A. van Wijngaarden

In Memoriam A. van Wijngaarden

1916 - 1987

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On February 7, 1987, Adriaan van Wijngaarden passed away. In him the Wiskundig Genootschap has lost a distinguished and valued member, and the scientific community at large a highly respected and productive scientist.

Van Wijngaarden was born on November 2, 1916, at Rotterdam. He attended the Gymnasium Erasmianum in that place, and then studied Mechanical Engineering at the Technical University in Delft. He was particularly influenced by the courses of prof. J.M. Burgers and prof. C.B. Biezeno, and much enjoyed their strongly mathematical approach to mechanics. After some initial work, under Burgers, in fluid dynamics (cf. W1, W2*)), van Wijngaarden wrote a thesis, under supervision of Biezeno, on 'Some applications of Fourier integrals to elastic problems' (W3); on December 12, 1945, he obtained his Ph. D.

In 1946 van Wijngaarden held a position with the National Aeronautical Laboratory at Amsterdam. On January 1, 1947, he started to work at the newly founded Mathematical Centre (MC, for short) in Amsterdam; eventually, he became its director (1961-1980). In addition, he held a part-time professorship at the University of Amsterdam since 1952. In December 1981 he went into retirement.

Aad van Wijngaarden will be mainly remembered for his contributions to computer science. In the 1940's, however, there was no independent discipline called computer science (or informatics or whatever you will). In effect, van Wijngaarden was one of those who helped call it into being. Indeed, as far as

*)The n-th publication of van Wijngaarden in the list of his publications appended to this paper will be referred to by Wn; with [m] we refer to the m-th publication in the list of References.

informatics in The Netherlands is concerned, he is to be considered the founding father. But before we go into more detail, we will first discuss his contributions to mathematics.

These contributions are of three kinds. As a researcher, van Wijngaarden contributed to the theory of elasticity, fluid dynamics, numerical analysis and number theory. As a teacher, he inspired those who worked with him, while his lectures on numerical mathematics, both at the Mathematical Centre and at the University of Amsterdam, provided essential education for many generations of students. Also, for many years he was chairman of the Committee for Scientific Computation of the Wiskundig Genootschap; he participated both as a lecturer and as an examiner.

The third way in which van Wijngaarden contributed to mathematics was in his capacity of director of the Mathematical Centre. He stimulated the research going on in this institute and, in addition, he made the technical and administrative apparatus of the institute available for the scientific community. From its first issue, the *Mededelingen* (Notices) of the Wiskundig Genootschap (WG) were produced at, and distributed by the MC. The MC also publishes the scientific journal *Nieuw Archief voor Wiskunde* of the WG. In 1978 the bicentennial celebration of the WG could be given such a dignified and festive expression thanks to the wholehearted cooperation of van Wijngaarden, both personally and through 'his' institute.

In his papers on fluid dynamics and on elasticity theory (W1-W6, W9, W18, W32), van Wijngaarden exhibited considerable skill in the treatment of differential equations, by analytic as well as by algebraic methods. In particular, he had to master the techniques of numerical mathematics, using the available mechanical calculators of the time. (The calculations for his thesis (W3) were performed partly - at the university - on a Millionaire, possibly the same machine which H.A. Lorentz used in his work for the Zuyderzee enclosure project, but mostly - at home - on a Marchant.)

Van Wijngaarden's experience with numerical analysis turned out to be of vital importance when he came to work at the Mathematical Centre. His first task was setting up a department of computation. Under his personal direction, a contingent of 'computers' (i.e. young ladies, at that time) was set to work on large projects of scientific calculation, usually on behalf of clients, such as the National Aeronautical Laboratory or Shell. Van Wijngaarden prepared - 'programmed' - the numerical work and regularly gave mathematical instruction to the 'computing girls'. For a captivating description of those activities, see the interview with van Wijngaarden in [1] pp. 276-288. Apart from contract work, the computing department prepared a number of numerical tables, such as W11, W15, W16, W21, W23 and W37.

