PUBLICATION OF THE NETHERLANDS GEODETIC COMMISSION

GEODETIC WORK

IN

THE NETHERLANDS

1971—1974

Report prepared for the General Assembly of the International Association of Geodesy, XVIth General Assembly of the International Union of Geodesy and Geophysics, Grenoble, 1975

1975
Rijkscommissie voor Geodesie, Thijsseweg 11, Delft, The Netherlands

1 CONTROL SURVEYS

1.1 **Primary triangulation**

The network around the former Zuiderzee could not be completed because no permission was obtained to continue the observations at the new station Bergen aan Zee after a transfer in ownership of the tower used for this purpose. As no suitable replacement was available in the vicinity and building of a special observation tower would have been very costly, it was decided to modify the network originally planned. This modified net will be strengthened by measuring some of the sides with a MRA4-tellurometer.
The primary station Monnikendam, included in this network, appears to be disturbed. New lower order measurements from control points in this region resulted in coordinates that differ from the original ones. It is very likely that this disturbance occurred after the dam (Afsluitdijk) between Noord-Holland and Friesland was built, resulting in a lowering of the water-table in this area. New first order measurements will be carried out to determine the new coordinates of Monnikendam.

1.2 **Electromagnetic distance measurement**

The high precision traverse between Kester and the the two sites of the Delft satellite observation station was completed in 1971. Again a MRA4-tellurometer was used to carry out the measurements. The station was moved from Delft to a specially built satellite observatory at Kootwijk (near Apeldoorn) at the end of 1973.
The traverse Kester-Delft will therefore be extended to this observatory and from there to the Belgian station Tongeren. Both Kester and Tongeren are included in the high precision traverse Malvern-Graz. The new observatory has also been connected to the primary stations Amersfoort and Rhenen by direction- and distance measurements.

1.3 **Base lines**

A comprehensive report on the base and base extension net "Afsluitdijk" was published in 1972.

1.4 **Levelling**

1.4.1 *General*

The hydrostatic measurements for a levelling network covering the whole country were continued. This network will consist of a series of concatenated hydrostatic levellings in the canals and

