ADATA: PRIORITY; monadic.
ALEPH: ALEPH letter f.
ALPHA: a; b; c; d; e; f; g; h; i; j; k; l; m; n; o; p; q; r; s; t; u; v; w; x; y; z.
ANY: sign; zero; digit; point; exponent; complex; character; suppressible ANY; replicatable ANY.
BITS: row of boolean.
CLAUSE: statement; MODE expression.
CLOSED: closed; collateral; conditional.
COERCED: FORCED; hip FORCED.
COERCEND: MODEITY FORM.
COERCETY: COERCED; EMPTY.
COMPLEX: structured with a real named letter r letter e and a real named letter l letter m.
DELIVERY: delivering a MODE; EMPTY.
DIGIT: digit zero; digit FIGURE.
EIGHT: SEVEN plus one.
EMPTY:.
FIELD: MODE named TAG.
FIELDS: a FIELD; FIELDS and a FIELD.
FIGURE: one; two; three; four; five; six; seven; eight; nine.
FIVE: FOUR plus one.
FORCED: adapted; adjusted; arrayed; called; depressed; expressed; fitted; peeled; united; widened.
FORESTY: FORCED; EMPTY.
FORM: ADIC formula; cohesion; confrontation.
FOUR: THREE plus one.
INTEGRAL: LONGSETY integral.
INTEGRAL: INTEGRAL; REAL.
LETTER: letter ALPHA.
LFIELDSA: FIELDS and a; a.
IMODE: MODE.
IMODESETY: MODES and; EMPTY.
LONGSETY: long LONGSETY; EMPTY.
LOWER: lower; upper.
LABEL: MODE; label.
MODE: NONUNITED; UNITED.
MODES: MODE; MODES and MODE.
MODEITY: MODE; EMPTY.
NINE: EIGHT plus one.
NONPROC: structured with FIELDS.
PLAIN: row of MODE; UNITED; procedure with PARAMETERS DELIVERY; reference to NONPROC.
NONREF: TYPE; row of MODE; UNITED.
NONROW: TYPE; reference to MODE; UNITED.
NONUNITED: TYPE; PREFIX MODE.
NOTION: ALPHA; NOTION ALPHA.
NUMBER: one; two; three; four; five; six; seven; eight; nine.
OPERATIVE: procedure with a RMODE parameter DELIVERY;
procedure with a IMODE parameter and a RMODE parameter DELIVERY.
PARAMETER: MODE parameter.
PARAMETERS: a PARAMETER.
PARAMETERS and a PARAMETER.
PARAMETY: with PARAMETERS; EMPTY.
PHRASE: declaration; CLAUSE.
PLAIN: INTREAL; boolean; character.
PREFIX: row of; reference to.
PRIMITIVE: integral; real; boolean; character; format.
PRIORITY: priority NUMBER.
PROCEDURE: procedure PARAMETY DELIVERY.
REAL: LONGSETY real.
REFETY: reference to; EMPTY.
RFIELDSETY: and FIELDS; EMPTY.
RMODE: MODE.
RMODESETY: and MODES; EMPTY.
ROWS: row of; row of ROWS.
ROWSETY: ROWS; EMPTY.
ROWSETY: ROWSETY.
SELECTOR: selection; selector; declarator.
SEPARATENET: comma symbol.
ENCYCTH: go on symbol; completer.
SEQUENCER: EMPTY.
SEVEN: SIX plus one.
SIX: FIVE plus one.
SOME: serial; unitary; CLOSED; choice; THELSE.
STRING: row of character.
TAG: LETTER; TAG LETTER; TAG DIGIT.
THELSE: then; else.
THREE: TWO plus one.
TWO: one plus one.
TYPE: PLAIN; PROCEDURE; format; structured with FIELDS.
UNITED: union of MODES mode.
VICTAL: VIRACT; formal.
VIRACT: virtual; actual.
Errata

1.1.6.d-7 "MODE slice" → 'MODE slice'

2.2.2.b+1 "to contain" {1.1.6.b}, "to be a constituent of" → to contain {1.1.6.b}, to be a constituent of

4.4.3.f-1 . → ,

6.1.2.g+1 constituent → expression

7.4.2.-3 7 → 7 + d.11+8d+2d = ; ;

7.4.2.+15, 7.4.2.+19 value + value which is or is referred to by the value

8.1.2.-5 (g)??g2; + g) - 2; (a > 0 | a | goto exit) ;

8.1.2.b-3 ; ; if → ; its value, if any, is then that of the formula; if →

8.2.1.2.+5 ; ; if → ; its value, if any, is then that of the unaccompanied-call; if →

8.3.2.a is → is a new instance of

8.7.2. Step 5 ; ; if → ; its value, if any, is then that of the accompanied-call; if →

8.8.2.-4 := 7 := 7 ;

8.8.2.d-10 instance → instance is made to be referred to by the given name and

10.b+23 lengths → lengths

10.5.1. continued+23 The → the

TABLE II-2 10. + 10 +

11.11.bc . → 


11.12.aw ; ( → ; put ( 

EE.2.2. continued+4 identity → identity

The authors
Errata
29 Feb. 1968

0.2.2.b+2 × addition → addition, ×
0.2.2.b+3 × for use → , for use e.g. ×
0.2.2.b+4 × constituent → member ×
0.2.6.e+4 × clause" → "clause ×
1.1.4.-3 × The → In the ×
1.1.4.-2 × ) → ) ×
1.1.4.-1 × has → the metanotion 'EMPTY' has ×
2.1.+6 × For → For opens and closes see 3.0.6.b, c, for ×
2.1.+6 × 10 → 10, for serial-declarations see 5.1.1.a, for label-
sequence-options see 3.0.1.b, e and 6.1.1.g, ×
2.2.1.+3 × "values???. → "instances" of "values" {2.2.3}. ×
2.3.c+4 × all → ×
3.0.2.+4 × 1.1.4.a → 1.1.4. Step 2 ×
3.1.2.c.2+4 × two letter-tokens??representation. → letter-token {3.0.2}
or indication {4.2} has the same representation as any other
basic-token {3.0.1.a}, and that no comment-item {3.0.9.c}
(string-item {5.3.1.b}) has the same representation as any
other comment-item or the comment-symbol (any other
string-item or the quote-symbol). ×

7.5.2. Step 1 × expression → actual-parameter ×
8.3.2. continued+2 × 10.4.b → 10.4.a ×
8.6.1.+7 × language → Language ×
10.5.+2 × it? → it?" ×
10.5.0.1.c+1 × modes → modes, except that specified by tamref, which are ×
10.5.3.e+3 × L w → L10 ×
10.5.3.e+4 × x → s ×
10.5.4.n+8 × sup → supp ×
10.5.5.g+6 × true → true ×
EE.2.5.+4:5 × 1.??12.2 → 2.2 ×
EE.2.5. continued+2 × 5.5 → 5.5.2 ×
EE.2.5. continued+12 × 8.1.1.b, c → 8.1.1.b, c, ×

The authors
Printed at the Mathematical Centre at Amsterdam, 49, 2nd Boerhaavestraat, The Netherlands.

The Mathematical Centre, founded the 11th of February 1946, is a non-profit institution aiming at the promotion of pure mathematics and its applications, and is sponsored by the Netherlands Government through the Netherlands Organization for the Advancement of Pure Research (Z.W.O.) and the Central Organization for Applied Scientific Research in the Netherlands (T.N.O.), by the Municipality of Amsterdam and by several industries.
DRAFT REPORT ON THE ALGORITHMIC LANGUAGE

ALGOL 68

A. VAN WIJNGAAARDEN (EDITOR), B.J. MAILLLOUX, J.E.L. PECK
AND C.H.A. KOSTER

COMMISSIONED BY WORKING GROUP 2.1 ON ALGOL OF THE
INTERNATIONAL FEDERATION FOR INFORMATION PROCESSING

SUPPLEMENT TO ALGOL BULLETIN 26

MATHEMATISCH CENTRUM
MR 93
SECOND PRINTING, MARCH 1968
Contents

PP. Provisional Prologue
  PP.2. Membership of the Working Group
  PP.3. Distribution of the Draft Report
  PP.4. References

0. Introduction
  0.1. Aims and principles of design
      0.1.1. Completeness and clarity of description
      0.1.2. Orthogonal design
      0.1.3. Security
      0.1.4. Efficiency
      0.1.4.1. Static mode checking
      0.1.4.2. Independent compilation
      0.1.4.3. Loop optimization
  0.2. Comparison with ALGOL 60
      0.2.1. Values in ALGOL 68
      0.2.2. Declarations in ALGOL 68
      0.2.3. Dynamic storage allocation in ALGOL 68
      0.2.4. Collateral elaboration in ALGOL 68
      0.2.5. Standard declarations in ALGOL 68
      0.2.6. Some particular constructions in ALGOL 68

1. Language and metalanguage
  1.1. The method of description
      1.1.1. The strict, extended and representation languages
      1.1.2. The syntax of the strict language
      1.1.3. The syntax of the metalanguage
      1.1.4. The production rules of the metalanguage
      1.1.5. The production rules of the strict language
      1.1.6. The semantics of the strict language
      1.1.7. The extended language
      1.1.8. The representation language
  1.2. The metaproduction rules
      1.2.1. Metaproduction rules of modes
      1.2.2. Metaproduction rules associated with modes
      1.2.3. Metaproduction rules associated with phrases
      1.2.4. Metaproduction rules associated with formulas
      1.2.5. Other metaproduction rules
  1.3. Pragmatics

