	53° 13′.00	5° 08′.00	(7° 26′)	17717γ	17568γ	2292γ	44261γ	+ 14γ	— 33γ	+205γ
I	Lange Zand	53° 11′.50	5° 12′.10					44247γ			+203γ
J	N. v. Scheurrak	53° 06′.30	5° 03′.20	(7° 19′)	17882γ	17736γ	2280γ	44071γ	+133γ	— 6γ	+ 71γ
K	Einde Doove Balg	53° 04′.90	5° 16′.25					43993γ			+ 4γ
L	Stompe Waard	53° 02′.90	5° 07′.10					43984γ			+ 12γ
M	Harde Bollen	53° 00′.33	4° 51′.65	(7° 17′)	17863γ	17719γ	2265γ	43926γ	+ 78γ	+ 41γ	— 25γ
N	Lutjeswaard	52° 59′.70	5° 02′.70	(7° 17′)	17881γ	17737γ	2267γ	43921γ	+ 82γ	+ 11γ	+ 12γ



Δ-CHART. GEOMAGNETIC ANOMALIES IN THE NETHERLANDS. RED ARE POSITIVE REGIONS (TOO LARGE VALUE OF THE VERTICAL COMPONENT), WHITE ARE NEGATIVE REGIONS (TOO SMALL VALUE OF THE VERTICAL COMPONENT). THE FIGURES GIVE VALUES OF ΔZ (IN γ), THE VECTORS INDICATE THE DIRECTION AND THE MAGNITUDE OF THE HORIZONTAL DEVIATIONS. THE ISANOMALS OF ΔZ HAVE BEEN DRAWN FOR EVERY 20γ.

