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An eighteenth-century medical–meteorological society in the Netherlands: an investigation of early organization, instrumentation and quantification. Part 2

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Tools for quantification: the reception of new instruments

One of the most fascinating experiences gained by the meteorological observers of the Correspondentie Sociëteit concerned the practical use of new instruments. In the period after 1775 renewed interest in meteorology had stimulated the development of various new meteorological instruments. These instruments seemed at first to be a welcome addition or improvement in quantitative meteorology. How did the Correspondentie Sociëteit cope with these new developments? What factors determined whether or not the instruments were accepted as a useful addition to instruments already available? Four examples will be used to illustrate how this issue was tackled.

The spiral thermometer

The spiral thermometer was introduced to the Netherlands in 1778. The promoter of this instrument was the 'highly skilled' Austrian 'weatherglass maker' Carlo Bianchi. The instrument was developed in Vienna in 1767 by Jacob Bianchi, possibly the father of the Dutch producer.[1] Bianchi's spiral thermometer was distinguished from the standard

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1 Bianchi's spiral thermometer was announced in the *Amsterdamsche Courant*, 31 December 1778 and 9 January 1779, and reprinted in other newspapers, such as the *Middelburgsche Courant*, 12 January 1779. A copy made by Bianchi of Amsterdam is at the Conservatoire National des Arts et Métiers in Paris; see B. Bolle, *Barometers in beeld*, Lochem-Poperinge, 1983, Figure 462. A similar instrument at the Deutsches Museum in Munich is signed, 'Thermometre selon Réaumur inventé et fait par Bianchy Vienne, 1767'. This thermometer was probably made by Jacob Bianchi, the author of the book *Das merkwürdigste vom Barometre und Thermometre*, Vienna, 1762, in which the spiral thermometer is not mentioned. Bianchi did not pretend to be the inventor of the spiral thermometer; he only wanted to introduce the instrument to the Netherlands. Carlo Bianchi had worked in Amsterdam since 1770, first in partnership with the barometer-maker Lodewijk Primavesi, but from 1778 on with a brother and under his own name. B. Bolle, *Barometers in beeld*, note 350; W. E. Knowles Middleton, *The History of the Thermometer and Its Use in Meteorology*, Baltimore, 1966, 116, 139. For details see Mohr to Van Swinden, 27 September 1779, 9 November 1779, 11 January 1780, 5 April 1780, 12 June 1780; Van Swinden to Mohr, 19 October 1779, 18 November 1779, 14 March 1780,

Figure 1. Spiral thermometer 'after Fahrenheit's scale', made by Bianchy & Comp. à Amsterdam (Musée des Arts & Métier-CNAM, Paris/Photo Studio CNAM).

mercury thermometers not only by its exceptionally large mercury reservoir in the form of a spiral, but also because the level was read with two pointers. The large reservoir guaranteed a larger absolute expansion; the movement of the mercury meniscus in relation to the temperature was transferred to the pointers by means of a weight-and-gear construction. The dial consisted of three graduated scales, the innermost in degrees Réaumur, the middle one in degrees Fahrenheit and the outermost a precise graduated scale intended for the second pointer. The movement of this pointer was greatly enlarged by means of another gear mechanism. The sound construction of the instrument gave it a solid and reliable appearance. The large reservoir and the highly graduated scale suggested a greater degree of sensitivity and precision. But was this pretension justified? A major discussion arose between some meteorological observers of the Correspondentie Sociëteit.

Mohr, an Amsterdam observer, was a great advocate of Bianchi's product, which he considered to be a considerable improvement on the cylinder thermometer developed earlier in the century by Fahrenheit. Mohr attached great value to the correction tables Bianchi supplied, with which the observed temperature could be adjusted for the expansion of the tubes. Mohr also discovered that the mercury in a spiral thermometer

18 May 1780; Van der Weyde to Van Swinden, 20 January 1784; and R. Holl to J. H. van Swinden, 18 March 1784.

'rises and falls more quickly'. He wondered whether this increased sensitivity of the instrument was due to Bianchi's preference for German glass as opposed to English glass, which was usually regarded as exquisite. According to Bianchi, English glass became dirty faster, as a result of which the internal friction in the 'pipes' increased. On the other hand, J. H. van Swinden, whose thermometric skill was unequalled in the Netherlands, was unconvinced by Mohr's arguments: 'the best writers approve the single thermometer as the best'.[2] But Van Swinden respected Mohr enough to agree to test the instrument, as did others. Despite its high price of almost four gold ducats, a dozen observers of the Correspondentie Sociëteit used the spiral thermometer as a complement to the classical mercury thermometer.[3] 'Time will tell which is the best', Mohr wrote in the winter of 1780,[4] committing himself to an intensive research programme.

The first doubts about the superiority of the instrument emerged in April 1781, when Mohr informed Van Swinden that he now no longer preferred the Bianchi device; the thermometer indicated 1.5 to 2 degrees less than standard thermometers made by Prins, Wast or Ruspinus, which 'generally agreed quite well with each other'. Mohr had been most surprised, however, that Bianchi's experimental thermometer did correctly indicate the freezing and boiling points of water. In June 1781 Mohr thought that he had found an explanation. Whereas Bianchi set the freezing point at 32 degrees, Wast and Ruspinus set it at 33 degrees, 'because this temperature is not actually frost but the lowest step of thawing'. This calibration method had been introduced by Hendrik Prins (1696–1762), a pupil of Fahrenheit. A personal acquaintance of Prins had solemnly declared that his thermometers were always calibrated at 33 degrees, in melting ice or snow, irrespective of the barometric pressure. According to Mohr, the observed differences could be explained by this information and by the fact that Bianchi calibrated his thermometers by complete submersion in boiling water, during which he also ensured a fixed barometer position. Mohr concluded that although Bianchi had 'a better basis', the classical thermometers were still more convenient; other experiments supported this observation.[5] With this conclusion, the expensive spiral thermometer left the theatre of meteorology. Only one copy of this rare instrument is now known to have survived.

2 Van Swinden to Mohr, 18 November 1779.

3 Bianchi's spiral thermometer was used by Brunings, Van Swinden, Mohr, Holl, Van de Perre and Van der Weyde. See Brunings, 'Bericht wegens de weerkundige waarnemingen op Zwaanenburg', *Verhandelingen uitgegeven door de Hollandsche Maatschappij der Wetenschappen* (1780), **19**, 138–42 and [Van der Weyde], 'Bericht wegens de luchtgesteldheid in eenige plaatsen der Vereenigde Nederlanden, geduurende het jaar 1779' [Meteorological report of the weather in a number of places in the Netherlands during the year 1779], *Verhandelingen Correspondentie Sociëteit* (1783), **1**, 43–380.