2. The computer and the program
  2.1. Syntax
  2.2. Terminology
      2.2.1. Objects
      2.2.2. Relationships
      2.2.3. Values
      2.2.3.1. Plain values
      2.2.3.2. Structured values
      2.2.3.3. Multiple
Contents continued
values. 2.2.3.4. Routines and formats. 2.2.3.5. Names.
2.2.4. Modes and scopes. 2.2.4.1. Modes. 2.2.4.2. Scopes,
inner and outer scopes. 2.2.5. Actions
2.3. Semantics

3. Basic tokens and general constructions
3.0. Syntax
  3.0.1. Introduction. 3.0.2. Letter tokens. 3.0.3. Denotation
  tokens. 3.0.4. Action tokens. 3.0.5. Declaration tokens.
  3.0.6. Syntactic tokens. 3.0.7. Sequencing tokens. 3.0.8.
  Hip tokens. 3.0.9. Extra tokens and comments
3.1. Symbols
  3.1.1. Representations. 3.1.2. Remarks

4. Identification and context conditions
4.1. Identifiers
  4.1.1. Syntax. 4.1.2. Identification of identifiers
4.2. Indications
  4.2.1. Syntax. 4.2.2. Identification of indications
4.3. Operators
  4.3.1. Syntax. 4.3.2. Identification of operators
4.4. Context conditions
  4.4.1. The identification condition. 4.4.2. The mode conditions.
  4.4.3. The uniqueness conditions

5. Denotations
5.1. Plain denotations
  5.1.1. Integral denotations. 5.1.2. Real denotations. 5.1.3.
  Boolean denotations.
5.2. Row of boolean denotations
5.3. Row of character denotations
5.4. Routine denotations
5.5. Format denotations
  5.5.1. Syntax. 5.5.1.1. Integral patterns. 5.5.1.2. Real
  patterns. 5.5.1.3. Boolean patterns. 5.5.1.4. Complex patterns.
  5.5.1.5. String patterns. 5.5.1.6. Transformats. 5.5.2. Semantics
Contents continued 2

6. Phrases
   6.1. Serial phrases
   6.2. Unitary statements
   6.3. Collateral phrases
   6.4. Closed phrases
   6.5 Conditional clauses

7. Unitary Declarations
   7.1. Declarers
   7.2. Mode declarations
   7.3. Priority declarations
   7.4. Identity declarations
   7.5. Operation declarations

8. Unitary expressions
   8.1. Formulas
   8.2. Coercends
      8.2.1. Unaccompanied calls. 8.2.2. Expressed coercends.
      8.2.3. Depressed coercends. 8.2.4. United coercends. 8.2.5.
            Widened coercends. 8.2.6. Arrayed coercends.
   8.3. Primaries
   8.4. Slices
   8.5. Generators
   8.6. Field selections
   8.7. Accompanied calls
   8.8. Assignations
   8.9. Conformity relations
   8.10. Identity relations

9. Extensions
   9.1. Comments
   9.2. Contracted declarations
   9.3. Repetitive statements
   9.4. Contracted conditional clauses
   9.5. Complex values
Contents continued 3

10. Standard declarations

10.1. Environment enquiries

10.2. Standard priorities and operations

10.2.0. Standard priorities. 10.2.1. Operations on boolean operands. 10.2.2. Operations on integral operands. 10.2.3. Operations on real operands. 10.2.4. Operations on arithmetic operands. 10.2.5. Complex structures and associated operations. 10.2.6. Bit rows and associated operations. 10.2.7. Operations on character operands. 10.2.8. String mode and associated operations. 10.2.9. Operations combined with assignations

10.3. Standard mathematical constants and functions

10.4. Synchronization operations

10.5. Transput declarations

10.5.0. Transput modes and straightening. 10.5.0.1. Transput modes. 10.5.0.2. Straightening. 10.5.1. Channels and files. 10.5.1.1. Channels. 10.5.1.2. Files. 10.5.2. Formatless output. 10.5.3. Formatless input. 10.5.4. Formatted output. 10.5.5. Formatted input. 10.5.6. Binary output. 10.5.7. Binary input.

11. Examples

11.1. Complex square root

11.2. Innerproduct 1

11.3. Innerproduct 2

11.4. Innerproduct 3

11.5. Largest element

11.6. Euler summation

11.7. The norm of a vector

11.8. Determinant of a matrix

11.9. Greatest common divisor

11.10. Continued fraction

11.11. Formula manipulation

11.12. Information retrieval
12. Glossary

EE. Ephemeral Epilogue

EE.1. Errata

EE.1.1. Syntax. EE.1.2. Representations. EE.1.3. Semantics

EE.2. Correspondence with the Editor

EE.2.1. Example of a letter to the Editor. EE.2.2. Reply by the Editor to the letter in EE.2.1. EE.2.3. Second example of a letter to the Editor. EE.2.4. Reply option by the Editor to the letter in EE.2.3. EE.2.5. Third example of a letter to the Editor. EE.2.6. Reply by the Editor to the letter in EE.2.5
PP. Provisional Prologue


(Habent sua fata libelli.
De litteris, Terentianus Maurus.)

a) Working Group 2.1 on ALGOL of the International Federation for
Information Processing has discussed the development of "ALGOL X", a
successor to ALGOL 60 [3] since 1963. At its meeting in Princeton in
May 1965, WG 2.1 invited written descriptions of the language based on
the previous discussions. At the meeting near Grenoble in October 1965,
three reports describing more or less complete languages were amongst
the contributions, by Niklaus Wirth [5], by Gerhard Seegmüller [4] and
by Aad van Wijngaarden [6]. In [4] and [5], the descripional technique
of [3] was used, whereas [6] featured a new technique for language design
and definition. Another significant contribution was a paper by Tony
Hoare [2].

b) At meetings in Kootwijk in April 1966, Warsaw in October 1966 and
Zandvoort near Amsterdam in May 1967, a number of successive approximations
to a final report were submitted by a team working in Amsterdam,
consisting first of A. van Wijngaarden and Barry Mailloux [7], later
reinforced by John Peck [8], and finally by Kees Koster. A rather complete
version [9] was used during a course on ALGOL 68 held in Amsterdam in
the end of 1967. This course served as a test case and the present Draft
Report was made on the basis of it using the experience of explaining
the language to a skilled audience.

c) The authors acknowledge with pleasure and thanks the whole-hearted
cooperation, support, interest, criticism and violent objections from
members of WG 2.1 and many other people interested in ALGOL (Rev.
3.15, 16). Deserving special mention are Jan Garvick, Jack Merner,
Peter Ingerman and Manfred Paul for [1] and above all Miss Betty
Schuuring for still smiling after several years of most demanding
typing of a continuously varying manuscript. An occasional choice of
a, not inherently meaningful, identifier in the sequel may compensate
for not mentioning more names in this section.

d) The dogmatic, perhaps pedantic, approach of the authors, and the many
errors they made, caused this Draft Report to appear late; they are
convinced, however, that their approach is the right one.
PP.2. Membership of the Working Group

(Verum homines notos sumere odiosum est.
Pro Roscio Amerino,            M.T. Cicero.)

At this moment, the members of WG 2.1 are:

F.L. Bauer, H. Bekić, L. Bolliet, E.W. Dijkstra, F.G. Duncan, A.P. Ershov,
J.V. Garwick, A. Grau, C.A.R. Hoare, P.Z. Ingerman, E.T. Irons, C. Katz,
I.O. Kerner, P.J. Landin, S.S. Lavrov, H. Leroy, J. Loeckx, B.J. Mailloux,
A. Mazurkiewicz, J. McCarthy, J.N. Merner, S. Moriguti, P. Naur, M. Nivat,
M. Pacelli, M. Paul, J.E.L. Peck, W.L. van der Poel (Chairman), B. Randell,
D.T. Ross, K. Samelson, G. Seegmüller, W.M. Turski (Secretary),
A. van Wijngaarden, N. Wirth, M. Woodger and N. Yozeda.

PP.3. Distribution of the Draft Report

{A perfect judge will read each work of wit
with the same spirit that its author writ.
An Essay on Criticism,       A. Pope.}

a) The Draft Report is, on request of WG 2.1, distributed as a supplement
   to ALGOL Bulletin 26 in order that all people interested in ALGOL have
   insight in the Draft Report and can send remarks to improve the final
   Report. These remarks should be sent to:

   EDITOR ALGOL 68,
   Mathematisch Centrum,
   2e Boerhaavestraat 49,
   AMSTERDAM-O, HOLLAND.

b) All remarks will be considered, but not necessarily individually
   answered. If they are received in time and if they seem relevant, then
   they will be taken into account in drafting the final Report, which will
   be submitted for approval to WG 2.1, Technical Committee 2 on Programming
   Languages and the General Assembly of IFIP.

c) It is pointed out that anyone, even an author, is invited to send
   remarks. In order to make it at all possible to review all incoming
   remarks, one is, however, requested to use, as far as feasible, the
   method of indicating errata given in the Ephemeral Epilogue; this
   method will be clear after reading at least a part of the Draft Report.
d) Before reading all of the Draft Report, one should first read Sections EE 2.5, 6.

PP. 4. References

Report of the ALGOL-X-I-O Subcommittee, WG 2.1 Working Paper,
July 1966.

also AB.21.3.6, November 1965.

[3] P. Naur (Editor), Revised Report on the Algorithmic Language ALGOL 60,
Regncentralen, Copenhagen, 1962, and elsewhere.

Successor to ALGOL 60, Bavarian Acad. Sci., Munich, October 1965.

Mathematische Centrum, Amsterdam, MR 75, August 1965.

