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Report on a Visit to Germany and Switzerland in November 1958

1. Objects of Visit

To obtain detailed information on the intentions and achievements of the joint committee of GAMM (Gesellschaft für Angewandte Mathematik und Mechanik) and ACM (Association for Computing Machinery) towards a unified language for the expression of computing processes in automatic programming ("ALGOL").

To exchange information and experience on automatic computing matters in general.

2. Persons and Places Visited

(i) Prof. F. L. Bauer at the Institute for Applied Mathematics at the University of Mainz, 21st-23rd November.

(ii) Prof. H. Rutishauser at the Institute for Applied Mathematics, Swiss Federal Institute of Technology, Zürich, 24th-26th November.

3. Status of "ALGOL"

3.1 A notation has been devised in which sequences and loops of arithmetic processes can be concisely expressed, roughly equivalent in scope to the better-known FORTRAN system of I.B.M. Inevitably where great generality is achieved the result appears cumbrous, but there is no doubt that the use of the system in its entirety would reduce considerably the time necessary to program a wide class of ad hoc problems for any machine equipped with the translation programmes appropriate to it. This statement applies equally to a great number of present day proposals for automatic programming schemes, and their relative merits are best assessed in actual use. Progress in the realisation of translators of ALGOL for the continental machines has however been so slight that this assessment is as yet not possible.

3.2 The attempt to obtain general agreement on one common language for arithmetic processes (or "algorithms" as they are called) is praiseworthy, but appears to be an uphill struggle despite the agreement between four continental computing centres (Zürich, Munich, Mainz, Darmstadt) and a part of the United States A.C.M. The difficulty is at least partly due to the more extensive development and use of potentially rival schemes such as FORTRAN and UNICODE in the U.S.A. and the relatively slight use of any such scheme in Europe. Although Backus and other originators of some American schemes have cooperated in the specification of ALGOL, it will have to show a clear superiority over those schemes to have a chance of widespread adoption elsewhere than on the Continent. In England a wide variety of automatic programming schemes are developing, no one of which tries to be as all-embracing as ALGOL but which do at least exist as programs for computers in everyday use. A feature of most Continental and American machines which simplifies the realisation of translator programs is their predominantly single-level store, and the essentially two-level nature of the stores of English machines has been a barrier to the development here of very general programs of this kind.

3.3 A principal objective was to make the language as close as possible to standard mathematical notation and readable with little further explanation. In this I feel it has failed, and that indeed one cannot expect as much as this. Certainly the algebraic equations occurring as components of the expressions of the language are close to ordinary mathematical notation, but the logical structure of the processes intended, the control of the sequence of operations and of the use of storage requires a great deal of explanation and study before it is properly understood. There is of course no existing standard mathematical notation for this logical control.

3.4 It is intended to have a standard reference language, ALGOL proper, and various representations of it defined by explicit rules and adapted to various purposes. Thus there will be a publication language in which variations in the symbolism according to customary printing usage are permitted. Also, for each computer equipped with a translator program for ALGOL there will be a so-called "hardware representation" of the language, a condensation of it enforced by the limited number of characters on the standard input equipment of the computer but having the same structure and content.

3.5 It is intended that any program written in ALGOL shall be interchangeable between all computer installations provided with ALGOL translators, through for example the medium of international Telex codes, and usable with a minimum of preparatory work on the computer concerned.

3.6 As a first stage towards the realisation of efficient translator programs for ALGOL the four participating Continental organisations are preparing <u>interpreter</u> programs. Each of these will accept a source program expressed in the appropriate hardware representation of ALGOL and will carry out the indicated processes in the program, but interpreting each component operation afresh on each occasion regardless of the existence of loops of repetition in the calculation. Since the interpretation time is considerable the result is a very slow program. Ultimately the interpreter programs will be replaced by <u>generators</u>, each of which will accept a source program as before, process it in much the same way, but finally produce an object program in ordinary machine code before actually carrying out the calculation expressed by that program. It is anticipated that generation time will be of the same order as interpretation time on each computer, so that the simplest programs having no loops would be little or no faster using a generator - but these are expected to be rather uncommon.

Pilot stage interpreters with only rudimentary facilities have been produced for -

(i) ERMETH (Zürich), occupying 2600 orders (1300 words) and using about 700 auxiliary storage locations. The ratio of interpretation time to computing time turned out to be less than 100 on a simple example.

(ii) PERM (Munich), occupying 2200 orders, using less than 800 auxiliary storage locations. Here the interpretation time is less than 50 times computer time, and less than the standard teletype input speed. This means that the program could be interpreted by the computer as fast as it could be typed in. It is expected that the generator will take less than one second per order.

(iii) Z22 (Aachen, and shortly also Mainz), occupying 1500 orders, using less than 600 auxiliary storage locations. No generator will be made for this machine because of its moderate size - it will be used for teaching, with the interpreter, rather than for production or research.

An interpreter has yet to be made for DERA (Darmstadt) or the Siemens 2002 machine.

It was estimated for a particular program in linear algebra, which Rutishauser took 20 hours (over 14 days) to prepare in the ordinary ERMETH machine code, that about 3 hours machine time would be needed to generate it automatically. This of course takes no account of the time required to write the program in ALGOL or to get it right. About 1000 ERMETH instructions were involved in this program.