4 Mohr to Van Swinden, 11 January 1780.

5 Elaborate tests of Bianchi's spiral thermometer by fellow instrument-makers Molteni in Amsterdam and Bochia in Leiden are mentioned in a letter of Van der Weyde to Van Swinden, 20 January 1784. In 1825 a spiral thermometer by Bianchi filled with spirit instead of mercury was auctioned in Amsterdam from the cabinet of Gerrit van Varik, lecturer in physics at the Amsterdam society 'Felix Meritis'. According to the catalogue (*Catalogus … van Wis- en Natuurkundige Werktuigen … bijeen verzameld door den heer Gerrit van Varik*, Amsterdam, 1825, no. 205; copy at Museum Boerhaave, Leiden) the instrument was accurate to one-three-hundredth of a degree Réaumur.

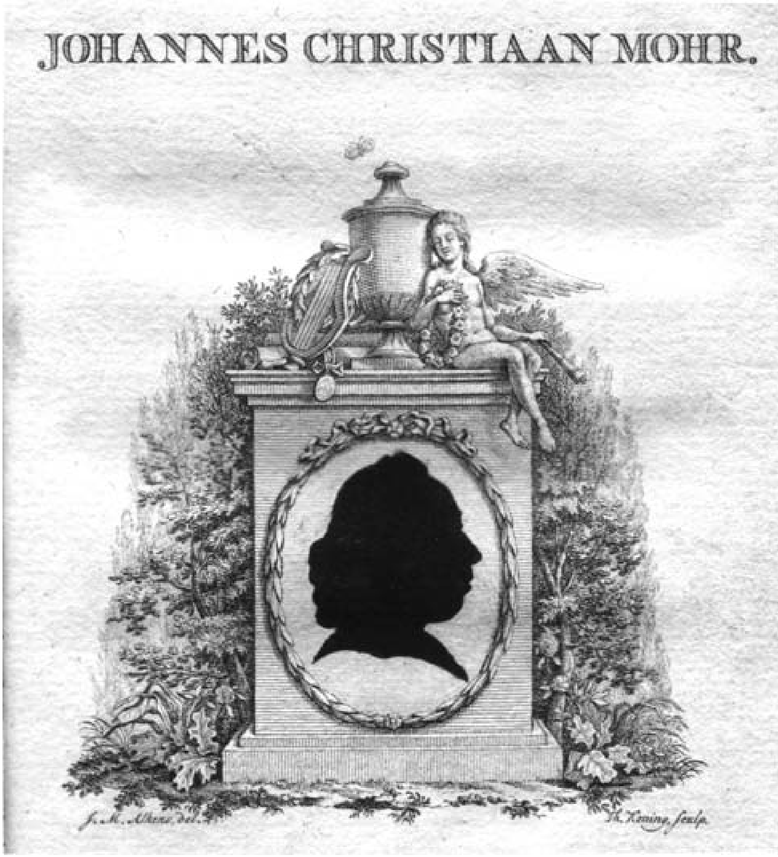

Figure 2. Johannes Christiaan Mohr (1747–87). Silhouette by Th. Koning after J. M. Alkens, taken from a volume of obituary poems, *Ter gedachtenisse* (Amsterdam, 1788).

The hygrometer

Another innovation in the field of meteorology was the hygrometer, also known as the 'damp meter'. Such instruments had existed for some time, though usually rejected as unreliable.[6] Quantifiable results could not be obtained; as the naturalist Jean Senebier put it in 1778, there were only hygro*scopes* available, not hygro*meters*.[7] But in 1780 an instrument appeared on the market that inspired confidence because it generated fairly reproducible results. This was the goose-quill hygrometer, attributed both to Noël Retz

6 See the 'Hygroscopium' lemma in W. de la Bordus (ed.), *Groot en volledig woordenboek der wiskunde, sterrekunde, meetkunde, rekenkunde*, Amsterdam, 1758. See also J. Dalencé, *Verhandelingen over de barometers, thermometers, en notiometers of hygrometer*, 's-Gravenhage, 1730 (Dutch translation of *Traité des baromètres, thermomètres et notiomètres ou hygromètres*, Amsterdam, 1688).

7 W. E. Knowles Middleton, *Invention of the Meteorological Instruments*, Baltimore, 1969, 99–100 (citation from *Observations sur la physique* (1778), **11**, 421).

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and to Antoine-Joseph Buissart.[8] A variant of this instrument had already been published by de Luc in 1773. The instrument was based on the contraction and expansion of organic material such as ivory (in the case of de Luc) or the shaft of a goose feather (by Buissart and Retz). The empty space of the shaft was linked by a sealing ring to a glass tube containing mercury. The mercury column in the tube therefore responded to humidity changes. Every reading had to be corrected for temperature, so a thermometer was necessarily annexed to the instrument. It was also important that there be fixed calibration points, so that a scale could be maintained.

Van Swinden had heard of Buissart's hygrometer through his French correspondent Cotte and put some confidence in the instrument, especially after he had received his own copy from a Paris artisan. After testing the new instrument, he sought the quickest means of publishing a description. Van Swinden reckoned this hygrometer 'one of the most necessary tools' for meteorology. He had always regretted that it had not yet been possible to construct a proper 'damp meter' capable of making 'comparative' measurements. This new instrument offered hope of achieving this objective; the device was not expensive (van Swinden's copy had only cost him nine guilders), so he called upon every meteorological observer to order a copy.[9]

Most of the observers of the Correspondentie Sociëteit heeded Van Swinden's call, even though Mohr, for example, considered the scale of the instrument too complicated. Mohr also expressed doubts about measurement reproducibility, because a comparison between seven such instruments produced poor results. But other observers, such as the Delft medical doctor Jacob van Breda, were highly satisfied. Van Breda found the Retz hygrometer to be highly sensitive. 'If breathed upon once it falls by about three degrees', he reported.[10] Rutgerus Holl from Maastricht expressed less satisfaction. He had also made a copy of this hygrometer, together with a friend, the Lutheran preacher Franckenhoff. Franckenhoff was a well-known enthusiast, with a skill for constructing 'fine scientific instruments'. He was particularly skilled in 'blowing and welding' of glass; this expertise made him particularly useful in the construction of meteorological instruments. Dissatisfied with Buissart's model, Holl and Franckenhoff produced a different type of hygrometer in 1786, 'according to the design of a professor in Halle'. This model also consisted of a glass tube filled with mercury, sealed on one side, while the other contained a wooden ring over which was pulled a tightly strung pig's bladder. Holl found this German-inspired instrument to be

8 Antoine-Joseph Buissart (1737–1820) had been President of the Académie Royale d'Arras since 1780. Because of his meteorological studies he was often called by his nickname, 'Monsieur le baromètre'.