Language, Mathematische Centrum, Amsterdam, MR 76, October 1965.


for the Algorithmic Language ALGOL 67,

for the Algorithmic Language ALGOL 68,
Mathematisch Centrum, Amsterdam, MR 92, November 1967.
0. Introduction

0.1. Aims and principles of design

a) In defining the Algorithmic Language ALGOL 68, the members of Working Group 2.1 of the International Federation for Information Processing express their belief in the value of a common programming language serving many people in many countries.

b) The language is designed to communicate algorithms, to execute them efficiently on a variety of different computers, and to aid in teaching them to students.

c) The members of the Group, influenced by several years of experience with ALGOL 60 and other programming languages, hope that the following has been achieved:

0.1.1. Completeness and clarity of description

The Group wishes to contribute to the solution of the problems of describing a language clearly and completely. It is recognized, however, that the method adopted in this Report may be difficult for the uninitiated reader.

0.1.2. Orthogonal design

The number of independent primitive concepts was minimized in order that the language be easy to describe, to learn, and to implement. On the other hand, these concepts have been applied "orthogonally" in order to maximize the expressive power of the language, and yet without introducing deleterious superfluities.

0.1.3. Security

ALGOL 68 has been designed in such a way that nearly all syntactical and many other errors can be detected easily before they lead to calamitous results. Furthermore, the opportunities for making such errors are greatly restricted.

0.1.4. Efficiency

ALGOL 68 allows the programmer to specify programs which can be run efficiently on present-day computers and yet do not require sophisticated and time-consuming optimization features of a compiler; see e.g. 11.8.
0.1.4.1. Static mode checking

The syntax of ALGOL 68 is such that no mode checking during run time is necessary except during the elaboration of conformity-relations (8.9) the use of which is required only in those cases in which the programmer explicitly makes use of the flexibility offered by the united mode feature.

0.1.4.2. Independent compilation

ALGOL 68 has been designed such that the main line programs and procedures can be compiled independently of one another without loss of object program efficiency, provided that during each such independent compilation, specification of the mode of all nonlocal quantities is provided; see the remarks after 2.3.c.

0.1.4.3. Loop optimization

Iterative processes are formulated in ALGOL 68 in such a way that straightforward application of well-known optimisation techniques yields large gains during run time without excessive increase of compilation time.

0.2. Comparison with ALGOL 60

a) ALGOL 68 is a language of wider applicability and power than ALGOL 60. Although influenced by the lessons learned from ALGOL 60, ALGOL 68 has not been designed as an expansion of ALGOL 60 but rather as a completely new language based on new insights into the essential, fundamental concepts of computing and a new description technique.

b) The result is that the successful features of ALGOL 60 reappear in ALGOL 68 but as special cases of more general constructions, along with completely new features. It is, therefore, difficult to isolate differences between the two languages; however, the following sections are intended to give insight into some of the more striking differences.

0.2.1. Values in ALGOL 68

a) Whereas ALGOL 60 has values of the types integer, real, boolean and string, ALGOL 68 features an infinity of "modes", i.e. generalizations of the concept type.
0.2.1. continued

b) Each plain value is either arithmetic, i.e. of integral or real mode and then it is of one of several lengths, or it is of boolean or character mode.

c) In ALGOL 60, composition of values is possible into arrays, whereas in ALGOL 68, in addition to such "multiple" values, also "structured" values, composed of values of possibly different modes, are defined and manipulated. An example of a multiple value is a character array, which corresponds approximately to the ALGOL 60 string; examples of structured values are complex numbers and symbolic formulae.

d) In ALGOL 68, the concept of a "name" is introduced, i.e. a value which is said to "refer to" another value; such a name-value pair corresponds to the ALGOL 60 variable. However, any name may take the value position in a name-value pair and thus chains of indirect addresses can be built up.

e) The ALGOL 60 concept of a procedure body is generalized in ALGOL 68 to the concept "routine", which also includes the formal parameters, and which is itself a value and therefore can be manipulated like any other value; the ALGOL 68 concept "format" has no ALGOL 60 counterpart.

f) In contrast with plain values and multiple and structured values composed of plain values only, the significance of a name, routine or format or of a multiple or structured value composed of names, routines or formats, possibly amongst other values, is, in general, dependent on the context in which it appears. Therefore, the use of names, routines and formats is subject to some natural restrictions related to their "scope".

0.2.2. Declarations in ALGOL 68

a) Whereas ALGOL 60 has type declarations, array declarations, switch declarations and procedure declarations, ALGOL 68 features the "identity-declaration" whose expressive power includes all of these, and more. In fact, the identity-declaration declares not only variables, but also constants, of any mode and, moreover, forms the basis of a highly efficient and powerful parameter mechanism.
0.2.2. continued

b) Moreover, in ALGOL 68, a "mode-declaration" permits the construction of new modes from already existing ones. In particular, the modes of multiple values and structured values may be defined this way; in addition a union of modes may be defined for use in an identity-declaration allowing each value referred to by a given name to be of one of the constituent modes.

c) Finally, in ALGOL 68, a "priority-declaration" and an "operation-declaration" permit the introduction of new operators, the definition of their operation and the extension or revision of the class of operands applicable to already established operators.

0.2.3. Dynamic storage allocation in ALGOL 68

Whereas ALGOL 60 (apart from the so-called "own dynamic arrays") implies a "stack"-oriented storage-allocation regime, sufficient to cope with a statically (i.e. at compile time) determined number of values, ALGOL 68 provides, in addition, the ability to generate a dynamically (i.e. at run time) determined number of values, which ability implies the use of additional, well established, storage-allocation techniques.

0.2.4. Collateral elaboration in ALGOL 68

Whereas, in ALGOL 60, statements are "executed consecutively", in ALGOL 68 "phrases" are "elaborated serially" or "collaterally". This last facility is conducive to more efficient object programs under many circumstances, and increases the expressive power of the language. Facilities for parallel programming, though restricted to the essentials in view of the none-too-advanced state of the art, have been introduced.

0.2.5. Standard declarations in ALGOL 68

The ALGOL 60 standard functions are all included in ALGOL 68 along with many other standard declarations. Amongst these are "environment enquiries", which make it possible to determine certain properties of an implementation, and "transput" declarations, which make it possible, at run time, to obtain data from and to deliver results to external media.
0.2.6. Some particular constructions in ALGOL 68

a) The ALGOL 60 concepts of block, compound statement and parenthesized expression are unified in ALGOL 68 into "closed-clause". A closed-clause may be an expression and possess a value. Similarly, the ALGOL 68 "assiguation", which is a generalization of the ALGOL 60 assignment statement, may be an expression and, as such, also possesses a value.

b) The ALGOL 60 concept of subscription is generalized to the ALGOL 68 concept of "indexing", which allows the selection not only of a single element of an array but also of subarrays with the same or any smaller dimensionality and with possibly altered bounds.

c) ALGOL 68 provides not only the multiple values mentioned in 0.2.1.c, but also "collateral-expressions" which serve to compose these values from other, simpler values.

d) The ALGOL 60 for statement is modified into a more concise and efficient "repetitive statement".

e) The ALGOL 60 conditional expression and conditional statement, unified into a "conditional-clause", are improved by requiring them to end with a closing symbol whereby the two alternative clauses admit the same syntactic possibilities. Moreover, the conditional-clause is generalized into a "case clause" which allows the efficient selection from an arbitrary number of clauses depending on the value of an integral expression.

f) Some less successful ALGOL 60 concepts, such as own quantities and integer labels have not been included in ALGOL 68, and some concepts like designational expressions and switches do not appear as such in ALGOL 68, but their expressive power is included in other, more general, constructions.

{True wisdom knows it must comprise some nonsense as a compromise, lest fools should fail to find it wise. Grooks, Piet Hein.}
1. Language and metalanguage

1.1. The method of description

1.1.1. The strict, extended and representation languages

a) ALGOL 68 is a language in which "programs" can be formulated for "computers", i.e. "automata" or "human beings". It is defined in three stages, the "strict language", "extended language" and "representation language".

b) For the definition partly the "English language", and partly a "formal language" is used. In both languages, and also in the strict language and the extended language, typographical marks are used which bear no relation to those used in the representation language.

1.1.2. The syntax of the strict language

a) The strict language is defined by means of a syntax and semantics. This syntax is a set of "production rules" for "notions", i.e. nonempty sequences of "small letters" ("abcdefghijklmnopqrstuvwxyz"), possibly interspersed with nonsignificant blanks and/or hyphens.

(Note that those small letters are in a different type font than this sentence.)

b) A "list of notions" either is empty, or is a notion, or consists of a list of notions followed either by a "comma" (",") or by a comma followed by a notion.

c) A production rule for a notion consists of that notion, possibly preceded by an "asterisk" ("*"), followed by a "colon" (":") and followed by a list of notions, a "direct production" of that notion, and followed by a "point" (".").

d) A "symbol" is a notion ending with 'symbol'.

e) A "production" of a given notion is either a direct production of that given notion or a list of notions obtained by replacing a second notion in a production of the given notion by a direct production of that second notion.

f) A "terminal production" of a notion is a production of that notion consisting of symbols and commas only.
1.1.2. continued

(In the production rule
'variable-point numeral : integral part option, fractional part.'
(5.1.2.1.b) of the strict language,
'integral part option, fractional part'
is a direct production of the notion 'variable-point numeral'. A terminal
production of this same notion is
'digit zero symbol, point symbol, digit one symbol'.
The notion 'digit zero symbol' is an example of a symbol. The line
'twas brillig and the slithy toves' is not a relevant notion of the
strict language, in that it does not end with 'symbol' and no production
rule for it is given (1.1.5 Step 3, 4). }

1.1.3. The syntax of the metalanguage

a) The production rules of the strict language are partly enumerated and
partly generated with the aid of a "metalanguage" whose syntax consists of
a set of production rules for "metanotions", i.e. nonempty sequences of
"capital letters" ("ABCDEFGHIJKLMNOPQRSTUVWXYZ").