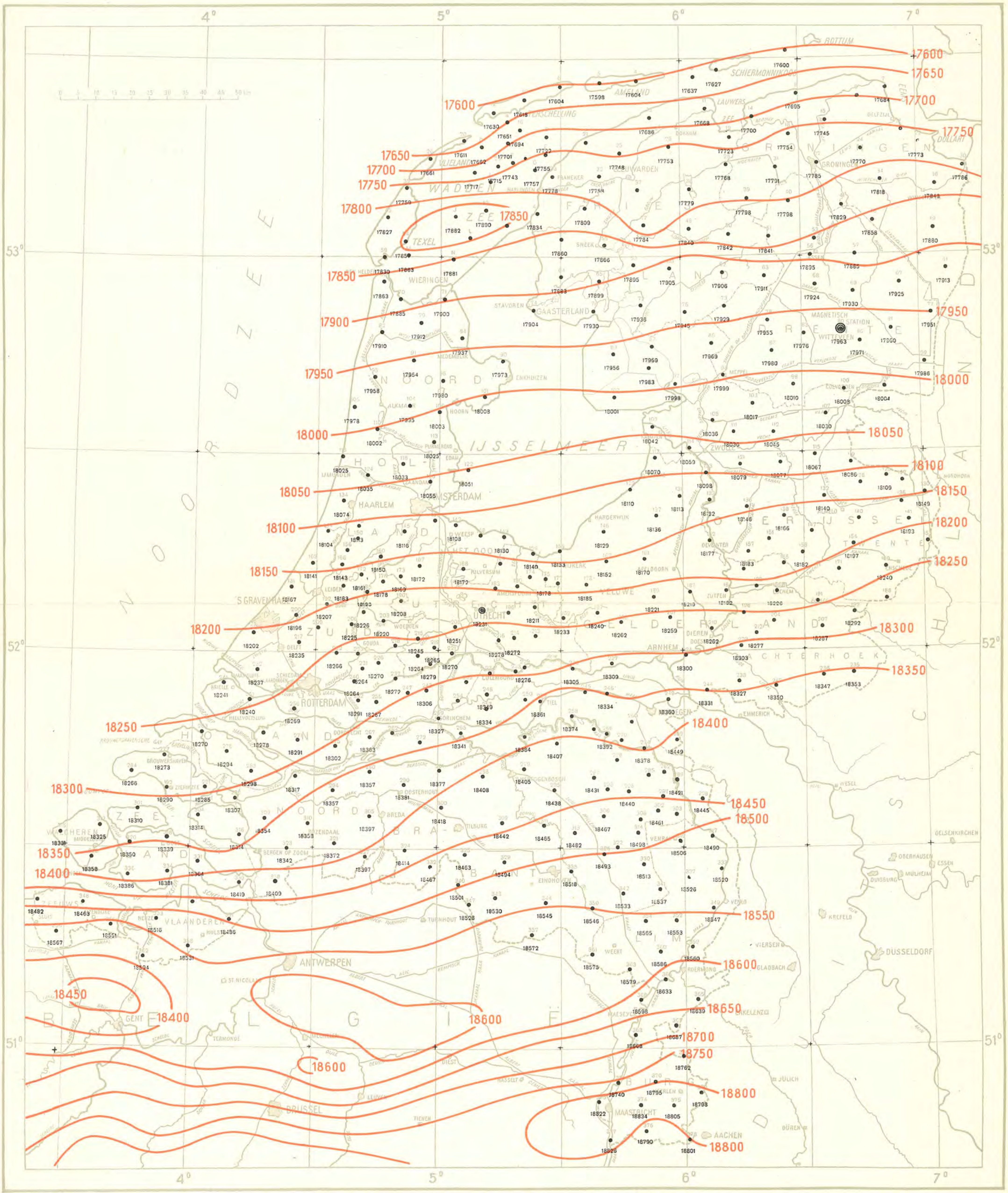


D-CHART. WESTERLY DECLINATION OF THE GEOMAGNETIC FIELD IN THE NETHERLANDS, EPOCH 1945.0. ANNUAL DECREASE ABOUT 8′.

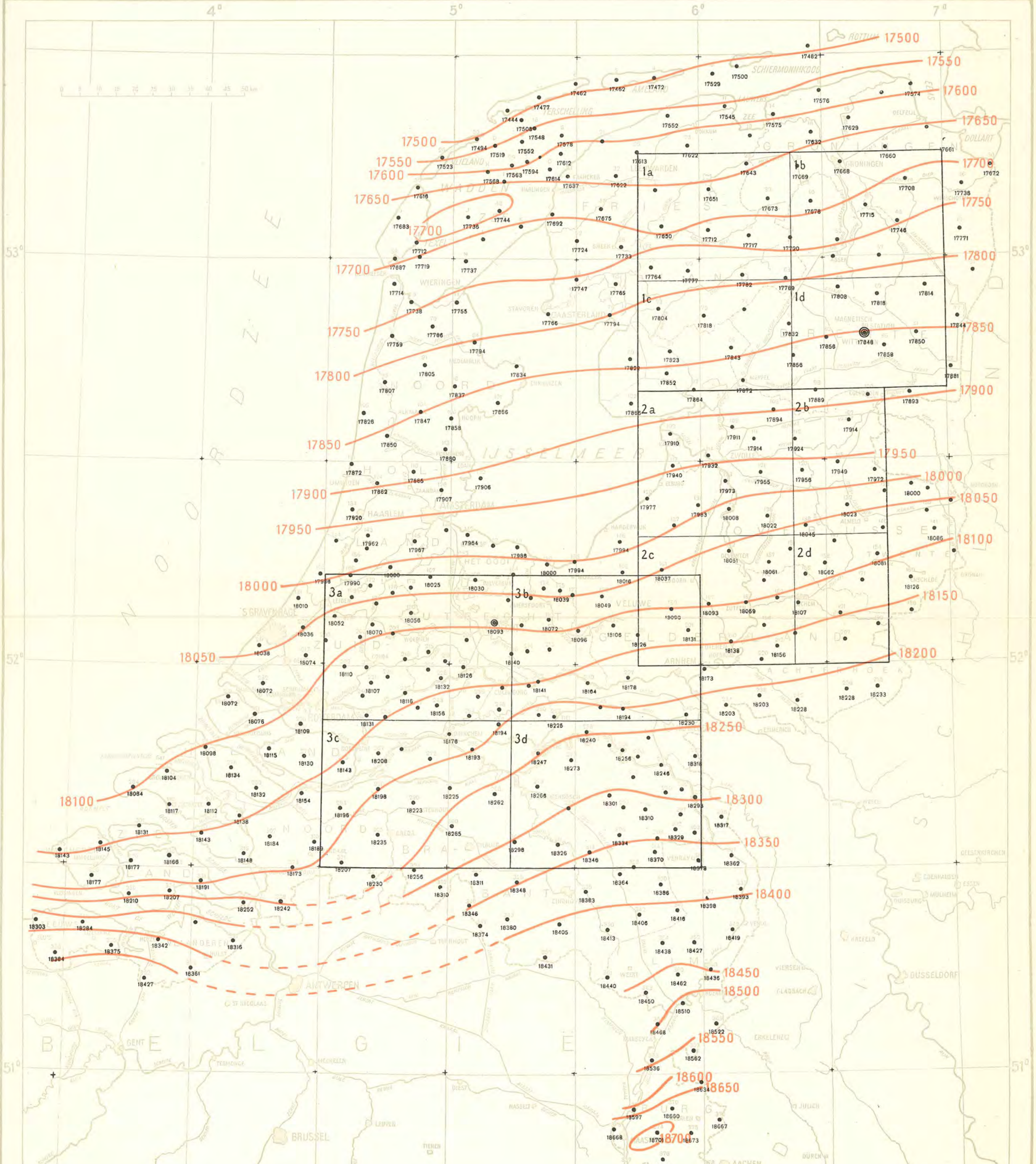


G-CHART. GRAVITY ANOMALIES (IN MGAL) IN THE NETHERLANDS. RED ARE POSITIVE REGIONS, WHITE ARE NEGATIVE REGIONS. THE ISOGAMS HAVE BEEN DRAWN FOR EVERY 5 MGAL.