9 J. H. van Swinden, 'Over een nieuwen vergelijkbaaren Vogtmeter', in *Genees-, Natuur- en Huishoudkundig Kabinet* (ed. J. Voegen van Engelen), Volume 2, 'Nieuwe uitvindingen, ontdekkingen en verbeteringen', 1781, 89–106. The calibration of the instrument is discussed on 99–104. The manuscript was submitted by Van Swinden to J. Voegen van Engelen on 24 October 1780. Van Swinden's copy of the hygrometer was made in Paris by Mossy, 'according the design of Buissart'. Hygrometers of this type were made by the Rotterdam instrument-maker Anthony Christoffel Reballio (*c.* 1720–1801), who had worked in the Netherlands since roughly 1749. Two examples of a contra-barometer, with a thermometer and a hygrometer according to Retz and Buissart, are published by B. Bolle, op. cit. (1), 113, 115. Cf. Van Swinden to S. J. Brugmans, 7 May 1781; and Van Swinden to Brunings, 10 August 1781.

10 Mohr to Van Swinden, March 1781. See also Van Swinden to Mohr, 15 March 1781. Van Breda to Van Swinden, 11 March 1784.

'simpler and more sensitive' than any other hygrometer he had seen. Van Swinden, however, doubted Holl's findings. Holl's hygrometer did not much differ from the design of Buissart and Retz. Furthermore, the Mannheim Societas Meteorologicae Palatina had accepted the goose-quill hygrometer as their standard model, so the instrument was now being distributed from Mannheim throughout Europe. Needs of standardization suggested the avoidance of major differences in instrumentation.[11]

In the meantime, however, Van Swinden had become enthusiastic about another hygrometer, sent to him from Geneva in August 1781 by the Swiss scholar de Luc. De Luc was well acquainted with the subject of hygrometry. In 1773 he had designed a forerunner of the goose-quill hygrometer of Buissart and Retz. The de Luc design had already been marketed by the English-born instrument-maker John Cuthbertson in Amsterdam. However, Van Swinden had nothing positive to say about this instrument of Dutch origin. Not only had Cuthbertson changed de Luc's sophisticated scale but, worse, he had also abandoned the necessarily annexed thermometer. According to Van Swinden, this merely demonstrated that Cuthbertson 'does not understand the basic principles of the hygrometer and is therefore incapable of making a good one'. He judged it shameful that good inventions were undermined in such a manner by the incompetence of 'craftsmen who were otherwise considered skilled and famous'.[12] How different was this from de Luc's case. Due to his skill 'in lathing and other crafts', de Luc probably was the only maker who could have succeeded where the 'most able craftsmen of London and Geneva' had failed. Van Swinden expected overall that the hygrometers according to de Luc, Retz and Buissart would eventually be just as comparable as the thermometers filled with alcohol or mercury.

This would not, however, prove to be the case. The organic reference substances in different hygrometer types responded too differently to humidity changes. So an absolute measure for humidity remained a desideratum; a humidity-sensitive substance with an acceptable tolerance was needed. This was ultimately realized to some extent in the hair-hygrometer, designed by the Swiss scholar Saussure. In January 1782 early rumours circulated that Saussure was working on just such a different hygrometer. This instrument would be 'even more sensitive' and would provide more reproducible measurements than the whalebone hygrometer of de Luc. At the end of 1783 reports of such an instrument proved correct. Van Swinden, who now used both the Buissart hygrometer as well as new ones from de Luc, also made haste in requesting Saussure to send him such an 'exquisitely beautiful and sensitive hair hygrometer'. The instrument was delivered in about 1785 'by a gentleman from Geneva'. But Van Swinden, who had moved to Amsterdam the same year and acquired a house that was completely unsuitable for meteorological observations, would no longer take part in this development. Of all of the remaining active observers of the Correspondentie Sociëteit, only the aristocrat Van de Perre would effectively make use of Saussure's new hair hygrometer.

11 Holl to Van Swinden, 19 October 1780 and 17 April 1786. Van Swinden to Holl, April 1786.

12 Van Swinden to Brunings, 30 August 1781. Cutbertson enjoyed some fame for his electrical machines; see W. D. Hackmann, *John and Jonathan Cuthbertson: The Invention and Development of the Eighteenth-Century Plate Electrical Machine*, Leiden, 1973.

Thanks to his private membership of the Societas Meteorologicae Palatina, Van de Perre's observations are the earliest published hair hygrometer observations in the Netherlands.[13]

The eudiometer

Van de Perre was also one of the rare observers of the Correspondentie Sociëteit who regularly made observations with the eudiometer.[14] This lack of enthusiasm for the eudiometer is somewhat surprising, because this very instrument most closely satisfied the primary medical objective of the Correspondentie Sociëteit. Developed at the end of the 1770s, the eudiometer was mainly intended to determine the quality of atmospheric air, interpreted by some as the volumetric concentration of dephlogisticated air (or oxygen gas).[15] After the identification of dephlogisticated air, the question arose as to whether the quantity of vital air in the atmosphere was subject to change. A relationship was suspected between the quantity of dephlogisticated air, or of oxygen gas, and the general state of health. So a proper knowledge about airs of different kinds seemed to contain the key to solving the problem of epidemic diseases.[16]

The Groningen pharmacist Boudewijn Tieboel, correspondent of the Correspondentie Sociëteit from 1780, was enchanted by this possibility: 'one may consider this invention … one of the most splendid and useful discoveries in natural philosophy'. The Amsterdam medical doctor and chemist Jan Rudolf Deiman, 'member consultant' and also 'correspondent for medical affairs' of the Correspondentie Sociëteit, asserted that the eudiometer was 'one of the most useful instruments in human society'.[17] Jacob van Breda, the society's observer at Delft, was also a firm defender of the eudiometer. As the Dutch translator of some papers of Jan Ingenhousz, he was well informed about

13 Cf. H. B. de Saussure, *Essai sur l'hygrometer*, Neuchâtel, 1783; Van Swinden to Holl, June 1786; J. A. van de Perre, 'Observationes Mettelloburgenses', in *Ephemerides Societatis Meteorology Palatinae* (1788), 128.

14 Van den Bosch to Van de Perre, 3 October 1783 (Zeeuwse Bibliotheek, Middelburg, Mss. KZGW, 427.).

15 Jan Golinski, *Science as Public Culture: Chemistry and the Enlightenment in Britain, 1760–1820*, Cambridge, 1992, 105–28; and Trevor H. Levere, 'Measuring gases and measuring goodness', in *Instruments and Experimentation in the History of Chemistry* (ed. F. L. Holmes and T. H. Levere), Cambridge, 2000, 105–35.