{NOTE THAT THOSE CAPITAL LETTERS ARE IN A DIFFERENT TYPE FONT THAN
THIS SENTENCE. }

b) A "list of metanotions" either is empty or is a notion, or consists
of one or more metanotions separated, and possibly preceded and/or
followed, by notions and/or blanks.

c) A production rule for a metanotion consists of that metanotion
followed by a colon and followed by a list of metanotions, a direct
production of that metanotion, and followed by a point.

d) A production of a given metanotion is either a direct production of
that given metanotion or a list of metanotions obtained by replacing a
second metanotion in a production of the given metanotion by a direct
production of that second metanotion.

e) A terminal production of a metanotion is a production of that
metanotion which is a notion.
1.1.3. continued

(In the production rule
'TAG : LETTER,.',
derived from 1.2.1.1, 'LETTER' is a direct production of the metanotion
'TAG'. A particular terminal production of the metanotion 'TAG' is the
notion 'letter x' (see 1.2.1.m, n). The production rule
'EMPTY: .' (1.2.1.1)
has an empty direct production.)

1.1.4. The production rules of the metalanguage

The production rules of the metalanguage are the rules obtained from
the rules in Section 1.2 in the following steps:
Step 1: If some rule contains one or more "semicclons" (";"), then it is
replaced by two new rules, the first of which consists of the part of
that rule up to and including the first semicolon with that semicolon
replaced by a point, and the second of which consists of a copy of
that part of the rule up to and including the colon, followed by the
part of the original rule following its first semicolon, whereupon,
Step 1 is taken again;
Step 2: A number of production rules for the metanotion 'ALPHA' (1.2.1.n),
each of whose direct productions is another small letter, may be added.

{For instance, the rule
'TAG : LETTER; TAG LETTER; TAG DIGIT,.'
from 1.2.1.1 is replaced by the rules
'TAG : LETTER,' and 'TAG : TAG LETTER; TAG DIGIT,'.
and the second of these is replaced by
'TAG : TAG LETTER,' and 'TAG : TAG DIGIT,'
thus resulting in three rules from the original one.

The reader may find it helpful to read ":" as "may be a", ",," as
"followed by a" and ";" as "or a".}

1.1.5. The production rules of the strict language

The production rules of the strict language are the rules obtained in
the following steps from the rules given in Chapters 2 up to 8 inclusive
under Syntax:
Step 1: Identical with Step 1 of 1.1.4;
1.1.5. continued

Step 2: If a given rule now contains one or more sequences of capital letters, then this (these) sequence(s) is (are) interpreted as (a) sequence(s) of the metanotions of Section 1.2 {The metanotions of 1.2 have been chosen such that this interpretation is unique.}, and then for each terminal production of such a metanotion, a new rule is obtained by replacing that metanotion, throughout a copy of the given rule, by that terminal production, whereupon the given rule is discarded and Step 2 is taken; otherwise, the given rule is a production rule of the strict language.

Step 3: A number of production rules for the notion 'other indication' {4.2.1.b, e, f} each of whose direct productions is a symbol different from any other symbol may be added.

Step 4: A number of production rules may be added for the notions 'other comment item' {3.0.9.c} and 'other string item' {5.3.1.b} each of whose direct productions is a symbol different from any character-token with the restrictions that no other-comment-item is the comment-symbol and no other-string-item is the quote-symbol.

{The rule
'actual LOWER bound : strict LOWER bound.'
derived from 7.1.1.r by Step 1 is used in Step 2 to provide two production rules of the strict language, viz.
'actual lower bound : strict lower bound.' and
'actual upper bound : strict upper bound.'

Note that
'actual lower bound : strict upper bound.'
is not a production rule of the strict language, since the replacement of the metanotion 'LOWER' by one of its productions must be consistent throughout. Since some metanotions have an infinite number of terminal productions, the number of notions of the strict language is infinite and the number of production rules for a given notion may be infinite; moreover, since some metanotions have terminal productions of infinite length, some notions are infinitely long. For examples see 4.1.1.

Some production rules obtained from a rule containing a metanotion may be blind alleys in the sense that no production rule is given for some notion to the right of the colon even though it is not a symbol. }
1.1.6. The semantics of the strict language

a) A terminal production of a notion is considered as a linearly ordered sequence of symbols. This order is called the "textual order", and "following" ("preceding") stands for "textually immediately following" ("textually immediately preceding") in the rest of this Report. Typographical display features, such as blank space, change to a new line, and change to a new page do not influence this order.

b) A sequence of symbols consisting of a second sequence of symbols preceded and/or followed by (a) sequence(s) of symbols "contains" that second sequence of symbols.

c) Unless otherwise specified {d}, a "paranotion" at an occurrence not under "Syntax", not between apostrophes and not within another paranotion stands for any terminal production of some notion; a paranotion being either

i) a notion ending with 'symbol', in which case it then stands for itself {e.g. "begin-symbol"}, or

ii) a notion whose production rule(s) do(es) not begin with an asterisk, in which case it then stands for any terminal production of itself {e.g., "number-token" (3.0.3.b) stands for 'digit zero symbol', 'digit one symbol', 'digit two symbol', 'digit three symbol', 'digit four symbol', 'digit five symbol', 'digit six symbol', 'digit seven symbol', 'digit eight symbol', 'digit nine symbol', 'point symbol' or 'times ten to the power symbol'}, or

iii) a notion whose production rule(s) do(es) begin with an asterisk, in which case it then stands for any terminal production of any of its direct productions {e.g. "trimscription" (8.4.1.1) stands for any terminal production of 'trimmer option' or 'subscript'}, or

iv) a paranotion followed by "s", or a paranotion ending with "y" in which "y" has been replaced by "ies", in which case it then stands for some number of the terminal productions stood for by that paranotion {e.g. "trimscriptions" stands for some number of terminal productions of 'trimmer option' and/or 'subscript', and "primaries" stands for some number of terminal productions stood for by 'primary.'}, or

v) a paranotion whose first small letter has been replaced by the corresponding capital letter, in which case it then stands for the terminal productions stood for by that paranotion before the replacement
1.1.6. continued 1

(e.g. "Identifiers" stands for what 'identifiers' stands for), or
vi) a paranotion in which a "mode", i.e. a terminal production of 'MODE',
has been omitted, in which case it then stands for any terminal
production stood for by any paranotion from which the given paranotion
could be obtained by omitting a terminal production of 'MODE' {e.g.
"slice" stands for any terminal production of "MODE slice" (8.4.1.a),
where "MODE" stands for any terminal production of the metanotion
'MODE').}

(As an aid to the reader, paranotions, when not under Syntax or between
apostrophes, are printed with hyphens instead of spaces. As an additional
aid, a number of superfluous rules beginning with an asterisk have been
included. )

d) When a paranotion is said to be a "constituent" of a second paranotion,
then the first paranotion stands for any terminal production stood for by
it according to 1.1.6.c which is contained in a terminal production stood
for by the second paranotion but not contained in a terminal production
stood for by either of these paranotions contained in that second terminal
production.

(e.g. \( j := 1 \) is a constituent assignation (8.8) of the assignation
\( i := j := 1 \), but not of the serial-statement (6.1.1.b)
\( i := j := 1 ; k := 2 \). )

e) In sections 2 up to 8 under "Semantics", a meaning is associated with
certain sequences of symbols by means of sentences in the English language,
as a series of processes (the "elaboration" of those sequences of symbols
as terminal productions of given notions), each causing a specific effect.
Any of these processes may be replaced by any process which causes the
same effect.

f) The "preelaboration" of a sequence of symbols as a terminal production
of a given notion consists of its elaboration as terminal production of that
notion which is a direct production of the given notion and of which it is
a terminal production; except as otherwise specified, the elaboration of a
sequence of symbols as terminal production of a given notion is its
preelaboration as terminal production of that notion.

(e.g. the elaboration of random as a fitted-real-cohesion is its
elaboration as a called-real-cohesion (8.2.0.1.e). )
1.1.6. continued 2

g) If something is left undefined or is said to be undefined, then this means that it is not defined by this Report alone, and that, for its definition, information from outside this Report has to be taken into account.

1.1.7. The extended language

The extended language encompasses the strict language; i.e. a program in the strict language, possibly subjected to a number of notational changes by virtue of "extensions" given in Chapter 9 is a program in the extended language and has the same meaning.

{e.g. \texttt{real } x, y, z \text{ means the same as } (\texttt{real } x, \texttt{real } y, \texttt{real } z) \text{ by 9.2.c and 9.2.d.}}

1.1.8. The representation language

a) The representation language represents the extended language; i.e. a program in the extended language, in which all symbols are replaced by certain typographical marks by virtue of "representations", given in Section 3.1.1, and in which all commas (commas, not comma-symbols) are deleted, is a program in the representation language and has the same meaning.

b) Each version of the language in which representations are used which are sufficiently close to the given representations to be recognized without further elucidation is also a representation language. A version of the language in which notations or representations are used which are not obviously associated with those defined here but bear a one-to-one relationship with them, is a "publication language" or "hardware language" (i.e. a version of the language suited to the supposed preference of the human or mechanical interpreter of the language).