As a side remark, it is of importance to keep in mind that numerical analysis - as understood and practized up to the fifties - had a wider scope than what nowadays is called numerical mathematics. In fact, one could maintain that both numerical mathematics (the mathematical study of the methods of computation) and numerical computation (the implementation and realization of these methods on electronic computers) branched off from what used to be called numerical analysis. Of course, van Wijngaarden not only lived through this development, he also contributed actively to it.

Van Wijngaarden lectured on numerical mathematics, both at the MC and, from 1952 - when he was appointed part-time professor of 'Numerical, Graphical and Mechanical Methods in Mathematics' at the University of Amsterdam - at the university (see e.g. W10, W39). But he also contributed to the development of the field. His fundamental discussion of rounding errors was quite influential at that time (cf. W13, W14 and W31). More fundamental reflections on the essence of numerical mathematics are expressed in W57.

Van Wijngaarden's best known theoretical contribution to numerical mathematics is to be found in W29. This concerns the so-called van Wijngaarden transformation, used to transform a slowly convergent or even divergent series into another one which usually converges more rapidly. The method is very suitable for numerical treatment; one feature is the use of standard functions together with some associates (selected suitably to the problem under consideration) that need be computed only once. For numerical aspects, see [12]; a nice analysis of the van Wijngaarden transformation as the Laplace transform of the Euler transformation is presented in [5]. Not only numerical and applied mathematics held van Wijngaarden's attention: he was particularly captivated by number theory. Together with H.J.A. Duparc he worked on Fermat's last theorem (W33, W34). Number theoretical problems lay behind W16, W30 and W58. In W27 an elegant proof is presented of D. van Dantzig's conjecture that $2 \cdot (2^{2n}-1)B_{2n}$ (where B_{2n} denotes the n-th Bernoulli number) is an integer. In addition, he showed this integer to be odd.

It is important to mention here that van Wijngaarden enjoyed working in a team. Several of his papers have co-authors or depend on joined efforts. Of his close collaborators - apart from his lady computers - we mention J. Berghuis, H.J.A. Duparc, A.J.W. Duijvestijn and W.L. Scheen.

We already mentioned that the most important scientific contributions of van Wijngaarden concern computer science. When appointed at the MC in 1947, he was sent on a study trip to Great Britain and the USA, to learn 'everything' about the emerging field of electronic computing. He spent almost all of 1947 abroad. He visited Cambridge, the National Physical Laboratory, Harvard and the Institute of Advanced Study, and met with computer pioneers such as Turing, Wilkes, Wilkinson, Hartree, Aiken, Goldstine and Von Neumann. In between, during a short return to Amsterdam, he set in motion the activities which were to lead to the building of the first modern computers in The Netherlands, and to the birth of a Dutch computer industry. Some of his collaborators in those early years were B.J. Loopstra, C.S. Scholten, G.A. Blaauw, E.W. Dijkstra and J.A. Zonneveld. There was also a close cooperation with W.L. van der Poel (who was the first to obtain a Ph. D. under van Wijngaarden's supervision). The enthousiasm of the pioneers and the circumstances under which they worked are captured in Scholten [10]; cf. also W17 and the van Wijngaarden interview in [1].

In 1952 the ARRA (Automatische Relais Rekenmachine Amsterdam) was taken into use, followed by the ARRA II in 1953, the FERTA (Fokker Electronische Rekenmachine Type ARRA) in 1955 and the ARMAC (Automatische Rekenmachine Mathematisch Centrum) in 1956. In 1956 a commercial firm, NV Electrologica, was set up, and the activities of designing and building hardware were gradually transfered. The first commercial computer - the fully transistorized X1, a prototype of which was operational at the end of 1957 - had yet been mostly designed at the MC.

In the meantime van Wijngaarden had started courses in computer programming (cf. W19, W40, W43). Both in speech and in writing he had been promoting modern computing and computers from 1947 (cf. W7-8, W12, W24-26, W35-36, W40-42, W50, W52, W68-69). Programming, as an essential part of modern computing, naturally had his attention. In fact, van Wijngaarden maintained that even in the late forties, when computers were still human beings, his preparation of the calculation jobs for the computer team essentially was a form of programming (cf. [1] pp. 283-285). However, in 1958 he refocussed his attention and became much involved in the development and definition of higher programming languages. Later he described this switch of attention as 'consciously opting for a new vocation' (cf. [1] p. 288).