16 M. J. van Lieburg and H. A. M. Snelders, *De bevordering en volmaking der proefondervindelijke wijsbegeerte. De rol van het Bataafsch Genootschap te Rotterdam in de geschiedenis van de natuurwetenschappen, geneeskunde en techniek* (*1769–1988*), Amsterdam and Atlanta, 1989, 55–66 and 94–9.

17 Boudewyn Tieboel, 'Verhandeling over de Vaste Lucht' (1779), *Verhandelingen van het Bataafsch Genootschap der Proefondervindelyke Wysbegeerte te Rotterdam* (hereafter *Verh. BGPW*) (1781), 5, 97–192, 171–2. Cf. M. J. van Lieburg, *Het Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte te Rotterdam 1769–1984. Een bibliografisch en documenterend overzicht*, Amsterdam, 1985, 116 (Prize contest no. 11); J. R. Deiman and A. Paets van Troostwyk, 'Verhandeling over de Vaste Lucht' (1779), *Verh. BGPW* (1781), 5, 1–96, 61–2. Jan Deiman, a medical doctor, had been a 'member consultant' and a 'correspondent for medical affairs' of the Correspondentie Sociëteit since 1779. With his friend, the merchant Paets van Troostwyk, he was a member of the small, but very active Society of Dutch Chemists (Gezelschap der Hollandsche Scheikundigen). They made some name as early adherents of Lavoisier's system of chemistry. Cf. H. A. M. Snelders, *Het gezelschap der Hollandsche Scheikundigen. Amsterdamse chemici uit het einde van de achttiende eeuw*, Amsterdam, 1980.

Figure 3. Johan Adriaen van de Perre (1738–90). Portrait by P. de Sompsois, 1784 (Zeeuws Museum Middelburg, Collection Koninklijk Zeeuwsch Genootschap der Wetenschappen).

the discoveries of this famous natural philosopher. Not only did Ingenhousz analyse the vital effects of plant matter on air quality, he also claimed to have experimentally demonstrated with the eudiometer that air at sea level contained more oxygen gas than

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air inland. Other Dutch researchers, such as Van Marum and Paets van Troostwyk, reached quite similar results.[18]

The version of the eudiometer most commonly used in the Netherlands followed the design of Felice Fontana.[19] According to Van Breda, this version far excelled all other eudiometers 'in simplicity and accuracy'. A measurement with the Fontana eudiometer depended on the contraction of an air column, which occurred when air was mixed with nitrogen monoxide. After the reaction the volume reduction of the air could be read on the graduated scale engraved on the glass tube. It was the alleged simplicity of Fontana's eudiometer that led van Breda to express the opinion that all meteorological observers 'in our fatherland' should also perform eudiometric measurements. He had personally taken daily measurements since October 1780.[20] Very few observers heeded his call; correct use of the instrument needed much practice and not many observers managed to achieve the necessary skills. Van Swinden, who experimented with the eudiometer in 1778, had therefore abandoned the apparatus, characterizing the instrument as being 'too difficult' for an average meteorological observer. Experiments he performed during 1781 had given him reason to doubt the instrument's reliability. He even questioned published results of Ingenhousz, Deiman and Paets van Troostwyk. In a letter to Tieboel, Van Swinden stated that Ingenhousz 'had failed as much as he had made progress'. However, Van Swinden was not sure enough about the instrument to issue a final judgement. Due to health problems he had not been able to carry out all the eudiometric experiments he had in mind.[21]

There were indeed many complicating factors associated with the instrument. In April 1781 Van Breda discovered that water purity considerably affected his results. He observed a difference in solubility of the 'nitric air' (the NO_2 formed), depending on whether the apparatus contained distilled water, well water or rainwater.[22] Van de Perre heard of Van Breda's results at first hand and questioned these findings, as he was highly satisfied with his own 'improved eudiometer'. This was probably the eudiometer

18 Both Van Marum and Paets van Troostwyk used Fontana's eudiometer. See M. van Marum and A. Paets van Troostwyk, 'Verhandeling over de schadelyke uitdampingen' (1783), *Verhandelingen Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte* (1787), **8**, 1–61. An unpublished treatise on eudiometry by Van Marum and Paets van Troostwyk is in the archive of the Kongelige Dansk Videnskabernes Selskab at Copenhagen. See G. L'E. Turner, *Van Marum's Scientific Instruments in Teyler's Museum*, Volume 4 of *Martinus van Marum: Life and Work* (ed. R. J. Forbes, E. Lefebvre and J. G. de Bruijn), 4 vols., Leiden, 1973, 245. A Dutch description of Fontana's eudiometer was published in 1780 by Jacob van Breda, in his translation of J. Ingenhousz, *Proeven op Plantgewassen* (Experiments upon Vegetables), Delft, 1780, 166–71 and 263–5. See also Willem van Barneveld and Joachim Fredrik Muller, 'Over het planten van boomen …', *Verhandelingen van het Provinciaal Utrechtsch Genootschap van Kunsten en Wetenschappen* (1785), **3**, 1–189, 116, 182, 185.

19 Fontana had been employed by the Grand Duke of Tuscany since 1766. He designed several eudiometers, all based on the same principle. The type most used in the Netherlands was in fact based on an older design by Fontana's colleague Marsilio Landriani. In this eudiometer plain water instead of mercury was used to separate the various gases. Levere, op. cit. (15), 112–16.

20 J. van Breda, 'Voorbericht', in J. Ingenhousz, *Verzameling van Verhandelingen over Verschillende Natuurkundige Onderwerpen* (tr. J. van Breda), 2 vols., Delft, 1785, i, p. xv, and ii, 413.

21 Van Swinden to B. Tieboel, 10 August 1781, 30 December 1781 and 28 February 1783. Tieboel to Van Swinden, 5 September 1781; cf. also Levere, op. cit. (15), 111.

22 Van Breda to Van Swinden, 28 October 1783.

invented by Van de Perre's friend the Middelburg medical doctor Van der Kemp.[23] Van de Perre even offered Van Breda a 'replica' of this instrument, but eventually Van de Perre also became convinced of the chemical eudiometer's inadequacy, though remaining loyal to the eudiometric principle. In 1785 Van de Perre switched to Volta's 'improved' spark eudiometer, constructed by Cuthbertson.[24] In this type of eudiometer hydrogen reacted with the oxygen in the air during the discharge of an electrical spark. Volta's model would be used far into the nineteenth century, yet the eudiometer failed as a meteorological instrument. The variation in the amount of atmospheric oxygen was too small for accurate measurement, and the instrument appeared to be useless as a device for tracing infectious diseases. What had first appeared to be a highly promising effort to quantify a new meteorological parameter was found to have contributed nothing.