{e.g., \texttt{begin}, \texttt{begin} and \texttt{BEGIN} are all representations of the begin-symbol in the representation language.}
1.2. The metaproduction rules

1.2.1. Metaproduction rules of modes

a) \texttt{MODE : NONUNITED ; UNITED.}
b) \texttt{NONUNITED : TYPE ; PREFIX MODE.}
c) \texttt{TYPE : PLAIN ; structured with FIELDS ; PROCEDURE ; format.}
d) \texttt{PLAIN : INTREAL ; boolean ; character.}
e) \texttt{INTREAL : INTEGRAL ; REAL.}
f) \texttt{INTEGRAL : LONGSETY integral.}
g) \texttt{REAL : LONGSETY real.}
h) \texttt{LONGSETY : long LONGSETY ; EMPTY.}
i) \texttt{EMPTY : .}
j) \texttt{FIELDS : a FIELD ; FIELDS and a FIELD.}
k) \texttt{FIELD : MODE named TAG.}
l) \texttt{TAG : LETTER ; TAG LETTER ; TAG DIGIT.}
m) \texttt{LETTER : letter ALPHA.}
n) \texttt{ALPHA : a ; b ; c ; d ; e ; f ; g ; h ; i ; j ; k ; l ; m ; n ; o ; p ; q ; r ; s ; t ; u ; v ; w ; x ; y ; z.}
o) \texttt{DIGIT : digit zero ; digit FIGURE.}
p) \texttt{FIGURE : one ; two ; three ; four ; five ; six ; seven ; eight ; nine.}
q) \texttt{PROCEDURE : procedure PARAMETY DELIVERY.}
r) \texttt{PARAMETY : with PARAMETERS ; EMPTY.}
s) \texttt{PARAMETERS : a PARAMETER ; PARAMETERS and a PARAMETER.}
t) \texttt{PARAMETER : MODE parameter.}
u) \texttt{DELIVERY : delivering a MODE ; EMPTY.}
v) \texttt{PREFIX : row of ; reference to.}
w) \texttt{UNITED : union of MODES mode.}
x) \texttt{MODES : MODE ; MODES and MODE.}

{The reader may find it helpful to note that a metanotion ending in 'ETY' always has an empty production.}
1.2.2. Metaproduction rules associated with modes

a) PRIMITIVE : integral ; real ; boolean ; character ; format.
b) ROWS : row of ; row of ROWS.
c) ROWSETY : ROWS ; EMPTY.
d) ROWSETY : ROWSETY.
e) NONROW : TYPE ; reference to MODE ; UNITED.
f) REFETY : reference to ; EMPTY.
g) NONREF : TYPE ; row of MODE ; UNITED.
h) NONPROC : PLAIN ; structured with FIELDS ;
   procedure with PARAMETERS DELIVETY ; row of MODE ; UNITED ;
   reference to NONPROC.
i) LMODE : MODE.
j) RMODE : MODE.
k) MODETY : MODE ; EMPTY.
l) LMODESETY : MODES and ; EMPTY.
m) RMODESETY : and MODES ; EMPTY.
n) LFIELDSA : FIELDS and a ; a.
o) RFIELDSETY : and FIELDS ; EMPTY.
p) COMPLEX : structured with a real named letter r letter e
   and a real named letter i letter m.
q) STRING : row of character.
r) BITS : row of boolean.
s) MABEL : MODE ; label.

1.2.3. Metaproduction rules associated with phrases

a) PHRASE : declaration ; CLAUSE.
b) CLAUSE : statement ; MODE expression.
c) SOME : serial ; unitary ; CLOSED ; choice ; THEELSE.
d) THEELSE : then ; else.
e) CLOSED : closed ; collateral ; conditional.
f) COERCETY : COERCED ; EMPTY.
g) COERCED : FORCED ; hip FORCED.
h) FORCED : adapted ; adjusted ; arrayed ; called ; depressed ;
   expressed ; fitted ; peeled ; united ; widened.
i) FORCETY : FORCED ; EMPTY.
1.2.4. Metaproduction rules associated with formulas

a) COERCEND : MODITY FORM.
b) FORM : ADIC formula ; cohesion ; confrontation.
c) ADIC : PRIORITY ; monadic.
d) PRIORITY : priority NUMBER.
e) NUMBER : one ; TWO ; THREE ; FOUR ; FIVE ; SIX ; SEVEN ; EIGHT ;
   NINE.
f) TWO : one plus one.
g) THREE : TWO plus one.
h) FOUR : THREE plus one.
i) FIVE : FOUR plus one.
j) SIX : FIVE plus one.
k) SEVEN : SIX plus one.
l) EIGHT : SEVEN plus one.
m) NINE : EIGHT plus one.

a) OPERATIVE : procedure with a RMODE parameter DELIVERY ;
   procedure with a LMODE parameter and a RMODE parameter DELIVERY.

1.2.5. Other metaproduction rules

a) VIRACT : virtual ; actual.
b) VICTAL : VIRACT ; formal.
c) LOWER : lower ; upper.
d) ALEPH : ALEPH letter f.
e) ANY : sign ; zero ; digit ; point ; exponent ; complex ; character ;
   suppressible ANY ; replicatable ANY.

f) NOTION : ALPHA ; NOTION ALPHA.
g) SEPARATORE : comma symbol ; go on symbol ; completer ; sequencer ;
   EMPTY.
h) SELECTOR : selection ; selector ; declarator.

{Rule f implies that all notions (1.1.2.a) are productions (1.1.3.d)
of the metanotion (1.1.3.a) 'NOTION'; for the use of this metanotion,
see 3.0.1.b, c, d, e, f. Rule d yields an infinite sequence; for the
use of this metanotion, see 5.5.1.6.a.}

"Well 'slithy' means 'lithe' and 'slimy'....
You see it's like a portmanteau - there are
two meanings packed into one word."
Through the Looking Glass,
Lewis Carroll.
1.3. Pragmatics

{Merely corroborative detail, intended to
give artistic verisimilitude to an otherwise
bald and unconvincing narrative.
Mikado,
W.S. Gilbert.}

Scattered throughout this Report are "pragmatic" remarks included between
the braces { and }. These do not form part of the definition of the
language but are intended to help the reader to understand the implications
of the definitions and to find corresponding sections.

{Some of these pragmatic remarks are examples written in the
representation language. In these examples, identifiers occur out of
context from their defining occurrences. Unless otherwise specified, these
occurrences identify those in the identity-declarations of the standard-
declarations in Chapter 10 (e.g. random from 10.3.k or pi from 10.3.a)
or those in:

\[
\begin{align*}
\text{int } & i, j, k, m, n ; \text{ real } a, b, x, y ; \text{ bool } p, q, overflow ; \text{ char } c ; \\
\text{ format } f ; \text{ bite } t ; \text{ string } s ; \text{ compl } w, z ; \\
\text{ ref real } & xx, yy ; [1:n] \text{ real } x1, y1 ; [1:m, 1:n] \text{ real } x2 ; \\
[1:n, 1:n] \text{ real } & y2 ; [1:n] \text{ int } i1 ; \\
\text{ proc } & x \text{ or } y = \text{ ref real expr (random < .5 | x | y)} ; \\
\text{ proc } & \text{ naos } = (\text{ int } i) \text{ real } : \cos(2 \times \pi \times i/n) ; \\
\text{ proc } & \text{ nein } = (\text{ int } i) \text{ real } : \sin(2 \times \pi \times i/n) ; \\
\text{ proc } & g = (\text{ real } u) \text{ real } : (\arctan(u) - a + u - 1) ; \\
\text{ proc } & \text{ stop } = \text{ expr}(1:1) ; \\
\text{ exit: princeton: grenoble: kootwijk: wareau: santoort: amsterdam: } x := 1. \\
\end{align*}
\]
2. The computer and the program

2.1. Syntax

a) program : open, standard declarations, library declarations option, particular program, close.

b) standard declarations : serial declaration, go on symbol.

c) library declarations : serial declaration, go on symbol.

d) particular program : label sequence option, CLOSED statement.

{For standard-declarations see Chapter 10, for collateral-statements see 6.3.1.b, for closed-statements see 6.4 and for conditional-statements see 6.5. The specification of library-declarations is undefined. }

2.2. Terminology

{"When I use a word," Humpty Dumpty said, in rather a scornful tone, "it means just what I choose it to mean — neither more nor less."
Through the Looking Glass, Lewis Carroll}

The meaning of a program is explained in terms of a hypothetical "computer" which performs a set of "actions" {2.2.5}, the elaboration of the program {2.3.a}. The computer deals with a set of "objects" {2.2.1} between which, at any given time, certain "relationships" {2.2.2} may "hold".

2.2.1. Objects

Each object is either "external" or "internal". External objects are "occurrences" of terminal productions {1.1.2.f} of notions. Internal objects are "values" {2.2.3}, at different "instances".

2.2.2. Relationships

a) Relationships are either "permanent", i.e. independent of the program and its elaboration, or actions may cause them to hold or cease to hold. Each relationship is either between external objects or between an external object and an internal object or between internal objects.

b) The relationships between external objects are:
"to contain" {1.1.6.b}, "to be a constituent of" {1.1.6.d} and "to identify".

c) A given occurrence of an "identifier" {4.1} ("indication" {4.2}, "operator" {4.3}) may identify a "defining" ("indication-defining", "operator-defining") occurrence of the same identifier (indication, operator).
2.2.2. continued 1

d) The relationship between an external object and an internal object is: "to possess".

e) An external object considered as a terminal production of a given notion may possess a value, called "the" value of the external object when it is clear which notion is intended.

f) An identifier (operator) may possess a value (more specifically) a "routine" (2.2.3.4). This relationship is caused to hold by the elaboration of an "identity-declaration" (7.4) ("operation-declaration" (7.5)) and ceases to hold upon the end of the elaboration of the smallest serial-clause (6.1.1.b) containing that declaration.

g) An external object other than an identifier or operator (e.g. an expression (6.0.1.c)) considered as terminal production of a given notion may be caused to possess a value by its elaboration as terminal production of that notion, and continues to possess that value until the next elaboration, if any, of the same occurrence of that external object is "initiated", whereupon it ceases to possess that value.

h) The relationships between internal objects (values) are: "to be of the same mode as", "to be equivalent to", "to be smaller than", "to be a component of" and "to refer to".

i) A value may be of the same mode as another value; this relationship is permanent.

j) A value may be equivalent to another value (2.2.3.1.d, f) and a value may be smaller than another value (10.2.2.a, 10.2.3.a). If one of these relationships is defined at all for a given pair of values, then either it does not hold, or it does hold and is permanent.

k) A given value is a component of another value if it is a "field" (2.2.3.2), "element" (2.2.3.3.a) or "subvalue" (2.2.3.3.c) of that other value or of one of its components.

l) Any "name" (2.2.3.5), except "nil" (2.2.3.5.a), refers to one instance of another value. This relationship (may be caused to hold by an "assignment" (8.8.2.c) of that value to that name and) continues to hold until another instance of a value is caused to be referred to by that name. The words "refers to an instance of" are often shortened in the sequel to "refers to".
2.2.3. Values

Values are
i) "plain" values {2.2.3.1}, which are independent of the program and its elaboration,
ii) "structured" values {2.2.3.2} or "multiple" values {2.2.3.3}, which are composed of other values in a way defined by the program,
iii) "routines" and "formats" {2.2.3.4}, which are certain sequences of symbols defined by the program, or
iv) names {2.2.3.5}, which are created by the elaboration of the program.