Van Wijngaarden always had been interested in language; witness e.g. his inaugural oration W26. He had a flair for languages, and was very meticulous and precise with regard to formulation and style. These traits, together with his intimate knowledge of computers, and his considerable expertise in numerical mathematics, undoubtedly were of great value when he switched to programming languages. In any case, here it is where van Wijngaarden's most important and original contributions to science lie.

The full story of the involvement of van Wijngaarden and his collaborators in the development of ALGOL 60 would require more space then is available in this obituary. And the history of ALGOL 68, in which van Wijngaarden played the central role, would need even more coverage. Fortunately, these stories have been told elsewhere: by P. Naur [7], W.L. van der Poel [9], W.M. Turski [13] and, more obliquely, by H. Zemanek [14].

From the contributions of van Wijngaarden to formal language theory, as witnessed by almost all of his publications from W45 onwards, we select the seminal working paper W54 and its follow-up as an example of van Wijngaarden's work. In W54, the concept of a two-level grammar (also called - by others - a Van Wijngaarden grammar or W-grammar) is introduced. This paper is important for historical reasons: it was crucial in the genesis of ALGOL 68. But it is not the most appetizing to read. In later publications, van Wijngaarden presented a much more polished account of his ideas (W73, W77). A two-level grammar, as the name suggests, consists of two separate levels. The upper level contains context-free metaproduction rules, which may create lower level instances of metanotions; the lower level contains patterns, called hyperrules, which, together with the metanotions, generate the actual context-free production rules of the grammar. Quoting from W77: 'Some experience shows that the two-level mechanism suits the human way of thinking well. The lower level of the grammar enables us to depict a specific situation, the higher level to express an abstraction, viz., a class of situations.'

This concept turned out to be very powerful. It was used to describe the full syntax of ALGOL 68 (W74). Sintzoff [11] proved that every recursively enumerable language is generated by a two-level grammar. Van Wijngaarden strengthened this result by showing that this can even be done using a grammar with only one metanotion (W73). This result was further refined by van Leeuwen [6]. Van Wijngaarden demonstrated by several elegant examples how these grammars can be used to obtain proofs of program correctness, analyze (fragments of) natural language, or express algorithms directly under avoidance of an intervening programming language (W70, W77-78). For a discussion of applications of two-level grammars in the treatment of natural languages, cf. [4]. A good textbook treatment is given in [3].

Not only through his research van Wijngaarden has contributed to the advancement of computer science. We already mentioned his part-time professorship at the University of Amsterdam; later on his courses on numerical mathematics were replaced by courses in programming and formal languages. He was the supervisor for fifteen doctorates: cf. Appendix I. He also taught as a visiting professor in New York (1953), Berkeley (1962) and Chicago (1968).

Van Wijngaarden's organizational contributions have already been mentioned with regard to mathematics. As far as computer science is concerned, much has to be added. For instance, he was one of the originators of the Nederlands Rekenmachine Genootschap (Dutch Association for Computing Machines; later this became a part of the Nederlands Genootschap voor Informatica, the Dutch Association for Informatics); he attended the 1959 International Conference on Information Processing in Paris, were the ground work was done for the founding of IFIP, the International Federation of Information Processing. For years, he was the representative of The Netherlands in the IFIP council and later in the General Assembly, serving as Vicepresident from 1962 to 1964, and as IFIP Trustee from 1967 to 1970. In 1974 the IFIP awarded him the Silvercore, in recognition of his outstanding service.