The atmospheric electrometer

Even more challenging than eudiometry was the question of atmospheric electricity. In this case, too, a link was proposed with both meteorology and medicine.[25] This connection was well demonstrated in a prize contest proposed in 1779 at Rotterdam by the Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte: 'what effect do natural electricity and its different distributions in our atmosphere have on the healthy and the ill body?'[26] Once again, the same investigators were interested in this subject. The gold medal in the Rotterdam prize contest was won by the Amsterdam investigators J. R. Deiman and his colleague Paets van Troostwyk. A similar prize contest, set in 1783 by the Hollandsche Maatschappij der Wetenschappen, was won three years later by Jacob van Breda of Delft.[27] This prize essay led to a quarrel with Van Breda's instrument-maker, Jan Reghter. As the designer and constructor of Van Breda's atmospheric electrometer, Reghter believed that he should be credited as the rightful

23 Johannes Theodorus van der Kemp (1747–1811) was a medical doctor at Middelburg and a member of the local Physical Society (Natuurkundig Gezelschap). In 1798 he went to South Africa, after being ordained in London as a pastor. Van de Perre refers to him as 'my friend Van der Kemp' in a letter to C. C. H. van der Aa, 16 May 1788 (RA Noord-Holland, Haarlem, arch. HMW). Cf. J. H. Enklaar, *De levensgeschiedenis van Johannes Theodorus van der Kemp, stichter van het Nederlandsch Zendeling Genootschap,* Wageningen, 1972, 47. See also Van de Perre to Van Breda, 8 November 1783.

24 Van de Perre to Van Breda, 28 September 1785. A similar electrical eudiometer made by John Cuthbertson was purchased in 1790 by Van Marum for Teyler's Society at Haarlem. Turner, op. cit. (18), 245–6. See also W. A. Osman, 'Alessandro Volta and the inflammable air eudiometer', *Annals of Science* (1958), **14**, 215–42.

25 W. D. Hackmann, 'Instruments and experiments: the case of atmospheric electricity in eighteenth-century Holland', *Tijdschrift voor de Geschiedenis der Geneeskunde, Natuurwetenschappen, Wiskunde en Techniek* (1987), **10**, 190–207.

26 Van Lieburg, op. cit. (17), 53 and 117. The answer was crowned in 1783 and published in *Verh. BGPW* (1787), **8**, 63–153.

27 J. G. de Bruijn, *Inventaris van de prijsvragen uitgeschreven door de Hollandsche Maatschappij der Wetenschappen 1753–1917*, Haarlem and Groningen, 1977, no. 50. Cf. J. van Breda, 'Over de Electriciteit van den Dampkring' (1786), *Verhandelingen uitgegeeven door de Hollandsche Maatschappij der Wetenschappen* (1788), **25**, 363–456. See also Van Breda's description of Volta's electrophore, *Algemeende Vaderlandsche Letter-oeffeningen* (1779), **1**, 251–66.

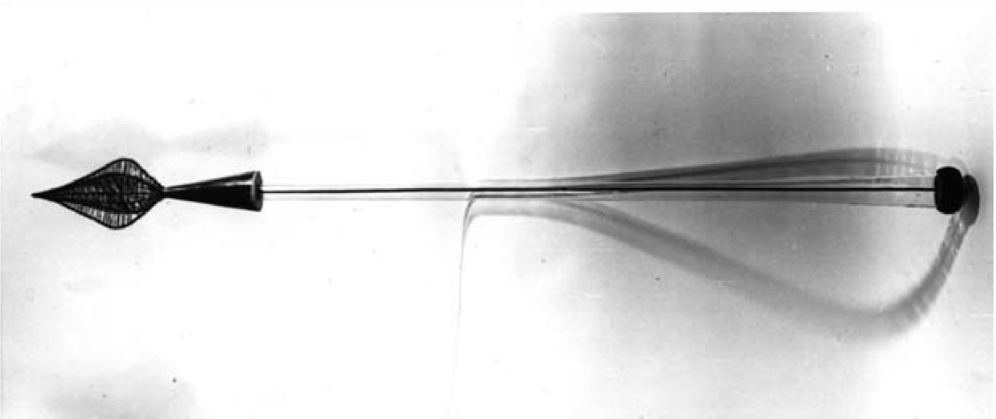

Figure 4. Rain electrometer, made after the design of T. Cavallo (Utrecht University Museum).

inventor of the instrument instead of only being mentioned as Van Breda's employee. Reghter had studied the theme of atmospheric electricity for many years. In 1779 he had already published on 'electrical kites' and 'lightning conductors' in the Dutch magazine *Vaderlandsche Letter-oeffeningen*.[28]

In 1781 Van Breda was the first to submit measurements on atmospheric electricity to the meteorological section of the Correspondentie Sociëteit. Secretary Van den Bosch found these observations very promising, while his co-editor, Van der Weyde, also hoped that the society's meteorological observers could extend their observations to the 'electrometer'.[29] But this wish turned out to be impractical; almost no one had suitable apparatus while only a few possessed enough patience to perform sensitive electrostatic measurements. The aristocrat Van de Perre was, again, almost the only observer of the Correspondentie Sociëteit to attempt to make such measurements. In the Mannheim *Ephemerides* for September 1784 Van de Perre described how he determined the electrical state of the atmosphere with Tiberius Cavallo's electrometer.[30] A Dutch

28 J. Reghter, 'Beschryving van een toestel, geschikt om met een vlieger veilig electrische proeven te nemen', *Vaderlandsche Letter-oeffeningen* (1779), **1-II**, 69–81; and J. Reghter, 'Beschryving van een vrijstaande electricalen afleider', *Vaderlandsche Letter-oeffeningen* (1780), **2-II**, 249–52. See also Van der Weyde to Van Swinden, 27 March 1784 about measurements made by J. Reghter, 'habile Artiste en Delft', referring to an article in *Genees- Natuur- en Huishoudkundig Kabinet* (undated), **3-II**, 59; S. P. van Swinden to J. H. van Swinden, 1785 (KB, Coll. Meteorologie & Noorderlicht, CCCIIa). Cf. H. A. M. Snelders, 'Natuurwetenschappen [in Delft]', in *De stad Delft. Cultuur en maatschappij van 1667 tot 1813*, Delft, 1982, 92–6; and Thera Wijsenbeek-Olthuis, 'Instrumenten voor wetenschap en vermaak', in *idem*, *Achter de gevels van Delft*, Hilversum, 1987, 262–4.

29 Van den Bosch to Van Breda, 29 January 1781; [G. van der Weyde], 'Bericht wegens de luchtgesteldheid [voor het jaar 1781]', *Verhandelingen Correspondentie Sociëteit* (1786), **3-I**, 5.