3.7 K. Samelson of Mainz (formerly of Munich) and Alan J. Perlis of ~~N.B.S.~~ Carnegie Institute of Technology, Pittsburg ~~Washington~~, appear to be the individuals responsible for a large proportion of the details of the ALGOL language.

I discussed the details of the pilot stage interpreter for ALGOL for ERMETH at ETH, Zürich, with Dr. Schwarz who prepared it. The program deals with the formula translation aspect satisfactorily and can call in subroutines, but there is still no provision for interpreting an ALGOL instruction calling for the repetition of a loop of instructions a specified number of times. To provide this will be the next step.

At Mainz the detailed construction of the ALGOL interpreter for the Z22 machine is due to M. Paul, and at Munich for the PERM machine to K. Samelson.

4. Computing Matters in General

4.1 Mainz. Professor Bauer has this year joined the Institute for Applied Mathematics at the Johannes Gutenberg University in Mainz, where he hopes shortly to take delivery of a Z22 computer. His team at present numbers six, and will be limited to ten. Dr. Samelson is there, and P Wynn is expected to join them also. They intend to study numerical analysis and especially procedures in linear algebra, and to use ALGOL exclusively for preparing problems for the computer. No direct programming in machine code will be allowed except in special non-numerical fields of work.

4.2 Zürich.

4.21 I delivered a lecture in the E.T.H. on "Numerical Methods in Matrix Algebra which have been used at the National Physical Laboratory".

Prof. Stiefel has a team of less than a dozen people working at the Institute for Applied Mathematics of the E.T.H. Prof. Rutishauser is concerned at present mainly with a variety of procedures for finding eigenvalues and eigenvectors of real symmetric matrices. The emphasis at the Institute is on the numerical study of a wide variety of procedures, using the computer ERMETH, rather than on the selection and exploitation of the better methods as is attempted at N.P.L. The attitude to jobs from outside sources, or even from other Institutes within the E.T.H., is that if a job is presented it may be dealt with, but no attempt should be made to advertise the numerical methods or computing facilities available, apart from publication of technical papers.

4.22 ERMETH

The ERMETH is a decimal machine of moderate size, speed and reliability. It was not working during the few days of my visit. The specially built Remington card punch units had recently burnt out their wiring (a design fault) and were being rewired, and the magnetic drum was said to be not fully warmed up at the time of the only attempted demonstration. Certain auxiliary facilities such as zero divisor indication and part of the number display were also not functioning. Nevertheless an examination of the day book showed that a great deal of apparently satisfactory work was done on the machine, much of it Rutishauser's "LR-transformation" of matrices requiring several hours of trouble-free computing.

The store of the machine consists chiefly of a physically large magnetic drum. The attainment of the required reading and writing head spacing from the surface of the drum of 5×10^{-4}ins. is a task of some delicacy, and at the annual dismantling and servicing of the drum the machine is closed down and the whole staff (with the exception of the mechanic) take a week's holiday. This is in contrast with the experience of Dijkstra on the X1 machine in Amsterdam, where the whole job is done overnight; of course the drum is smaller for that machine.

The ERMETH drum is filled with oil for lubricating purposes, and seepage of this onto the heads during the "warming-up" period (after which it apparently disperses from the heads) has caused prolonged delays in putting the machine into service after switching on. The phrase "warming-up" is misapplied here, the prolonged drum check failures being attributable not to the amplifiers being cold but to the magnetic signals being weak. It is preferred to leave ERMETH switched on from Monday morning to Saturday.

4.23 Partial Differential Equations of Elliptic Type

For the past year or two a considerable amount of attention has been devoted to iterative methods for solving finite difference equations arising from elliptic type partial differential equations, and the results are being incorporated in a booklet No.8 in the series "Mittelungen aus dem Institut für angewandte Mathematik", published by Birkhäuser of Basel, and due out in the Spring of 1959. The authors are Prof. Stiefel, Prof. Rutishauser, Dr. T. Ginsburg, and Dr. M. Engeli, and the title is "Refined Iterative Methods for the computation of the Solution and the Eigenvalues of Self-adjoint Boundary value problems".

This booklet will have four chapters, concerned with various approaches to the problem, and all illustrated by numerical work on a single numerical example - the equations for a rectangular plate, divided into 7 x 10 meshes, clamped along one short side and pivoted along the opposite side, and loaded over an excentric region of four clustered mesh points.

In the first chapter "energy methods" will be considered, having the advantages that the matrix is always symmetric and that the boundary conditions are easily incorporated.

In the second chapter the plain Conjugate Gradient (cg) method, or method of steepest descent, will be treated. This is shown to be quite hopeless in application to the numerical example - after 100 steps the error is reduced by a factor of less than 6.

By far the best method tried was the "cg-T" method, which consists of the conjugate gradient method interleaved every few steps with a stage of Chebyshev smoothing, to reduce the proportion of eigenfunctions remaining in the error vector which correspond to eigenvalues having moduli less than a certain limit, this limit being an estimate for the dominant eigenvalue. It was found that for many iterations the cg-T method gave no better results than the other methods, but it then suddenly improved at a much higher rate.

The last chapter, due to Engeli, deals with among other things the extension of the Property A of David Young (Trans. Amer. Math. Soc. 1954, vol.76, pp.92-111) to the case of block relaxation, in which he has had some success.

A solution to the test problem accurate to 11 decimals has been obtained by overrelaxation, and compared with an 8 decimals solution obtained on the IBM 704 in Paris using the cg-T method for the extended system obtained by halving the mesh.

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