The Amsterdam Academic Computer Centre SARA, which serves the two Amsterdam universities and - through the Mathematical Centre - the research institutes of NWO (Nederlandse Organisatie voor Wetenschappelijk Onderzoek), the Dutch science organization, was a logical follow-up to the computing service built up by van Wijngaarden at the MC, and van Wijngaarden was actively involved in the foundation of SARA. The many activities of van Wijngaarden received wide acclaim and recognition, both nationally and in international context. He was appointed a member of the Royal Dutch Academy of Sciences in 1959. He received honorary doctorates from the Institut National Polytechnique at Grenoble (1978) and from the Delft Technological University (1981). In 1973 Queen Juliana of The Netherlands granted him the honour 'Ridder in de Orde van de Nederlandse Leeuw'. The Österreichische Gewerbeverein in Vienna awarded him the Wilhelm Exler

Medal, the City of Amsterdam their Silver Medal, the City of Paris their Medaille d'Argent. In 1986, he received the Computer Pioneer Award of the IEEE.

Van Wijngaarden was Honorary Member of the NGI. And shortly before his death, the Wiskundig Genootschap started procedures which should have lead to his appointment as an Honorary Member.

Adriaan van Wijngaarden had a pleasant and charming personality. Colleagues mention his 'friendly and polite manner and flexible intelligence'. He worked hard, always striving for perfection. At the same time he showed a warm and personal attention to the people working with him.

All those who knew van Wijngaarden personally and had the privilige to work with him, will remember him with respect and gratitude.

Appendix I

Doctorates under Supervision of A. van Wijngaarden

1.	W.L. van der Poel	The logical principles of some simple computers (1956).
2.	N.C. de Troye	Classification and minimization of switching functions (1958).
3.	E.W. Dijkstra	Communication with an automatic computer (1959).
4.	G. Zoutendijk	Methods of feasible directions (1960).
5.	J.A. Zonneveld	Automatic numerical integration (1964).
6.	J.W. de Bakker	Formal definition of programming languages (1967).
7.	R.P. van de Riet	ALGOL 60 as formula manipulation language (1968).
8.	B.J. Mailloux	On the implementation of ALGOL 68 (1968).
9.	J. Verhoeff	Error detecting decimal codes (1969).
10.	H. Brandt Corstius	Exercises in computational linguistics (1970).
11.	M.H. van Emden	An analysis of complexity (1971).
12.	P. van Emde Boas	Abstract resource-bound classes (1974).
13.	H.J.J. te Riele	A theoretical and computational study of generalized aliquot sequences (1976).
14.	J.C. van Vliet	ALGOL 68 transput (1979).
15.	D. Grune	On the design of ALEPH (1981).

Appendix II

List of Selected Publications by A. van Wijngaarden

1942 1 *Laminar flow in radial direction along a plane surface,* Proc. Ned. Akad. Wet., *XLV* (1942) pp. 269-275.

1943 2 *Stroming in radiale richting tussen twee vlakke wanden,* Verslagen Ned. Akad. Wet., *LII* (1943) pp. 29-36.

1945 3 *Enige toepassingen van Fourierintegralen op elastische problemen,* Thesis T.H. Delft, Delft (Meinema, 1945) pp. 122.

1946 4 *Large distortions of circular rings and straight rods,* Proc. Kon. Ned. Akad. Wet. *XLIX* (1946) pp. 648-664.

1947 5 *The elastic stability of flat sandwich plates,* Rep. & Trans. Nat. Aeron. Res. Inst., *XIII* (1947) pp. S37-56.

6 *Over het niet-lineaire verband tusschen de doorbuiging en de belastende kracht van een in zijn beide uiteinden ingeklemden halfcirkelvormigen ring,* De Ingenieur, Techn. Wet. Onderz. 2, *59*, no. 8 (1947) pp. 1-3.

1948 7 *Principes der electronische rekenmachines,* Syllabus Math. Centre (1948) 27 pp.

1949 8 *Algemeen overzicht over moderne rekenmachines,* Ned. Tijdschrift voor Natuurkunde, *15* (1949) pp. 243-253.

9 *Ecoulement potential autour d'un corps de révolution,* in Méthodes de calcul dans des problèmes de mécanique, Coll. Int. *XIV*, Paris (CNRS, 1949) pp. 72-87.

10 *Cursus moderne rekenmethoden,* Syllabus Math. Centre, 166 pp.

11 *Table of Fresnel integrals,* (with W.L. Scheen), Verhandelingen Kon. Ned. Akad. Wet., Afd. Natuurkunde, 1e Sectie, *XIX*, no. 4 (1949) pp. 1-26.