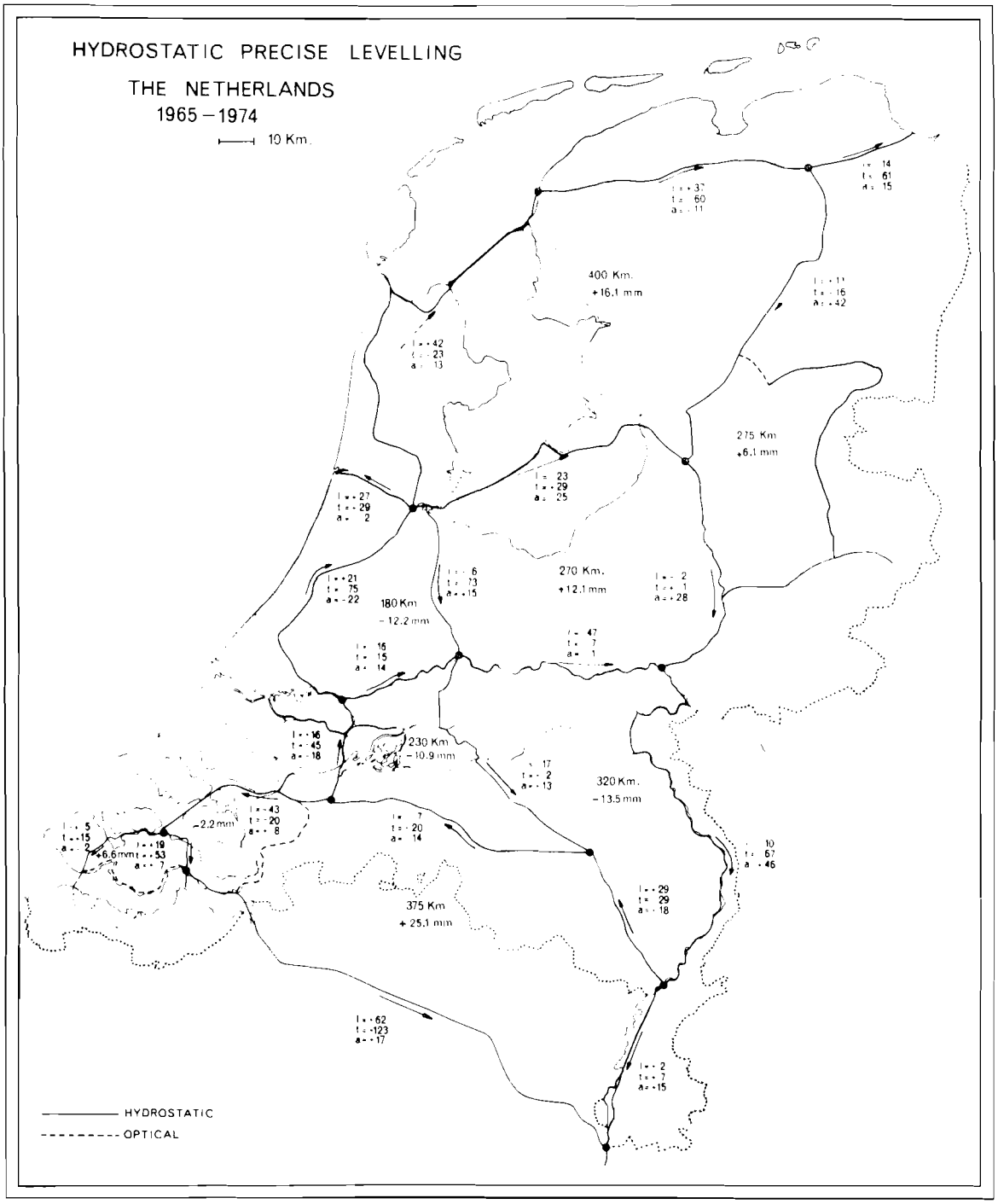

Fig. 1

rivers of The Netherlands. The 8 km long lead pipe used for this survey is laid out and taken up by a specially equipped ship. During the report period 590 km of this levelling were completed. The average length of one hydrostatic measurement was 4.6 km, the number of measurements amounts to 357. These circuits cover the whole country, see Fig. 1. A hydrostatic levelling line through the northern part of Belgium gave an additional circuit.

To connect the hydrostatic levelling network to underground benchmarks a series of short first-order levelling lines were measured. The total length of these levellings made during the period of reporting amounts to 447 km. In addition to this, approximately 5300 km of second order levellings were carried out for various purposes (including the levellings in mining areas.)

1.4.2 *Instruments*

For first order levelling work the automatic instruments Zeiss Ni-2, Zeiss Ni-1 and Jena Koni 007 were used.

1.4.3 *Methods*

The methods employed are the same as those described in the reports presented in Toronto (1957) and Helsinki (1960).

1.4.4 *Datum of the network*

The datum of the network is Normaal Amsterdams Peil (N.A.P.), fixed by an underground benchmark at Amsterdam.

1.4.5 *Junctions with contiguous networks*

In 1971 the section Rilland Bath-Zandvliet-Antwerp-Albert Kanaal-Maastricht has been measured.

1.4.6 *North-West European Lowlands Levelling*

The height of all benchmarks have been computed in the NWELL-system. The results will be published in 1975.

1.4.7 *Special measurements*

Hydrostatic levellings to connect isolated tide gauges at sea with the levelling network on land were continued. In total 180 km in the North Sea and the Shallows were measured, including a connection to the lighthouse "Goeree" (22 km offshore) and to the North Sea measuring-station near Noordwijk (11 km offshore).

1.5 **Geodetic astronomy**

1.5.1 *Laplace points*

The azimuth Zierikzee-Goedereede, determined in 1897 by Polaris, was redetermined by the same method in 1973. The results of the 1897 and 1973 measurements differ only 0".32. This completed the tree twin Laplace points, i.e. Leeuwarden-Ameland, Goedereede-Zierikzee, and Ubachsberg-Tongeren, in behalf of the readjustment of the European triangulation network. A report giving details of all observations and results will be published in 1975.

1.5.2 *Deflection of the vertical*

In 1974 geodetic-astronomical observations were carried out at a number of stations of the primary network for the determination of the deflection of the vertical. Latitude and longitude were determined simultaneously, using a Zeiss Ni-2 astrolabium, at: Aardenburg, Amersfoort,

Berkheide, Boschberg, Klifsberg, Lemelerberg, Monnikendam, Nederweert, Oudgastel, Rozendaal 3 (Imbosch), Venray, Winterswijk, Workum and Zaltbommel. For determining the observer's personal equation the satellite observatory at Kootwijk was used as a reference station. At the same stations the measurements will be repeated in 1975 to check the results.