30 J. A. van de Perre, 'Observationes Mettelloburgenses (Sept. 1784)', in *Ephemerides Societatis Meteorologicae Palatinae* (1785), 550. For this atmospheric electrometer see T. Cavallo, *Volledige verhandeling over de Electriciteit, vertaald door J. Th. Rossijn,* Utrecht, 1780, 305–12, Plate III-1. A copy of a glass atmospheric electrometer according to Cavallo is preserved in the Utrecht University Museum. See W. J. Lavèn and J. G. van Cittert-Eymers, *Electrostatical Instrumentes in the Utrecht University Museum: Descriptive Catalogue,* Utrecht, 1967, 58, Plate xxxvii.

description of this electrometer was published in 1780 by the Utrecht professor Johannes Theodorus Rossijn, a 'member consultant' of the Correspondentie Sociëteit since 1783. Van de Perre also tried other methods; his cabinet of scientific devices contained many instruments for 'Electricity of the Atmosphere'. But this subject proved recalcitrant. In September 1785 Van de Perre wrote to Van Breda that 'sometimes everything stops and one finds nothing, whatever one tries to do'; van Breda later agreed that this kind of measurement was indeed very difficult, particularly in the cities, where 'it is rarely possible to measure much electricity close to the buildings'. Van Breda rejected Cavallo's method, 'at least with the exception of thunderstorms, in which I have been able to measure some electricity with certainty'. The findings published by Deiman and Paets van Troostwyk were comparable. They had found the effect of atmospheric electricity completely negligible compared to the 'artificial electricity' generated by their electrical machines. They concluded that 'electricity, as usually present in the atmosphere, can have no noticeable effect upon us and therefore has no effect on healthy and ill bodies'.[31] So, like the eudiometer, the atmospheric electrometer also enjoyed a very short life in Dutch medical meteorology.

Summary and conclusions

Scholarship has offered a range of judgements of the Correspondentie Sociëteit. In their recent study of the Netherlands at the start of the nineteenth century, Joost Kloek and Wijnand Mijnhardt characterize the efforts of the Correspondentie Sociëteit as a 'temporary milestone' in 'medical involvement with society'. According to them, this involvement arose after 1750, after university-trained medical doctors had reoriented themselves towards empiricism as a working method. They claim that this resulted in a preventative medical programme starting in about 1770; this process made a significant contribution to increased professional feeling and professional respect of the medical class.[32] Far more negative in his assessment was Harry Snelders, who in 1981 conducted a general investigation of the *Verhandelingen* of the Correspondentie Sociëteit. He concluded that 'in the end the *Sociëteit* left us with little more than many particulars about the number of births and deaths in many places in the country, which illnesses people died from, some meteorological observations and an overview of the many contributors'. Also rather negative in his judgement was Frank Huisman, who in 1997 investigated the medical records of the Groningen section of the Correspondentie Sociëteit. Although Huisman underlined the importance of the Correspondentie Sociëteit in the process of the emancipation of the medical class, he also concluded that in the medical field scarcely any insight had been obtained into dominant illnesses. According to Huisman, the medical publications of the Correspondentie Sociëteit 'do not contain an expected level of abstraction, on the contrary they were very casuistic and contained many lists without any form of interpretation'. He judged that the

31 A. Paets van Troostwyk and J. R. Deiman, 'Verhandeling over de geneeskonstige electriciteit', *Verh. BGPW* (1787), 8, 63–153, 93. Their apparatus was a variation on Cavallo's. See 73–4 and Plate II.

32 J. Kloek and W. W. Mijnhardt (eds.), *1800: Blauwdrukken voor een samenleving*, Den Haag, 2001, 309–10.

medical doctors of the Correspondentie Sociëteit were no more than 'defective empiricists', because they never explicitly explained the transition from empirical material to theory. In Huisman's opinion, 'the correctness of the ideas adopted was indisputable, so that measurements could never have led to a modification, let alone a rejection, of the theory'.[33]

The question arises as to whether this is a useful way of making historical judgements. From a historical viewpoint, processes and efforts rather than results are most important, and innovations with respect to the institution's contemporary practices are to be assessed.[34] If the Correspondentie Sociëteit is examined from such a perspective, then the result is rather positive, at least for the society's meteorological aspect. In the meteorological section of the *Verhandelingen* attention was mostly devoted to the set-up, methodology and recording of observations. This is hardly surprising, because in this field organized and systematic work was something very new in the Netherlands; members of the Correspondentie Sociëteit had to discover this effectively at first hand. There was no previous expertise on which to rely. The Correspondentie Sociëteit was the first in the Netherlands to genuinely organize scientific research. Moreover, contributors to the society performed much work. During a period of just over ten years the society published eleven volumes with almost five thousand pages of printed observations, about one-third of which was concerned with meteorology. Although these volumes were indeed partly descriptive, this does not mean that a higher level of abstraction was not the aim. For example, in his report about the weather during the years from 1779 to 1781, Van der Weyde sought to draw thoroughly analytical conclusions and even provided methodological arguments. According to Van der Weyde, the body of knowledge formed 'one large structure' which would only progress when many investigators worked on it together. Various types of natural knowledge needed to be distinguished. Meteorological knowledge could only be deduced from observation. Van der Weyde held that reliable natural knowledge was generated in three stages: first, collection and description of the phenomena; then the more difficult step of deriving inferences or patterns from these observations; the third step, the most difficult, to find an underlying theory or explanation. This step could only be taken after much preliminary work had been done. Van der Weyde considered Van Swinden's work on the magnetic needle to be an example of the first phase, that of describing phenomena.[35] An example of the second phase, the derivation of inferences, was

33 H. A. M. Snelders, 'De natuur- en scheikundige wetenschappen in de medische tijdschriften', *Nederlands tijdschrift voor geneeskunde* (1981), **125**, 668–73, 671; F. Huisman, 'De correspondenten. Medici, staat en samenleving tijdens de Nederlandse Verlichting', in *Medische geschiedenis in regionaal perspectief* (ed. F. Huisman and P. Santing), Groningen, 1997, 75–93, 79.

34 G. S. Rousseau and Roy Porter (eds.), *The Ferment of Knowledge: Studies in the Historiography of Eighteenth-Century Science*, Cambridge, 1980.

35 Van der Weyde failed to recognize the meaning of Van Swinden's earlier analyses of barometric observations, in which Van Swinden had proved that the moon's position in the sky did not influence the daily fluctuation of the barometer. See J. H. van Swinden, *Mémoire sur les observations météorologiques faites à Franeker pendant le courant l'année MDCCLXXIX*, Amsterdam, 1780, 34. See also Th. S. Feldmann, 'Late Enlightenment meteorology', in *The Quantifying Spirit in the Eighteenth Century* (ed. T. Frängsmyr, J. L. Heilbron and R. E. Rider), 1990, 143–77, 171.