12 *Practisch rekenen,* ENSIE, Eerste Ned. Syst. Inger. Encycl. *IV* (1949) pp. 104-112.

1950 13 *Afrondingsfouten,* Math. Centre, Comp. Dept., MR3 (1950) 20 pp. (Translation: 'Rounding-off errors' by E. Lever and T.W. Hill, Divison of Math. Stat. CSIRO, Australia, Techn. Rep. 7 (1972) pp. 16).

14 *Grundsätzliche Probleme der Abrundungsfehler,* ZAMM, *30* (1950) pp. 275-276.

15 *Table of the cumulative symmetric binomial distribution,* Proc. Kon. Ned. Akad. Wet., *LIII* (1950) pp. 857-868.

16 *A table of partitions into two squares with an application to rational triangles,* Proc. Kon. Ned. Akad. Wet., *LIII* (1950) pp. 869-881.

17 *Computing machine projects in Holland,* in Report of a conference on high speed automatic calculating machines, Cambridge (Univ. Math. Lab., 1950) 113 pp.

1951 18 *Large deflections of semi-oval rings,* Rep. & Trans. Nat. Aeron. Res. Inst., *XVI* (1951) pp. 1-7.

19 *Programmeren voor de ARRA,* Math. Centre, Comp. Dept., MR7 (1951) 44 pp.

20 *Decimal-binary conversion and deconversion,* Math. Centre, Comp. Dept., R130 (1951) 41 pp.

1952 21 *Tables for use in rank correlation,* (with L. Kaarsemaker), Statistica, 7 (1953) pp. 41-54.

22 *Harmonic analysis of earth-tides measurements,* (with J. Berghuis), Math. Centre, Comp. Dept., R97 (1952) 18 pp.

23 *Table of the integral* $\int_0^1 \exp(-v^{-2}-xv)v^{-p}dv$, Math. Centre, Comp. Dept., R176 (1952) 6 pp.

24 *Rekenmachines,* in Winkler Prins Encyclopaedie, 6th edition, *XV* (Elsevier, 1952) pp. 841-842.

25 *Electronische rekenmachines,* (1952) pp. 67-76.

26 *Rekenen en vertalen,* Oratie UvA, Delft (Waltman, 1952) 21 pp.

27 *A note on Bernoulli numbers,* Math. Centre, Comp. Dept., DR 7 (1952) 3 pp.

1953 28 *On a certain asymptotic expansion,* Quarterly of Applied Math., *XI* (1953) pp. 244-246.

29 *A transformation of formal series,* Proc. Kon. Ned. Akad. Wet., ser. A, *LVI* (1953) pp. 522-543.

30 *On the coefficients of the modular invariant* $J(\tau)$, Proc. Kon. Ned. Akad. Wet., Ser. A, *LVI* (1953) pp. 389-400.

31 *Erreurs d'arrondiment dans les calculs systématiques,* in Les machines à calculer et le pensée humaine, Coll. Int. *XXXVII*, Paris (CNRS, 1953) pp. 285-293.

32 *Ut tensio sic vis,* (in English), in C.B. Biezeno Anniversary volume on applied mechanics, Haarlem (Stam, 1953) pp. 214-224.

33 *A remark on Fermat's last theorem,* (with H.J.A. Duparc), Nieuw Archief voor Wiskunde (3) *I* (1953) pp. 123-128.

1954 34 *Note on a previous paper on Fermat's last theorem,* (with H.J.A. Duparc), Nieuw Archief voor Wiskunde (3) *II* (1954) pp. 40-41.

35 *Het gebruik van automatische rekenmachines,* in Verslag van het tiende Nederlands Congres van leraren in de wiskunde en de natuurwetenschappen, Groningen (Wolters, 1954) pp. 13-18.

36 *Mathematics and computing,* in Automatic digital computation, NPL, Her Majesty's Stationary Office, (1954) pp. 125-127 (also p. 124).

1955 37 *Table of Everett's interpolation coefficients,* (with E.W. Dijkstra), Math. Centre, Comp. Dept., R294 (1955) pp. 204.