1.6 Marine-geodetic activities of the Hydrographic Department of the Royal Netherlands Navy

1.6.1 *The Netherlands*

For hydrographic surveys in the coastal area the available primary and secondary trig points are used. For the offshore areas the use of the Decca Hi-Fix Rijnmond chain for horizontal control was continued. In some cases the Hi-Fix IJmuiden chain and the Sea-Fix Waddenzee chain, operated by the "Rijkswaterstaat" (State Water Board) and used for harbour construction and sounding, were made available for hydrographic surveys.

1.6.2 *Netherlands Antilles*

Hydrographic and oceanographic surveys around the Netherlands Antilles started in 1970 with a Decca Survey chain for horizontal control. In 1971 this chain was replaced by a Decca Sea-Fix chain, which allowed higher accuracies in position fixing and provided greater flexibility in operation. In 1972, when this equipment was used in the Leeward Islands, geodetic discrepancies came to light in the relative position of the islands, which could be solved by transformation of coordinates into a common system, based on the re-examination of the available data of former surveys, on check-measurements, and on theoretical considerations.

1.6.3 *General*

For oceanographic positioning the use of the Navy Navigation Satellite System shows great promise. Plans for promotion of that system in marine geodesy are being studied.
The automation of hydrographic data logging and processing is proceeding favourably and is reaching its operational stage.

1.7 Marine surveys of the Survey Department of the State Water Board

Hydrographic surveys were carried out in coastal waters for project studies, for checking the effect of offshore civil engineering projects on the sea-bottom topography and for assisting and checking dredging operations. For these surveys use was made of the existing Decca survey-systems e.g. the Hi-Fix Rijnmond chain and local Hi-Fix and Sea-Fix systems. The Holland Chain and Frisian Islands Chain were used for surveys not requiring a high accuracy. The Holland Chain became operational in 1972; a detailed calibration programme has been carried out for this chain.
Small platforms, some metres square, were installed just above the bottom of the sea at a distance of about 30 miles from the coast. These platforms served as tidal base stations and as reference points for depth calibration and position fixing.
A complete software package was developed for the computation and plotting of position fixing patterns.

1.8 **Publications**

1.8.1 *Primary trigulation*

HAASBROEK, N. D. – Investigation of the accuracy of Krayenhoff's triangulation (1802–1811) in Belgium, The Netherlands and a part of North Western Germany. Netherlands Geodetic Commission, Delft, 1972–222 p., 30 figs.

HAASBROEK, N. D. – Investigation of the accuracy of Stamkart's Triangulation (1866–1881) in The Netherlands. Netherlands Geodetic Commission, Delft, 1974 – 144 p., 32 figs.

1.8.2 *Electronic distance measurement*

BRUIJN, D. C. DE – Elektronische afstandmeting. De Ingenieur, The Hague, 1971, No. 47, pp. B 150-B 155 – In Dutch, 6 p., 8 figs.

HAARSMA, M. and G. J. HUSTI – The high precision traverse Kester -Delft. Report submitted to A.I.G.-commission I (Readjustment of the European Triangulation), Delft, 1973 – 42 p., 7 figs.

1.8.3 *Base lines*

HONKASALO, T. – Remeasurement of the standard base Loenermark. Netherlands Geodetic Commission, Publications on Geodesy, New Series, Vol. 4, No. 2, Delft, 1971 – 24 p., 2 figs.

BAKKER, G., M. HAARSMA, B. G. K. KRIJGER and J. C. DE MUNCK Measurement of the base and base extension net "Afsluitdijk", Netherlands Geodetic Commission. Publications on Geodesy, New Series, Vol. 4, No. 4, Delft, 1972 – 98 p., 47 figs.

1.8.4 *Levelling*

WEELE, P. I. VAN DER – De geschiedenis van het N.A.P. (History of the N.A.P.). Netherlands Geodetic Commission, Delft, 1971 – In Dutch, 44 p., 6 figs.

WAALEWIJN, A. – Hydrostatische waterpassing. De Ingenieur, The Hague, No. 46, 1971, pp. B 129 - B 132 – In Dutch, 3 p., 4 figs.

BEUSEKOM, W. A. VAN – Hydrostatische waterpassingen. Geodesia, Delft, 1971, No. 10, pp. 227–279 – In Dutch, 3 p., 3 figs.