2.2.3.1. Plain values

a) A plain value is either an "arithmetic" value, i.e. an integer or a real number, or is a truth value or character.

b) An arithmetic value has a "length number", i.e. a positive integer characterising the degree of discrimination with which the value is kept in the computer. The number of integers (real numbers) of given length number that can be distinguished increases with the length number up to a certain length number, called the number of different lengths of integers (real numbers) \(10.1.a, c\), after which it is constant.

c) For each pair of integers (real numbers) of the same length number, the relationship to be smaller than is defined \(10.2.2.a, 10.2.3.a\). For each pair of integers of the same length number, a third integer of that length number may exist, the first integer "minus" the other one \(10.2.2.g\). Finally, for each pair of real numbers of the same length number, three real numbers of that length number may exist, the first real number minus ("times", divided by") the other one \(10.2.3.g, 1, m\); these real numbers are obtained "in the sense of numerical analysis", i.e. by performing the operations known in mathematics by these terms on real numbers which may deviate slightly from the given ones \(;\) this deviation is not defined in this Report.

d) Each integer of given length number is equivalent to a real number of that length number. Also, each integer (real number) of given length number is equivalent to an integer (real number) whose length number is greater by one. These equivalences permit the "widening" \(8.2.5\) of an integer into a real number and the increase of the length number of an integral or real number. The inverse transformations are only
2.2.3.1. continued

possible on those real numbers which are equivalent to an integer of
the same length number or on those values which are equivalent to
a value of smaller length number.

e) A truth value is either "true" or "false".

f) Each character has an "integral equivalent" (10.1.h), i.e. a
nonnegative integer of length number one; this relationship is defined
only in so far that different characters have different integral equivalents.

2.2.3.2. Structured values

(Yea, from the table of my memory
I'll wipe away all trivial fond records.
Hamlet,
William Shakespeare.)

A structured value is composed of a number of other values, its fields,
in a given order, each of which is "selected" (8.6.2. Step 2) by a
specific field-selector (7.1.1.e).

2.2.3.3. Multiple values

a) A multiple value is composed of a "descriptor" and a number of other
values, its elements, each of which is selected (8.4.2. Step 7) by a
specific integer, its "index".

b) The descriptor consists of an "offset", \( c \), and some number, \( n \geq 0 \), of
"quintuples" \( (l_i, u_i, d_i, s_i, t_i) \) of integers, \( i = 1, \ldots, n \); \( l_i \) is called
the \( i \)-th "lower bound", \( u_i \) the \( i \)-th "upper bound", \( d_i \) the \( i \)-th "stride",
\( s_i \) the \( i \)-th "lower state" and \( t_i \) the \( i \)-th "upper state". If any \( l_i > u_i \),
then the number of elements in the multiple value is zero; otherwise, it is

\[
(u_i - l_i + 1) \times \ldots \times (u_n - l_n + 1).
\]

The descriptor "describes" an element iff there exists an \( n \)-tuple
\( (r_1, \ldots, r_n) \) of integers satisfying \( l_i \leq r_i \leq u_i \) for all \( i = 1, \ldots, n \)
such that the element is selected by

\[
c + (r_1 - l_1) \times d_1 + \ldots + (r_n - l_n) \times d_n.
\]

(In a given instance of a multiple value, a state which is \( O(1) \) indicates
that the given value can (cannot) be "superseded" (8.8.2.a) by an instance
of a multiple value in which the bound corresponding to the state differs
from that in the given value. )
2.2.3.3. continued

c) A subvalue of a given multiple value is a multiple value referred to by the value of a slice \(8.4\) the value of whose constituent whole \(8.4.1.a, c\) refers to the given multiple value.

2.2.3.4. Routines and formats

A routine (format) is a sequence of symbols which is the same as some closed-clause \(6.4.1.a\) (format-denotation \(5.5\)).

2.2.3.5. Names

a) There is one name, called nil, whose "scope" \(2.2.4.2\) is the program and which does not refer to any value. Any other name is created by the elaboration of an actual-declarer \(7.1.2.c\). Step 7, and refers to precisely one instance of a value).

b) If a given name refers to a structured value \(2.2.3.2\), then to each of its fields there refers a name uniquely determined by the given name and the field-selector selecting that field, and whose scope is that of the given name.

c) If a given name refers to a given multiple value \(2.2.3.3\), then to each element (each multiple value whose elements are a proper subset of the elements) of the given multiple value there refers a name uniquely determined by the given name and the index of that element (and that subset), and whose scope is that of the given name.

2.2.4. Modes and scopes

2.2.4.1. Modes

a) Each instance \(2.2.1\) of a value is of one specific mode \(1.1.6.c.vi\) which is a terminal production of 'NONUNITED' \(1.2.1.b\); furthermore, all instances of a given value other than nil \(2.2.3.5.a\) are of one same mode.

b) The mode of a truth value (character, format) is 'boolean' ('character', 'format').

c) The mode of an integer (a real number) of length number \(n\) is \((n - 1)\) times 'long' followed by 'integral' (by 'real').
2.2.4.1. continued

d) The mode of a structured value is 'structured with' followed by one or more "portrayals" separated by 'and', one corresponding to each field taken in the same order, each portrayal being 'a' followed by a mode followed by 'named' followed by the terminal production of 'TAG' {1.2.1.e} whose terminal production (field-selector) selects {2.2.3.2} that field.

e) The mode of a multiple value is a terminal production of 'NONROW' {1.2.2.e} preceded by as many times 'row of' as there are quintuples in the descriptor of that value.

f) The mode of a routine is a terminal production of 'PROCEDURE' {1.2.1.q}.

g) The mode of a name is 'reference to' followed by another mode. {See 7.1.2.c. Step 8. }

h) A given mode is "adjusted (united) from" a second mode if the notion consisting of that second mode followed by 'cohesion' is a production of the notion consisting of 'adjusted' ('united') followed by the given mode followed by 'cohesion' {see 8.2}.

   (e.g. The mode specified by real is adjusted from the mode specified by ref real, and that specified by union(int, real) is united from those specified by int and real. )

i) A mode is "related to" a second mode if both modes are adjusted from one same mode {see 4.4.2.a and 4.4.3.c.}.

   (e.g. The modes specified by real, ref real, union(int, real) and proc real are all related to one another since all are adjusted from 'real'. )

j) A given mode is "structured from" a second mode if it begins with 'structured with' and the mode between 'a' and 'named' in one of its portrayals {d} is or is structured from that second mode.

   (e.g. In the context of the declarations

   struct a = (aa, bb) and
   struct b = (aa, ref real r) ,

   the mode specified by a is structured from those specified by a and b, whereas the mode specified by b is structured from that specified by a, and hence also from itself.)
2.2.4.2. Scopes, inner and outer scopes

a) Each value has one specific scope. Each instance of a value has, moreover, one specific "inner scope" and "outer scope".

b) The scope of a plain value is the program, that of a structured (multiple) value is the smallest of the scopes of its fields (elements), that of a routine or format possessed by a given denotation \{5.4, 5.5\} is the smallest range \{4.1.1.e\} containing a defining \{4.1.2.a\} (indication-defining \{4.2.2.a\}, operator-defining \{4.3.2.a\}) occurrence of an identifier (indication, operator), if any, applied but not defined (indication-applied but not indication-defined, operator-applied but not operator-defined) within that denotation, and, otherwise, the program, and that of a name is some \{8.5.2.c\} range.

c) The inner (outer) scope of a value possessed by an external object whose value can have only one scope is that scope.

d) The inner (outer) scope of a value possessed by an external object whose value can have one of a number of inner (outer) scopes, is the smallest (largest) of those inner (outer) scopes.

2.2.5. Actions

\{Suit the action to the word, the word to the action. Hamlet, William Shakespeare.\}

An action is either "elementary", "serial" or "collateral".

A serial action consists of actions which take place one after the other. A collateral action consists of actions merged in time; i.e. it consists of the elementary actions which make up those actions provided only that each elementary action of each of those actions which would take place before another elementary action of the same action when not merged with the other actions, also takes place before it when merged.

\{What actions, if any, are elementary is undefined, except as provided in 6.4.2.c. \}
2.3. Semantics

"I can explain all the poems that ever were invented, - and a good many that haven't been invented just yet."
Through the Looking Glass, Lewis Carroll.

a) The elaboration of a program is the elaboration of the closed-statement (6.4.1.a) consisting of the same sequence of symbols.
   (In this Report, the Syntax says which sequences of symbols are programs, and the Semantics which actions are performed by the computer when elaborating a program. Both Syntax and Semantics are recursive.)

b) In ALGOL 68, a specific notation for external objects is used which, together with its recursive definition, makes it possible to handle and to distinguish between arbitrarily long sequences of symbols, to distinguish between arbitrarily many different values of a given mode (except 'boolean') and to distinguish between arbitrarily many modes, which allows arbitrarily many objects to occur in the computer and which allows the elaboration of a program to involve an arbitrarily large, not necessarily finite, number of actions.