1956 38 *Introduction,* Proc. Inst. Electrical Engineers, *103* part B, Supplement number 1 (1956) pp. 112-113.

39 *Capita uit de numerieke wiskunde, coll. 1955/56,* A. van Wijngaarden (ed), J. Berghuis, E.W. Dijkstra, Syllabus Math. Centre, (1956) pp. 25.

40 *Programmeren voor automatische rekenmachines, cursus 1955/56,* A. van Wijngaarden, E.W. Dijkstra (eds.), Syllabus Math. Centre, (1956) pp. 128.

41 *Moderne Rechenautomaten in den Niederlanden* (Auszug aus dem Vortrag), Nachrichtentechnische Fachberichte *4* (1956) pp. 60-61.

1957 42 *Automatisering in de Wetenschap,* Economisch-Statistische Berichten, no. 2103 (1957) pp. 832-833.

43 *Programmeren voor automatische rekenmachines, cursus 1956/57,* A. van Wijngaarden (ed.), T.J. Dekker, E.W. Dijkstra, Syllabus Math. Centre, (1957) pp. 106.

1959 44 *The state of computer circuits containing memory elements,* in Proc. Int. Symp. on the theory of switching (1957), Annals Comp. Lab. Harvard Univ. *30* (1959) pp. 213-224.

1960 45 *Report on the algorithmic language ALGOL 60,* J.W. Backus, F.L. Bauer, J. Green, C. Katz, J. McCarthy, P. Naur (editor), A.J. Perlis, H. Rutishauser, K. Samelson, B. Vauquois, J.H. Wegstein, A. van Wijngaarden, M. Woodger, Num. Mathematik *2* (1960) pp. 106-136, and elsewhere.

1961 46 *L'influence de ALGOL sur l'analyse numérique,* in Colloque sur l'analyse numérique tenu à Mons le 22, 23 et 24 Mars 1961, CBRM, Paris (Gauthier-Villars, 1961) pp. 89-97.

1962 47 *Generalized ALGOL,* in Symbolic languages in data processing, New York (Gordon and Breach, 1962) pp. 409-419 and in Annual Review in Automatic programming, *3* (1963) pp. 17-26.

1963 48 *Revised Report on the algorithmic language ALGOL 60,* J.W. Backus, F.L. Bauer, J. Green, C. Katz, J. McCarthy, P. Naur (editor), A.J. Perlis, H. Rutishauer, K. Samelson, B. Vauquois, J.H. Wegstein, A. van Wijngaarden, M. Woodger, Num. Mathematik *4* (1963) pp. 420-453, and elsewhere.

49 *Switching and programming,* in Switching theory in space technology, Stanford (Univ. Press, 1963) pp. 275-283.

50 *Zestien jaar rekenmachineresearch in Nederland,* Informatie, 5, nr. 77 (1963) pp. 25-26.

1964 51 *Recursive definition of syntax and semantics,* in Formal language description languages for computer programming, Amsterdam (North-Holland, 1966) pp. 13-24.

52 *Rekenen in Nederland,* in NRMG 1959-1964, Amsterdam (NRMG, 1964) pp. 5-23.

53 *The language of the future,* in Proc. Nat. Conf. on data processing, Rehovoth (1964), Inf. Proc. Ass. of Israel (1965) pp. 189-211.

1965 54 *Orthogonal design and description of a formal language,* Math. Centre, Comp. Dept., MR76 (1965) p. 25.

55 *Procesanalyse,* Syllabus Math. Centre (1965) 129 pp.

56 *Formal properties of newspaper Dutch,* J.A.Th.M. van Berckel, H. Brandt Corstius, R.J. Mokken, A. van Wijngaarden, Math. Centre Tracts 12 (1965) 119 pp.

1966 57 *Numerical analysis as an independent science,* BIT, Nordisk Tidskrift for Informationsbehandling, 6 (1966) pp. 66-81.

58 *Triangular arrays of digits,* Math. Centre, Comp. Dept., MR83 (1966) 28 pp.

59 *De kwadratuur van de cirkel,* Mededelingen NRMG, 8, nr. 1 (1966) pp. 1-3 and cover.