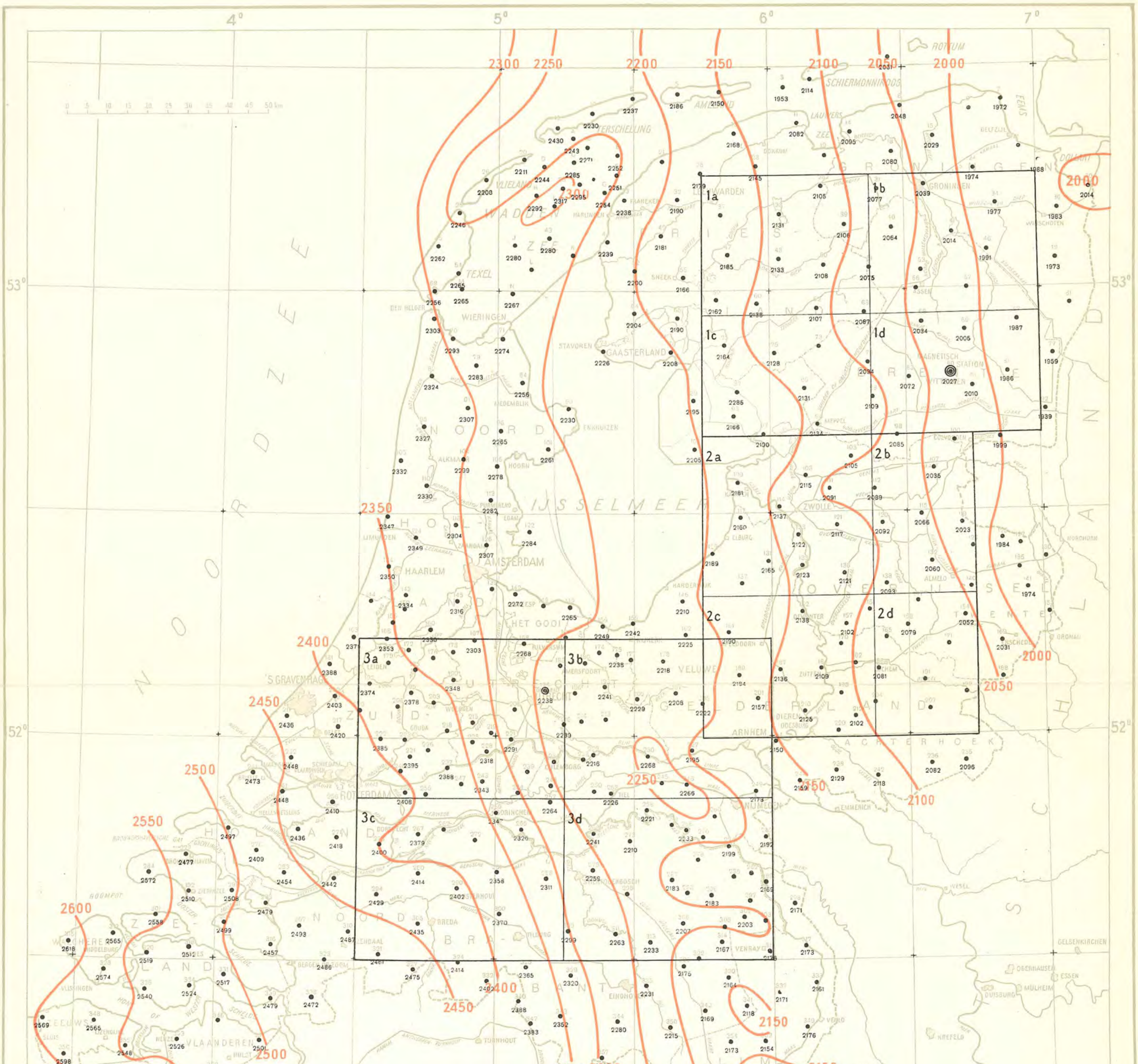
This chart was supplied by the Bataafse Petroleum Maatschappij.