This is not meant to imply that the notation of the objects in the computer is that used in ALGOL 68 nor that it has the same possibilities. It is, on the contrary, not assumed that the computer can handle arbitrary amounts of presented information. It is not assumed that these two notations are the same or even that a one-to-one correspondence exists between them; in fact, the set of different notations of objects of a given category may be finite. It is not assumed that the number of objects and relationships that can be established is sufficient to cope with the requirements of a given program nor that the speed of the computer is sufficient to elaborate a given program within a prescribed lapse of time.

c) A model of the hypothetical computer, using a physical machine, is said to be an "implementation" of ALGOL 68, if it does not restrict the use of the language in other respects than those mentioned above. Furthermore, if a language is defined whose particular-programs are all particular-programs of ALGOL 68 and have the same meaning, then that language is called a "sublanguage" of ALGOL 68. A model is said to be an implementation of a sublanguage if it does not restrict the use of the sublanguage in other respects than those mentioned above.
2.3. continued

{A sequence of symbols which is not a program but can be turned into one by a certain number of deletions or insertions of symbols and not by a smaller number could be regarded as a program with that number of syntactical errors. Any program that can be obtained by performing that number of deletions or insertions may be called a "possibly intended" program. Whether a program or one of the possibly intended programs describes the process its writer in fact intended to describe is a matter which falls outside of this Report. }

{In an implementation, the particular-program may be "compiled", i.e. translated into an "object program", written in the code of the physical machine. Under circumstances, it may be advantageous to compile parts of the particular-program independently, e.g. parts which are common to several particular-programs. If such a part contains occurrences of identifiers (indications, operators) whose defining ( indication-defining, operator-defining) occurrences (Chapter 4) are not contained in that part, then compilation into an efficient object program may be assured by preceding the part by a chain of formal-parameters (5.4.1.e) (mode-declarations (7.2) or priority-declarations (7.3), captions (7.5.1.b)) containing those defining ( indication-defining, operator-defining) occurrences.}
3. Basic tokens and general constructions

3.0. Syntax

3.0.1. Introduction

a)* basic token : letter token ; denotation token ; action token ;
   declaration token ; syntactic token ; sequencing token ;
   hip token ; extra token ; quote symbol ; comment symbol.

b) NOTION option : NOTION ; EMPTY.

c) chain of NOTIONs separated by SEPARATORs : NOTION ;
   NOTION, SEPARATOR, chain of NOTIONs separated by SEPARATORs.

d) NOTION list : chain of NOTIONs separated by comma symbols.

e) NOTION sequence : chain of NOTIONs separated by EMPTYs.

f) NOTION pack : open symbol, NOTION, close symbol.

   (Examples:
   a) $a ; 0 ; + ; int ; if ; . ; nil ; for ; " ; e ;$
   b) $0 ;$
   c) $0 , 1 , 2 ;$
   d) $0 ; 0 , 1 , 2 ;$
   e) $0 ; 000 ;$
   f) $(1 , 2 , 3) ;$

   (For letter-tokens see 3.0.2, for denotation-tokens see 3.0.3, for
   action-tokens see 3.0.4, for declaration-tokens see 3.0.5, for syntactic-
   tokens see 3.0.6, for sequencing-tokens see 3.0.7, for hip-tokens see
   3.0.8 and for extra-tokens see 3.0.9.)

3.0.2. Letter tokens

a) letter token : LETTER.

b) LETTER : LETTER symbol.

   (Examples:
   a) $a ; \pi \ (\text{see } 1.1.4.a) ;$

   (Letter-tokens are constituents of identifiers (4.1.1.a), field-
   selectors (7.1.1.i), format-denotations (5.1.5) and row-of-character-
   denotations (5.3).)
3.0.3. Denotation tokens

a) denotation token : number token ; true symbol ; false symbol ;
   formatter symbol ; expression symbol ; parameter symbol ; flipflop ;
   comma symbol ; space symbol.

b) number token : digit token ; point symbol ;
   times ten to the power symbol.

c) digit token : DIGIT.

d) DIGIT : DIGIT symbol.

e) flipflop : flip symbol ; flop symbol.

   {Examples:
   a) 7 ; true ; false ; f ; expr ; : ; l ; , ; . ;
   b) 7 ; . ; 10 ;
   c) 7 ;
   e) 1 ; 0 }

   {Denotation-tokens are constituents of denotations (Chapter 5). Some
denotation-tokens may, by themselves, be denotations, e.g. the digit-token
7, whereas others, e.g. the expression-symbol, serve only to construct
denotations.}

3.0.4. Action tokens

a) action token :
   . operator token ; equals symbol ; value of symbol ; confrontation token.

b) operator token : or symbol ; and symbol ; not symbol ;
   differs from symbol ; is less than symbol ; is at most symbol ;
   is at least symbol ; is greater than symbol ; plusminus ;
   times symbol ; over symbol ; quotient symbol ; modulo symbol ;
   absolute value of symbol ; lengthen symbol ; shorten symbol ;
   round symbol ; sign symbol ; entier symbol ; odd symbol ;
   representation symbol ; real part of symbol ;
   imaginary part of symbol ; conjugate symbol ; binal symbol ;
   to the power symbol ; minus and becomes symbol ; plus and becomes symbol ;
   times and becomes symbol ; over and becomes symbol ;
   modulo and becomes symbol ; plus and becomes symbol ; up symbol ;
   down symbol.

c) plusminus : plus symbol ; minus symbol.

d) confrontation token : becomes symbol ; conforms to symbol ;
   conforms to and becomes symbol ; is symbol ; is not symbol.
3.0.4. continued

(Examples:
   a) + ; = ; val ; := ;
   b) \lor ; \land ; \neg ; \# ; < ; \leq ; \geq ; + ; \times ; / ; \div ; \div ; \div ; \div ; \div ; \div ;
   short ; round ; sign ; entier ; odd ; repr ; re ; im ; conj ; bin ;
   \downarrow ; minus ; plus ; times ; over ; mod ; prim ; up ; down ;
   c) + ; - ;
   d) := ; :: ; ::= ; ::= ; :\# ;)

(Operator-tokens are constituents of formulas (8.1). An operator-
token may be caused to possess an operation by the elaboration of an
operation-declaration (7.5).
Confrontation-tokens are constituents of confrontations (8.0.1.c).}

3.0.5. Declaration tokens

a) declaration token : PRIMITIVE symbol ; long symbol ;
   reference to symbol ; procedure symbol ; structure symbol ;
   union of symbol ; local symbol ; complex symbol ; bits symbol ;
   string symbol ; mode symbol ; priority symbol ; operation symbol.

(Examples:
   a) int ; long ; ref ; proc ; struct ; union ; loc ;
      compl ; bits ; string ; mode ; priority ; op )

(Declaration-tokens are constituents of declarers (7.1), which
specify modes (2.2.4), or of declarations (7.2, 3, 4, 5).}

3.0.6. Syntactic tokens

a) syntactic token : open ; close ; elementary symbol ; parallel symbol ;
   sub symbol ; bus symbol ; up to symbol ; at symbol ; if symbol ;
   THEELSE symbol ; fi symbol ; of symbol ; label symbol.

b) open : open symbol ; begin symbol.

c) close : close symbol ; end symbol ; end symbol, TAG.

(Examples:
   a) ( ; ) ; elem ; par ; [ ; ] ; ; ; ; ; if ; then ; fi ; of ; ;
   b) ( ; begin ;
   c) ) ; end ; end zero)

(Syntactic-tokens separate external objects or group them together.)
3.0.7. Sequencing tokens

a) sequencing token: go on symbol; completion symbol; go to symbol.

{Examples:
a) ; ; ; \textit{go to} 

{Sequencing-tokens are constituents of phrases, in which they
specify the order of elaboration (6.1.2.c).}

3.0.8. Hip tokens

a) hip token: skip symbol; nil symbol.

{Examples:
a) \texttt{skip} ; \texttt{nil} 

{Hip-tokens function as skips (6.2.1.e) and nilhils (8.3.1.e).}

3.0.9. Extra tokens and comments

a) extra token: for symbol; from symbol; by symbol; to symbol;
while symbol; do symbol; then if symbol; else if symbol;
case symbol; in symbol; esac symbol; plus i times symbol.
b) comment: comment symbol, comment item sequence option, comment symbol.
c) comment item: character token; quote symbol; other comment item.
d) character token: letter token; number token; plus i times symbol;
open symbol; close symbol; space symbol; comma symbol.