60 *A draft proposal for the algorithmic language ALGOL X,* (with B.J. Mailloux), Math. Centre, Comp. Dept. (1966) 63 pp.

1967 61 *A draft proposal for the algorithmic language ALGOL 67,* (with B.J. Mailloux, J.E.L. Peck), Math. Centre, Comp. Dept. MR88 (1967) 129 pp.

62 *A draft proposal for the algorithmic language ALGOL 68,* (with B.J. Mailloux, J.E.L. Peck), Math. Centre, Comp. Dept. MR92 (1967) 124 pp.

1968 63 *Draft report on the algorithmic language ALGOL 68,* A. van Wijngaarden (ed), B.J. Mailloux, J.E.L. Peck, C.H.A. Koster, Math. Centre, Comp. Dept. MR93 (1968) 111 pp.

64 *Working document on the algorithmic language ALGOL 68,* A. van Wijngaarden (ed), B.J. Mailloux, J.E.L. Peck, C.H.A. Koster, Math. Centre, Comp. Dept. MR95 (1968) 180 pp.

65 *Penultimate draft report on the algorithmic language ALGOL 68,* A. van Wijngaarden (ed), B.J. Mailloux, J.E.L. Peck, C.H.A. Koster, Math. Centre, Comp. Dept. MR99 (1968) 183 pp.

66 *Final draft report on the algorithmic language ALGOL 68,* A. van Wijngaarden (ed), B.J. Mailloux, J.E.L. Peck, C.H.A. Koster, Math. Centre, Comp. Dept. MR100 (1968) 155 pp.

1969 67 *Report on the algorithmic language ALGOL 68,* A. van Wijngaarden (ed), B.J. Mailloux, J.E.L. Peck, C.H.A. Koster, Math. Centre, Comp. Dept. MR101 (1968, 3 printings) and elsewhere, especially Numerische Mathematik 14 (1969) pp. 79-218. Translated into French, German, Russian, Bulgarian and Chinese.

68 *Rekenmethodes voor automatische rekenmachines,* in Colloquium Moderne Rekenmachines 1, MC Syllabus 7.1 (1969) pp. 73-80.

69 *Dynamica van rekenmachines,* in Colloquium Moderne Rekenmachines 1, MC Syllabus 7.1 (1969) pp. 120-128.

1970 70 *On the boundary between natural and artificial languages,* in Linguaggi nella societa e nella tecnica, Milano (edizioni di Communità, 1970) pp. 165-176.

1971 71 *MC: MCMXLVI - MCMLXXI,* in ZWO Jaarboek 1971, pp. 105-109.

1973 72 *Ontwikkelingen op computergebied,* in Een kwart eeuw wiskunde 1946-1971, MC Syllabus 18 (1973) pp. 59-79.

1974 73 *On the generative power of two-level grammars,* in Proc. 2nd Colloquium on Automata, Languages and Programming, Saarbrücken, Springer Lecture Notes in Comp. Sci. 14 (1974) pp. 9-14.

1975 74 *Revised Report on the algorithmic language ALGOL 68,* (edited by) A. van Wijngaarden, B.J. Mailloux, J.E.L. Peck, C.H.A. Koster, M. Sintzoff, C.H. Lindsey, L.G.L.T. Meertens, R.G. Fisker, Acta Informatica 5 (1975) pp. 1-234, and elsewhere. Translated into French, German, Russian.

75 *Programmacorrectheid en grammatica's,* in Colloquium Programmacorrectheid 1975, MC Syllabus 21 (1975) pp. 177-186.

1977 76 *Het hangbuikzwijnwijfje,* in Lexicologie, opstellen voor F. de Tollenaere, Groningen (Wolters-Noordhoff, 1977) pp. 309-313.

1979 77 *Thinking on two levels,* in Proc. bicentennial congress Wiskundig Genootschap, part II, Math. Centre Tracts 101 (1979) pp. 417-428.

1982 78 *Languageless programming,* in Proc. IFIP/TC2/WG2.5 working conference on the relations between numerical computation and programming languages, Amsterdam (North-Holland, 1982) pp. 361-371.

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