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Toaldo's hypothesis that the seasons recurred according to the circulatory time of the phases of the moon. The last, finding an underlying explanation, had not yet been achieved in meteorology, but this was the universally appealing and ultimate goal. In the end meteorology would prove to be of immeasurable importance for agriculture, shipping and medicine; such was Van der Weyde's firm conviction.

Thus Van der Weyde was by choice a practising empiricist. In his analyses he only sought 'inferences', not underlying explanations, simply because to offer such explanations would be to take a step too far. Van der Weyde was particularly keen on finding parallelisms, such as possible relations between meteorological and astronomical phenomena. In this he was strongly influenced by Toaldo's prize essay of 1774, like other European scholars such as Joseph-Jérome le François de Lalande, Louis Cotte and Jean Senebier, and was well equipped for the task. He was one of the rare observers of the Correspondentie Sociëteit to also have a thorough knowledge of astronomy.[36] Due to his particular interest in Toaldo's astro-meteorological hypotheses, Van der Weyde was searching for periodicities in weather patterns. In 1782 he thought he had found that the weather conditions of 1779 fitted the astronomical Chaldean period; a year later he was surprised that the conditions of 1780 were similar to those of the eighteen-year Saros cycle. Because of these apparent discoveries, it became a matter of concern that the publication of the society's *Verhandelingen* was so severely delayed. The priority of 'a significant discovery' had been missed, according to the society's secretary, Van den Bosch. In September 1785 he wrote that 'if our *Verhandelingen* had been published earlier, we would have been before Lalande in determining the similarity [of the weather of 1780] with the weather of 1767'.[37] Yet after a few years of investigation it became clear that events would take a different course. In his last published analysis, Van der Weyde also had to admit that with respect to weather periodicities he had found just as many similarities as differences.[38] A positive conclusion simply could not be drawn. The hope of demonstrating astro-meteorological relationships was frustrated by the observations collected. David Cassidy comments that thus 'Toaldo's theory met its final refutation'. While this result may have been disappointing to those concerned, methodologically it was nevertheless important. Furthermore, it contradicts Huisman's assessment regarding the indisputable correctness of the adopted ideas.[39]

A new type of scientific organization was set up in 1779 in the Netherlands: a medical and meteorological society which for the first time in the country's history devoted itself to the standardization, collection and processing of scientific observations. Although

36 H. J. Zuidervaart, *Van 'Konstgenoten' en Hemelse Fenomenen. Nederlandse Sterrenkunde in de Achttiende Eeuw*, Rotterdam, 1999, 599–609. Of the remaining observers of the Correspondentie Sociëteit only Rutgerus Holl, officer of the cavalry, made both meteorological and astronomical observations.

37 Van der Weyde to Van Swinden, 4 November 1782, 23 August 1783 and 20 January 1784; I. J. van den Bosch, (preface to the meteorological observations of the year 1780, dated 29 September 1785), *Verhandelingen Correspondentie Sociëteit* (1785), **2-I**.

38 [Van der Weyde], 'Bericht wegens de luchtgesteldheid [voor het jaar 1781]' [Meteorological report of the weather in a number of places in the Netherlands during the year 1781], *Verhandelingen Correspondentie Sociëteit* (1786), **3-I**, 19–21, 34–8.

39 D. A. Cassidy, 'Meteorology in Mannheim: the Palatine Meteorology Society, 1780–1795', *Sudhoffs Arch.* (1985), **69**, 8–25, 22; F. Huisman, op. cit. (33), 179.

the main driving force was medical, meteorology much benefited from this motivation. New meteorological instruments were thoroughly tested and rejected or accepted for use on the basis of these tests. New measurement standards were developed and laid down in protocols and predetermined blank forms. In so doing, the Correspondentie Sociëteit contributed to awareness of instrumentation, standardization and quantification, a crucial process for the development of the natural sciences. For the first time in the Netherlands meteorological observations were obtained with the objective of centrally processing large files of data. The lack of a theoretical framework, combined with many organizational problems, made this goal too ambitious for that era.

In the area of medical demographics, some noteworthy aims were also realized. Never before in the Netherlands had the collection of birth and death rates taken place on such a large scale.[40] The fact that local environmental factors could be of vital importance for public health had never been acknowledged before in such a broad and general context. The *Verhandelingen* of the Correspondentie Sociëteit not only enriched Dutch scientific literature with a new genre, medical geography, but as a result of these efforts environmental medicine also became a recognized subject.[41] In short, the Correspondentie Sociëteit carried out pioneering work in many scientific fields in the Netherlands. That only a small band of people contributed to the meteorological work did not distinguish its situation from that elsewhere in Europe. While the meteorological section of the Correspondentie Sociëteit was heavily dependent on the zeal of a man like Jan Hendrik van Swinden, the same could be said of the relation between the Societé Royale de la Médecine and Louis Cotte, or that between the Societas Meteorologicae Palatina and Johann Hemmer. The functioning of the Natuur- en Geneeskundige Correspondentie Sociëteit was therefore comparable with that of its famous foreign counterparts.

Yet despite all this, the influence of the Correspondentie Sociëteit on the development of organized Dutch meteorology in the nineteenth century was negligible. Only in 1854, with the founding of the Koninklijk Nederlands Meteorologisch Instituut (the Royal Dutch Meteorological Institute), under the Utrecht mathematics professor C. H. D. Buys Ballot, was a more successful programme achieved. Even measurements collected by the Correspondentie Sociëteit were found to be unusable in later climatological studies. The Utrecht mathematics professor Willem Wenckebach, who in 1837 analysed all meteorological data he could find in Dutch literature, drew a shocking conclusion: according to Wenckebach the *Verhandelingen* of the Correspondentie Sociëteit contained a surprising number of printing mistakes and other errors. The few data Wenckebach could check against the original observation registers were nearly all incorrect.[42] Wenckebach was left with no choice but to reject all the data published by the Correspondentie Sociëteit. Only original or integrally published measurements,

40 F. W. A. van Poppel and J. P. van Dijk, 'The beginning of health statistics 1750–1870', in *The Statistical Mind in a Pre-statistical Era: The Netherlands 1750–1850* (ed. P. Klep and I. H. Stamhuis), Amsterdam, 2002, 241–77, 247–9.