1.8.5 *Geodetic astronomy*

HUSTI, G. J. – The twin Laplace point Ubachsberg-Tongeren, applying the Black Method. Netherlands Geodetic Commission, Publications on Geodesy, New Series, Vol. 4, No. 1, Delft, 1971 – 30 p., 13 figs.

HUSTI, G. J. – The universal theodolite DKM 3A with self-recording motor-micrometer. Nederlands Geodetisch Tijdschrift, 1973, No. 3, pp. 49–53 – 5 p., 6 figs.

1.8.6 *Refraction*

MUNCK, J. C. DE – Limits of the use of dispersion in determining terrestrial refraction angles. Paper presented at the Syposium "Terrestrial electromagnetic distance measurements and atmospheric effects on angular measurements", Stockholm 1974 – 18 p., 6 figs.

1.8.7 *Marine geodesy*

HUSTI, G. J. – De onderwatertechniek van de mariene geodesie. Nederlands Geodetisch Tijdschrift, Delft, 1971, No. 3, pp. 41–49 – In Dutch 9 p., 10 figs.

MUNCK, J. C. DE – Methoden van plaatsbepaling op zee met behulp van elektromagnetische golven korter dan enkele meters. Nederlands Geodetisch Tijdschrift, Delft, 1971, No. 9, pp. 189–195 – In Dutch, 7 p., 2 figs.,

ZIELEMAN, G. and L. H. VAN OPSTAL – Geometrical and mathematical properties of a modified hyperbolic pattern. The International Hydrographic Review, Vol. XLIX, No. 2, pp. 47–62, Monaco 1972 – 16 p., 7 figs.

WEELDE, H. H. VAN – Deep draught surveys in the southern North Sea. The International Hydrographic Review, Vol. L, No. 1, pp. 13–23, Monaco 1973 – 11 p., 7 figs.

GENT, W. G., VAN – A practical solution of some geodetic problems in the hydrographic survey near the Leeward Islands of the Netherlands Antilles. Hydrographic Newsletter, Vol. 2, No. 6 pp. 487–504, The Hague, 1973 – 18 p., 3 figs.

Buis, B. – Automation in the Netherlands Hydrographic Service. Hydrographic Newsletter, Vol. 2, No. 6, pp. 505–523, The Hague, 1973 – 18 p., 4 figs.

Weelde, H. H. van – HYDRAUT as a tool for surveys in the southern North Sea. Paper presented at the 14th F.I.G.-Congress, Washington 1974, Proceedings of the XIVth International Congress of Surveyors pp. 403.5.1.-403.5.6.. Washington, 1974 – 6 pag., 3 figs.

Schaaf, H. Ph. van der – Positiepatronen in het Waddengebied. De Ingenieur, The Hague, No. 46, 1971, pp. B. 133- B 135 – In Dutch, 3 p., 2 figs.

Wal, J. H. M. van der – Enkele toepassingen van de laser. De Ingenieur, The Hague, No. 47, 1971, pp. B 155 - B 158 – In Dutch, 4 p., 8 figs.

Schaaf, H. Pil. van der – Systems for automatic computations and plotting of position fixing patterns. Rijkswaterstaat Communications No. 13, The Hague, 1972 – 64 p., 17 figs.

Los, C. – Moderne radio-navigatie systemen. De Ingenieur, The Hague, 1972, No. 9, pp. ET 31 - ET 37 – In Dutch, 7 p., 7 figs.

2 SATELLITE TECHNIQUES

2.1 General

The Working Group for Satellite Geodesy at the Geodetic Institute of the Delft University of Technology continued making photographic observations of satellites (station- to - satellite directions). Contributions were made to the Western European Satellite Triangulation until the termination of its observation phase, to the International Satellite Geodesy Experiment (ISAGEX) and to the current European Short Arc Programme. All observations have been made with a Bouwers-Maksutov type camera ($f = 120$ cm; effective aperture 21 cm).
The manufacture of a geodetic satellite camera with refracting optics available on the market ($f = 90$ cm $f/4$) was completed. It features an automized plate advancing device and a focal plane timing chopper with punched tape output. Early 1974 the design and construction of laser equipment for ground based artificial satellite ranging and illumination for photographic direction measurement was undertaken. This work is partly contracted out to the Institute of Applied Physics TNO-TH at Delft. A ranging precision in the order of 10 to 20 cm is aimed at. The equipment is expected to be operational by the end of 1975.
At the end of 1973 the Working Group moved to a new satellite geodetic observatory at Kootwijk near Apeldoorn. The approximate geographic coordinates of this new site are:

Latitude	= 52° 10′ 45″
Longitude (east)	= 5° 48′ 40″

Theoretical work was concentrated on geometric applications of spatial techniques: stellar oriented satellite photography, laser ranging to artificial satellites, radio Doppler observations and VLBI. Extensive computer programming was devoted to preparing spatial geodetic network calculations using direction and/or range observations to satellites. In the resulting procedures special attention is paid to considerations of precision and reliability; statistical testing of observations is therefore included. The basic theories for this testing originate from W. Baarda and have been further developed by the Computing Centre of the Delft Geodetic Institute.
In a later stage the spatial network theory and calculations will be focussed on the detection of deformations of the earth's crust.

2.2 Publications

Sluiter, P. G. – Het gebruik van satellieten voor navigatiedoeleinden. Nederlands Geodetisch Tijdschrift, 1971, No. 1, pp. 3–11 – In Dutch, 9 p., 8 figs.

Aardoom, L. – Over satellietgeodesie. Ruimtevaart, 's-Gravenhage, No. 3, 1971, pp. 42–46 – In Dutch, 5 p.

Poelstra, T. J. – Satellietgeodesie in Nederland. Ruimtevaart, 's-Gravenhage, No. 3, 1971, pp. 47–58 – In Dutch, 12 p.

Aardoom, L. – Geometric accuracy obtainable from simultaneous range measurements to satellites. The use of artificial satellites for geodesy. AGU Geophysical Monograph 15, 1972. Washington D.C., pp. 9–18 – 10 p.

Aardoom, L. – Het gebruik van lasers in de satellietgeodesie. Proceedings Symposium Eigenschappen en Toepassingen van Laserstraling, Delft, 1972, pp. 149–153 – In Dutch, 5 p.

Aardoom, L. – On a geodetic application of multiple-station very long baseline interferometry. Netherlands Geodetic Commission. Publications on Geodesy, New Series, Vol. 5, No. 2, Delft, 1972, – 23 p., 10 figs.

Poelstra, T. J. – Facilities for satellite geodesy in the Netherlands. Mitteilungen der geodätischen Institute der Technischen Hochschule in Graz, Graz 1972, Folge 11–1, pp. 181–207 – 27 p., 21 figs.

AARDOOM, L. – On the concept of eccentric camera stations for geometric satellite geodesy. Mitteilungen der geodätischen Institute der Technischen Hochschule in Graz, Graz 1972, Folge 11–2, pp. 153-163 – 11 p., 4 figs.
AARDOOM, L. – Outline of a model for radio-doppler geometric satellite geodesy. Meddelande fran Geodetiska institutionen vid Uppsala Universitet. Uppsala, 1973, No. 11–24 p.
MUNCK, J. C. DE – Geodetische plaatsbepaling in de ruimte. NERG, Leidschendam, 1973, No. 4, pp. 67–71 – In Dutch, 5 p., 8 figs.
AARDOOM, L. – Schemes for global clock synchronization using very long baseline interferometry of stellar sources. Delft Progress Report, Series E: Geosciences, Vol. 1, 1974, No. 1, pp. 11–22 – 12 p., 12 figs.
AARDOOM, L. – Ruimtelijke geometrie met toepassingen. Delftse Universitaire Pers, Delft, 1974 – In Dutch, 23 p.
POELSTRA, T. J. and F. W. ZEEMAN – Delft University equipment for photographic satellite observations. Netherlands Geodetic Commission. Publications on Geodesy, Delft 1974, New Series, Vol. 5, No. 3 – 64 p., 36 figs.
POELSTRA, T. J. – A new satellite observatory at Kootwijk, Publication of the Netherlands Geodetic Commission, Delft, 1974 – 26 p., 12 figs.
POELSTRA, T. J. – Een nieuwe satellietwaarnemingspost te Kootwijk. Nederlands Geodetisch Tijdschrift, Delft, 1974, No. 6, pp. 155–162 – In Dutch, 8 p., 5 figs.