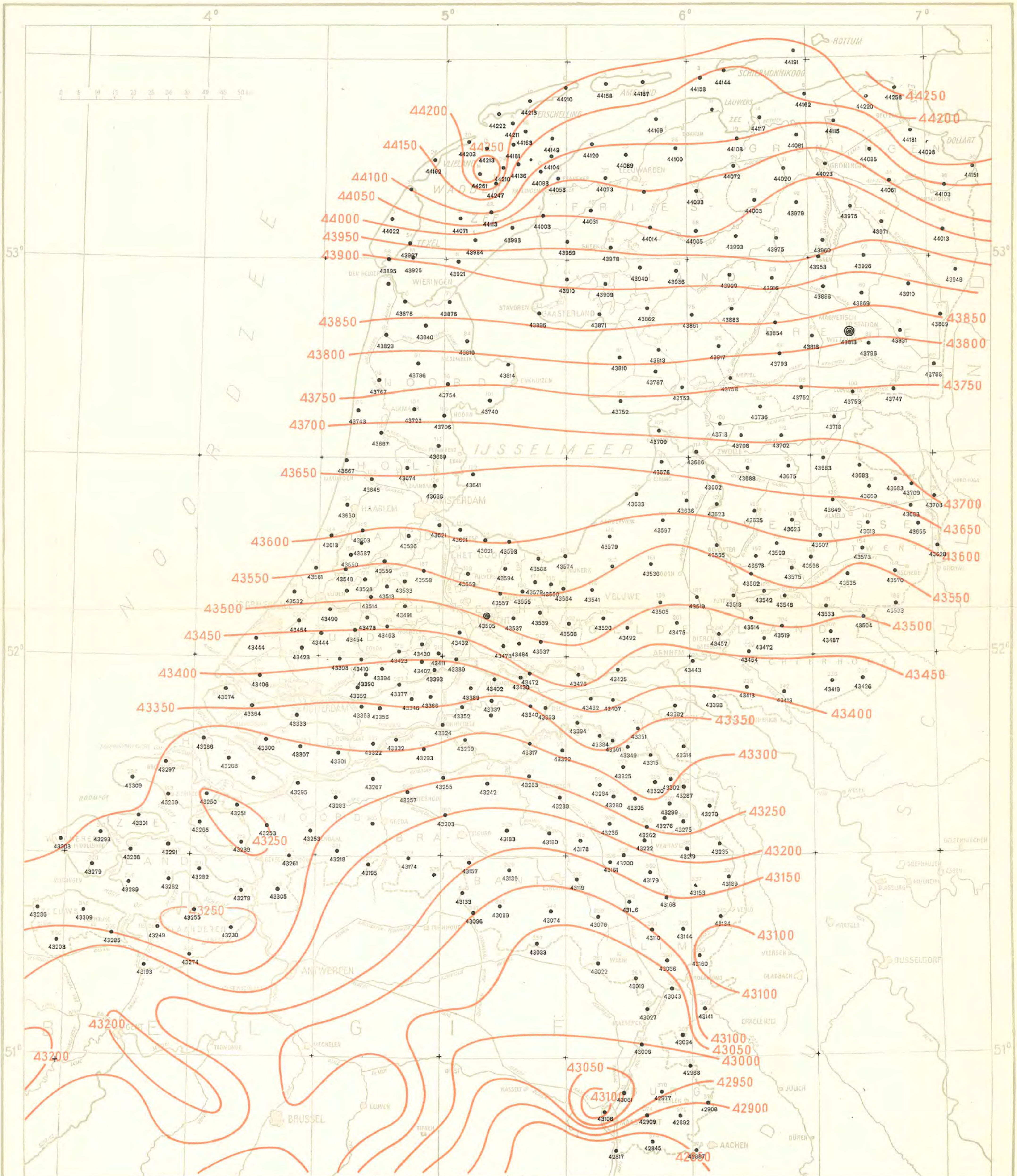
H-CHART. HORIZONTAL INTENSITY (IN γ) OF THE GEOMAGNETIC FIELD IN THE NETHERLANDS, EPOCH 1945.0. ANNUAL CHANGE ABOUT 0γ.



X-CHART. NORTHERLY COMPONENT (IN γ) OF THE GEOMAGNETIC FIELD IN THE NETHERLANDS, EPOCH 1945.0. ANNUAL CHANGE ABOUT 0γ.
IN THE TRAPEZIA THE AIR-EARTH CURRENTS HAVE BEEN COMPUTED.



Y-CHART. WESTERLY COMPONENT (IN γ) OF THE GEOMAGNETIC FIELD IN THE NETHERLANDS, EPOCH 1945.0. ANNUAL DECREASE ABOUT 50γ.
IN THE TRAPEZIA THE AIR-EARTH CURRENTS HAVE BEEN COMPUTED.



Z-CHART. VERTICAL COMPONENT (IN γ) OF THE GEOMAGNETIC FIELD IN THE NETHERLANDS, EPOCH 1945.0. ANNUAL INCREASE ABOUT 25γ.