41 Kloek and Mijnhardt, op. cit. (32), 310.

42 Willem Wenckebach, 'Uitkomsten uit in Nederland gedane weerkundige waarnemingen', *Natuur- en Scheikundig Archief* (1837), 5, 331–433, 358, 383.

such as those of Van Musschenbroek, Van Swinden or Mohr, were acceptable. The Correspondentie Sociëteit had to pay a very high price for the choice it made in 1780 to publish only monthly averages and not integral measurements.[43] Based on Wenckebach's authority, later meteorologists did not take the measurements of the Correspondentie Sociëteit seriously and all discarded the data produced by it. Maurits Snellen, the second director of the Royal Dutch Meteorological Institute (KNMI), even ignored the Natuur- en Geneeskundige Correspondentie Sociëteit in the first published history of Dutch meteorology.[44] Other historians have behaved in much the same manner. Simple 'success' is always considered more interesting than apparent 'failure'. As a consequence, an unforgiving oblivion has been the fate of all those diligent workers who in the 1780s struggled together for the 'benefit of the Fatherland' to collect instrumental data about the Dutch climate. This is not the historical fate these interesting meteorological pioneers deserve.

43 At the time only the Societas Meteorologicae Palatina had published the observations in full. These are still used in climatological studies. Cf. A. Kington, 'The Societas Meteorologicae Palatina: an eighteenth-century meteorological society', *Weather* (1974), **29**, 416–26.

44 M. Snellen, *Beknopt geschiedkundig overzicht van de beoefening der meteorologie in het algemeen en die in Nederland in het bijzonder*, Utrecht, 1897.

APPENDIX

Meteorological observers and meteorological correspondents of the Natuur-en Geneeskundige Correspondentie Sociëteit (NGCS)

				Period of observations						
No.	Name	Location	NGCS	Start obs.	Observ. used	End obs.	Reason ending	Obs > 3 years	Education	Profession
BRABANT										
1	Esdré, J. (1748–1828)	Heusden	MC	1781	x			x	Univ. (Ph.D.)	Teacher in physics
2	Holl, R. (*c.* 1747–*c.* 1814)	Breda	MC	1779	x	1780	1st move to Maastricht		Mil.	Military officer
				ret. 1782		1784	2nd move to Maastricht	x		
3	N.N.	Bergen op Zoom		1779	x				?	?
FRIESLAND										
4	Brouwer, Petrus (*c.* 1736–81)	Leeuwarden		1779	x	1781	died		?	Tax collector
5	Swinden, J. H. van (1746–1823)	Franeker	MC	1779	x	1785		x	Univ. (Ph.D.)	Phil. prof.
6	Swinden, Ph. H. van	Franeker		1783	x				Univ.	Phil. student
GRONINGEN										
7	Brugmans, S. J. (1763–1819)	Groningen		1781	x	1783	moved		Univ.	Phil. student
8	Tieboel, B. (1758–1814)	Groningen	C	1780	x	?			?	Apothecary
HOLLAND										
9	Breda, J. van (1743–1818)	Delft	MC	1779	x	1818		x	Univ. (M.D.)	Physician
10	Brunier, J.A.	Leiden		1779	x			x		
11	Brunings I, Chr. (1736–1805)	Halfweg	CM	1779	x			x	Surveyor	'Opsiener bij Rijnland'
12	Brunings II, Chr. (1756–1826)	Spaarndam		1783	x			x	?	'Opsiener bij Rijnland'
13	Deiman, J. R. (1743–1808)	Amsterdam	MED.C	1779	x				Univ. (M.D.)	Physician
14	Engelman, J. (1710–82)	Spaarndam	CM	1779	x	1782	died	x	Univ. (M.D.)	Physician/'Opsiener bij Rijnland'
15	Kuypers, G. (1706–84)	Dordrecht	MC	1779	x	1779			Sailor	Leader, local physical society
16	Mohr, J. C. (1747–87)	Amsterdam	MC	1779	x	1787	died	x	Accounting	Fur trader
17	Schellebeek, Dr van	Dordrecht	MC	1779					Univ. (?)	Former politician ('oud raad en schepen')

18	Stolker, A. (1751–1837)	Schoonhoven	MC	1779	x	1783		x	Univ. (Th.D.)	Minister (Remonstr.)
19	Swinden, S. P. van (1755–1835)	Den Haag	MC	1779	x	1787		x	Univ. (J.U.D.)	Lawyer
20	Wageningen, Dr J. van	Dordrecht	MC	1779					Univ. (M.D.)	Physician
21	Weyde, G. van der	Den Haag	MC	1782	x	1787	moved to St Petersburg		Mil.	Militairy officer
GELDERLAND										
22	Gorter, D. de (≃1783)	Zutphen	MC	1779	x		died		Univ. (M.D.)	'Former Physician of the Russian Tsar'
23	Martinet, J. F. (1729–95)	Zutphen	MC	1779	x				Univ. (Th.D.)	Minister (Reformed)
LIMBURG										
2	Holl, R. (*c.* 1747–*c.* 1814)	Maastricht	MC	1780	x	1782	moved to Breda		Mil.	Militairy officer
				ret. 1784		1788	moved to Nijmegen			
24	Franckenhoff	Maastricht		1781	x	1786		x	Univ. (Th.D.)	Minister (Lutheran)
UTRECHT										
25	Römer, E. J.	Utrecht	MC	1779	x			x	Univ. (M.D.)	Physician
ZEELAND										
26	Bomme, L. (1727–88)	Middelburg	MC	1779	x	1788	died		?	Merchant
27	Callenfels, G. W.	Sluis	MC	1779	x			x	Univ. (M.D.)	Physician
28	Cere, J. P.	Goes	MC	1779					Univ. (M.D.)	'Stads MD en operateur'
29	Fouw, J. de	Goes	MC	1779					?	'Eerste griffier der stad'
30	Heylman, Jacob	Hoedekenskerke	MC	1779					?	'Chirurgyn'
31	Jenoteau, Jaques	Goes	MC	1779					?	'Frans Kostschoolhouder'
32	Lichte, P. M. de	Middelburg	MC	1779	x				?	Clerk and poet
33	Perre, J. A. van der (1737–90)	Middelburg	MC	1779	x	1789	died	x	Univ. (J.U.D.)	Former politician
34	Schortinghuis, H.	Koudekerke	MC	1779					Univ. (Th.D.)	Minister (Reformed)
35	Schortinghuis, W.	Baarland	MC	1779					Univ. (Th.D.)	Minister (Reformed)
36	Slabber, M. (1740–1835)	Goes	MC	1779	x				?	'Baljuw van Baarland'
37	Walraven, J.	Goes	MC	1779					?	Tax collector

CM = Contributing correspondent.
C = Correspondent.
MC = Meteoroligical correspondent.
Med.C. = Medical correspondent.