3 GRAVIMETRY

3.1 **The Netherlands**

An accurate gravity connection was made between the gravity networks of The Netherlands and Germany. The measurements were carried out by the Technological Universities of Hannover and Delft. The gravity baseline in The Netherlands between Amsterdam and Eindhoven was also determined. The following instruments were used:

Two La Coste-Romberg gravity meters No. 79 and No. 85
One Worden gravimeter No. 642
One North American gravimeter No. 170.

Based on these results the whole gravity network of The Netherlands was recomputed and connected to the International Gravity Standardization Net 1971. (I.G.S.N. 71). The results were published by the Deutsche Geodätische Kommission (Reihe B, Nr. 195).

3.2 **Surinam**

A short report on the gravity survey of the continental shelve of Surinam and a map of free air anomalies were published in 1971.

3.3 **Publications**

TORGE, W., G. L. STRANG VAN HEES and H. DREWES – Verbindung des Niederländischen Schwerenetzes mit dem International Gravity Standardization Net 1971 (I.G.S.N. 71). Deutsche Geodätische Kommission, Reihe B, Nr. 195, München, 1973 – In German, 16 p., 6 figs.

STRANG VAN HEES, G. L. – Gravity measurements on the continental shelf of Surinam. In: Scientific Investigations on the shelf of Surinam H.N1.M.S. Luymes. Netherlands Hydrographic Office, Hydrographic Newsletter, Special publication No. 6, pp. 11–12, The Hague, 1971 – 2 p., 1 fig.

4 THEORY AND EVALUATION

4.1 Computing Centre, Geodetic Institute, Delft University of Technology

Since the Moscow A.I.G. General Assembly much experience was acquired with the planning of plane networks (with and without control points), based on the testing theory published in *Statistical Concepts in Geodesy* and *A Testing Procedure for Use in Geodetic Networks* and the precision theory developed in *S-Transformations and Criterion Matrices.**

Research is being carried out on the interrelation between *measures of reliability* of networks (following from the testing theory) and *measures for precision* of networks. Of importance are in this connection the λ-quantities invariant with respect to S-transformations as mentioned in: "A personal report on activities of S.S.G. 1.14 (now 4.14) Moscow, 1971".

The testing and precision theories have also been applied in the study of deformation measurements in which special attention has been paid to the power of tests of networks having different "Strength of figure".

Applying the testing- and precision theory to spatial networks is presently being studied. Detailed analyses of geometric networks using the quaternion theory have been carried out. These have resulted in the first formulae for spatial S-transformations. A reformulation of the Stokes-type theories in gravimetric geodesy gave a new insight into the connection between geometric and gravimetric methods in geodesy.

A start has been made with an extension of the programme library, i.e. the creation of SCAN-II (Systematic Computer Adjustment of Networks, 2nd version) in Fortran. A fundamental approach – in which the most important calculation processes are carried out with dimensionless quantities – enables computation of least-squares adjustment and planning of various types of geometric networks, including the computation of measures for reliability and precision.

4.2 Publications

BAARDA, W. – A personal report on activities in S.S.G. No. 1.14: Specifications for fundamental networks in geometric geodesy. Report presented at the 15th A.I.G.-General Assembly, Moscow, 1971. Traveaux de l'A.I.G. tome 24, pp. 51–65, Paris, 1972 – 15 p., 5 figs.

BAARDA, W. – Criteria for precision of geodetic networks. Paper presented at the 13th F.I.G.-congress, Wiesbaden, 1971. Proceedings of the XIIIth International Congress of Surveyors, pp. 503.1 – 503.8 – 8 pages, 4 figs.

KRIJGER, B. G. K. and J. C. P. DE KRUIF – Systematic computer adjustment of networks (SCAN). Paper presented at the 13th F.I.G.-congress, Wiesbaden, 1971. Proceedings of the XIIIth International Congress of Surveyors, pp. 506.1 – 506.8 – 8 pages. 4 figs.

BAARDA, W. – S-transformations and criterion matrices. Netherlands Geodetic Commission, Publications on Geodesy, New Series, Vol. 5, No. 1, Delft, 1973, – 168 pages, 41 figs.

MIERLO, J. VAN – Beoordeling van geodetische netten. Nederlands Geodetisch Tijdschrift, 1973, No. 6, pp. 107–119 – In Dutch, 13 p., 8 figs.

KRUIF, J. C. P. DE – Problemen met kringnetten. Nederlands Geodetisch Tijdschrift, 1973, No. 10 pp. 201–211 – In Dutch, 11 p., 7 figs.

* Netherlands Geodetic Commission, Publications on Geodesy, New Series, Vol. 2, Nos. 4 and 5 and Vol 5, No. 1.

ALBERDA, J. E. – Planning and optimization of networks: some general considerations. Paper presented at the A.I.G. Symposium on Computational Methods in Geometric Geodesy, Oxford, September, 1973. Bollettino di Geodesia e Scienze Affini, 1974, No. 2, pp. 209-240 – 32 p., 12 figs.

ALBERDA, J. E. – Aspects of large levelling nets. Paper presented at the International Symposium on Problems Related to the Redefinition of North-American Geodetic Networks, Fredericton, Canada, 1974 – 31 p., 6 figs.

MIERLO, J. VAN – Analyse deformatiemetingen. Nederlands Geodetisch Tijdschrift, 1974, No. 10, pp. 259–267 – In Dutch, 9 p., 13 figs.

MIERLO, J. VAN – Planning geodetic networks. Paper presented at the 14th F.I.G.–congress, Washington, 1974 – 9 p., 4 figs.

5 PHYSICAL INTERPRETATION

5.1 **Recent Movements of the Earth's Crust**

5.1.1 *Measurements*

At the request of the subcommission Crustal Movements of the Netherlands Geodetic Commission the precise levellings across a number of faults between Venlo and Roermond were repeated in 1971 (several measurements since 1923) and across the saltdome near Schoonlo in 1972 (first measurement 1967).

Daily vertical movements of coastal benchmarks were studied in terms of their relationship to the tide by means of hydrostatic levelling at Veerse Meer (1971) and Katwijk aan Zee (1972).

5.1.2 *Levellings in mining areas*

A total of 450 km was levelled across eight small oil- and gasfields to check the effect of oil- and gas exploitation.

The third levelling across the gasfield Groningen was carried out in 1972 (previous levellings in 1964/1965 and 1968/1969). The network consisted of 1260 km of levelling, 81 circuits, 166 nodal points and 246 sections. The standard deviation of this levelling was 0.6 mm/km. Since the beginning of the gas production in 1965, a surface subsidence of 2.5 cm was found in the centre of the field, see Fig. 2. In 1973 an additional 193 km was levelled to check the 1972 results (Note: the total of kms levelling in the Groninger gasfield is included in the figure given for second order levelling in section 1.4.1.)

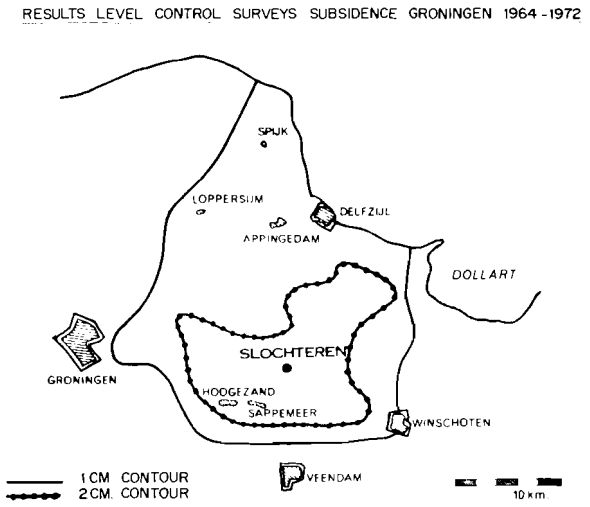

Fig. 2

5.2 **Publications**

LAMBECK, K. – The earth's gravity field: its determination and its interpretation. Nederlands Geodetisch Tijdschrift, 1972, No. 3, pp. 41-54 – 14 p., 7 figs.

RITSEMA, A. R. – Earthquake mechanism aspects of basin and arc formation in the Central Mediterrenean. Paper presented at the Symposium on Recent Crustal Movements and Associated Seismic and Volcanic Activity, Bandung, Indonesia, 1973.

RITSEMA, A. R. – Geodynamica, de mobiliteit van de vaste aarde. Nederlands Geodetisch Tijdschrift, 1974, No. 7, pp. 175–185 – In Dutch, 11 p., 11 figs.

LEEGTE, K. – Bodemdalingen in het Groninger gasveld. Nederlands Geodetisch Tijdschrift, 1974, No. 8, pp. 193–200 – In Dutch, 8 p. ,11 figs.