{Examples:
a) \texttt{for} ; \texttt{from} ; \texttt{by} ; \texttt{to} ; \texttt{while} ; \texttt{do} ; \texttt{thef} ; \texttt{elaf} ; \texttt{case} ; \texttt{in} ; \texttt{esac} ; \texttt{i} ;
b) \texttt{a with respect to a} ;
c) \texttt{w} ; " ; ? ;
d) \texttt{a} ; \texttt{1} ; \texttt{i} ; ( ; ) ; \texttt{1} ; ,

{For other-comment-items see 1.1.5. Step 4.}

{Extra-tokens and comments may occur in constructions which, by virtue
of the extensions of Chapter 9, stand for constructions in which no
extra-tokens or comments occur. Thus, a program containing an extra-token
or a comment is necessarily a program in the extended language, but the
converse does not hold.}
3.1. Symbols

3.1.1. Representations

a) Letter tokens

<table>
<thead>
<tr>
<th>symbol</th>
<th>representation</th>
<th>symbol</th>
<th>representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>letter a symbol</td>
<td>$a$</td>
<td>letter n symbol</td>
<td>$n$</td>
</tr>
<tr>
<td>letter b symbol</td>
<td>$b$</td>
<td>letter o symbol</td>
<td>$o$</td>
</tr>
<tr>
<td>letter c symbol</td>
<td>$c$</td>
<td>letter p symbol</td>
<td>$p$</td>
</tr>
<tr>
<td>letter d symbol</td>
<td>$d$</td>
<td>letter q symbol</td>
<td>$q$</td>
</tr>
<tr>
<td>letter e symbol</td>
<td>$e$</td>
<td>letter r symbol</td>
<td>$r$</td>
</tr>
<tr>
<td>letter f symbol</td>
<td>$f$</td>
<td>letter s symbol</td>
<td>$s$</td>
</tr>
<tr>
<td>letter g symbol</td>
<td>$g$</td>
<td>letter t symbol</td>
<td>$t$</td>
</tr>
<tr>
<td>letter h symbol</td>
<td>$h$</td>
<td>letter u symbol</td>
<td>$u$</td>
</tr>
<tr>
<td>letter i symbol</td>
<td>$i$</td>
<td>letter v symbol</td>
<td>$v$</td>
</tr>
<tr>
<td>letter j symbol</td>
<td>$j$</td>
<td>letter w symbol</td>
<td>$w$</td>
</tr>
<tr>
<td>letter k symbol</td>
<td>$k$</td>
<td>letter x symbol</td>
<td>$x$</td>
</tr>
<tr>
<td>letter l symbol</td>
<td>$l$</td>
<td>letter y symbol</td>
<td>$y$</td>
</tr>
<tr>
<td>letter m symbol</td>
<td>$m$</td>
<td>letter z symbol</td>
<td>$z$</td>
</tr>
</tbody>
</table>

b) Denotation tokens

<table>
<thead>
<tr>
<th>symbol</th>
<th>representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>digit zero symbol</td>
<td>0</td>
</tr>
<tr>
<td>digit one symbol</td>
<td>1</td>
</tr>
<tr>
<td>digit two symbol</td>
<td>2</td>
</tr>
<tr>
<td>digit three symbol</td>
<td>3</td>
</tr>
<tr>
<td>digit four symbol</td>
<td>4</td>
</tr>
<tr>
<td>digit five symbol</td>
<td>5</td>
</tr>
<tr>
<td>digit six symbol</td>
<td>6</td>
</tr>
<tr>
<td>digit seven symbol</td>
<td>7</td>
</tr>
<tr>
<td>digit eight symbol</td>
<td>8</td>
</tr>
<tr>
<td>digit nine symbol</td>
<td>9</td>
</tr>
<tr>
<td>point symbol</td>
<td>.</td>
</tr>
<tr>
<td>times ten to the power symbol</td>
<td>10 $e$</td>
</tr>
</tbody>
</table>
### 3.1.1. continued 1

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>true symbol</td>
<td><code>true</code></td>
</tr>
<tr>
<td>false symbol</td>
<td><code>false</code></td>
</tr>
<tr>
<td>formatter symbol</td>
<td><code>f</code></td>
</tr>
<tr>
<td>expression symbol</td>
<td><code>expr</code></td>
</tr>
<tr>
<td>parameter symbol</td>
<td><code>:</code> <code>expr</code></td>
</tr>
<tr>
<td>flip symbol</td>
<td><code>1</code></td>
</tr>
<tr>
<td>flop symbol</td>
<td><code>0</code></td>
</tr>
<tr>
<td>comma symbol</td>
<td><code>,</code></td>
</tr>
<tr>
<td>space symbol</td>
<td><code>.</code></td>
</tr>
</tbody>
</table>

#### c) Action tokens

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>or symbol</td>
<td><code>v</code> <code>or</code></td>
</tr>
<tr>
<td>and symbol</td>
<td><code>∧</code> <code>and</code></td>
</tr>
<tr>
<td>not symbol</td>
<td><code>¬</code> <code>not</code></td>
</tr>
<tr>
<td>equals symbol</td>
<td><code>=</code> <code>eq</code></td>
</tr>
<tr>
<td>differs from symbol</td>
<td><code>≠</code> <code>ne</code></td>
</tr>
<tr>
<td>is less than symbol</td>
<td><code>&lt;</code> <code>lt</code></td>
</tr>
<tr>
<td>is at most symbol</td>
<td><code>≤</code> <code>le</code></td>
</tr>
<tr>
<td>is at least symbol</td>
<td><code>≥</code> <code>ge</code></td>
</tr>
<tr>
<td>is greater than symbol</td>
<td><code>&gt;</code> <code>gt</code></td>
</tr>
<tr>
<td>plus symbol</td>
<td><code>+</code></td>
</tr>
<tr>
<td>minus symbol</td>
<td><code>-</code></td>
</tr>
<tr>
<td>times symbol</td>
<td><code>×</code> <code>*</code></td>
</tr>
<tr>
<td>over symbol</td>
<td><code>/</code></td>
</tr>
<tr>
<td>quotient symbol</td>
<td><code>:</code> <code>quotient</code></td>
</tr>
<tr>
<td>modulo symbol</td>
<td><code>::</code> <code>mod</code></td>
</tr>
<tr>
<td>absolute value of symbol</td>
<td><code>abs</code></td>
</tr>
<tr>
<td>lengthen symbol</td>
<td><code>leng</code></td>
</tr>
<tr>
<td>shorten symbol</td>
<td><code>short</code></td>
</tr>
<tr>
<td>round symbol</td>
<td><code>round</code></td>
</tr>
<tr>
<td>sign symbol</td>
<td><code>sign</code></td>
</tr>
<tr>
<td>entier symbol</td>
<td><code>entier</code></td>
</tr>
<tr>
<td>odd symbol</td>
<td><code>odd</code></td>
</tr>
</tbody>
</table>
3.1.1. continued 2

symbol
representation symbol repr
real part of symbol re
imaginary part of symbol im
conjugate symbol conj
binary symbol bin
to the power symbol ^ power *:
minus and becomes symbol minus
plus and becomes symbol plus
times and becomes symbol times
over and becomes symbol over
modulo and becomes symbol mod
prus and becomes symbol prus
up symbol up
down symbol down
value of symbol val
becomes symbol :=
conforms to symbol :: ct
conforms to and becomes symbol :=: ctb
is symbol := is
is not symbol :#: is not isnot
d) Declaration tokens
symbol
integral symbol int
real symbol real
boolean symbol bool
character symbol char
format symbol format
long symbol long
reference to symbol ref
procedure symbol proc
structure symbol struct
union of symbol union
local symbol loc
3.1.1. continued 3

symbol representation
complex symbol compl
bits symbol bits
string symbol string
mode symbol mode
priority symbol priority
operation symbol op

e) Syntactic tokens

symbol representation
open symbol open
begin symbol begin
close symbol close
end symbol end
elementary symbol elem
parallel symbol parallel
sub symbol [ ( ] )
bus symbol :
to up symbol :
at symbol at
if symbol if
then symbol then
else symbol else
fi symbol fi
of symbol of
label symbol :

f) Sequencing tokens

symbol representation
go on symbol ;
completion symbol . exit
go to symbol go to goto
3.1.1. continued 4

g) Hip tokens
    symbol representation
    skip symbol skip
    nil symbol nil

h) Extra tokens
    symbol representation
    for symbol for
    from symbol from
    by symbol by
    to symbol to
    while symbol while
    do symbol do
    then if symbol |: thef
    else if symbol |: elseif
    case symbol ( case
    in symbol | in
    esac symbol ) esac
    plus i times symbol | i

i) Special tokens
    symbol representation
    quote symbol "
    comment symbol a comment

3.1.2. Remarks

a) Where more than one representation of a symbol is given, any one of them may be chosen.

   (However, discretion should be exercised, since the text
     (a > b then b | a fi),
   though acceptable to an automaton, would be more intelligible to
   a human in either of the two representations
     (a > b | b | a)
   or
     if a > b then b else a fi. )
3.1.2. continued

b) A representation which is a sequence of underlined or bold-faced marks or a sequence of marks between apostrophes is different from the sequence of those marks when not underlined, in bold face or between apostrophes.

c) Representations of other letter-tokens (1.1.4. Step 2), other-indications (1.1.5. Step 3), other-comment-items and other-string-items (1.1.5. Step 4) may be added, provided that no two letter-tokens (3.0.2), no two indications (4.2), no two comment-items (3.0.9.c) and no two string-items (5.3.1.b) have the same representation.

d) The fact that the representations of the letter-tokens given above are usually spoken of as small letters is not meant to imply that the so-called corresponding capital letters could not serve equally well as representations. On the other hand, if both a small letter and the corresponding capital letter occur, then one of them is the representation of an other letter-token (1.1.4. Step 2).

(For certain different symbols, one same representation is given, e.g. for the parameter-symbol, up-to-symbol, at-symbol and label-symbol, the representation "::" is given. It follows uniquely from the Syntax which of these four symbols is represented by an occurrence of "::" outside comments and row-of-character-denotations. Also, some of the given representations appear to be "composite"; e.g. the representation "::=" of the becomes-symbol appears to consist of "::", which looks like the representation "::=" of the at-symbol, etc., and the representation "::=" of the equals-symbol. It follows from the Syntax that "::=" or even "::=" can occur outside comments and row-of-character-denotations as representation of the becomes-symbol only (since "::=" cannot occur as representation of a monadic-operator). Similarly, the other given composite representations do not cause ambiguity.)
4. Identification and context conditions

4.1. Identifiers

4.1.1. Syntax

a) *identifier : MAEBEL identifier.
b) MAEBEL identifier : TAG.
c) TAG LETTER : TAG, LETTER.
d) TAG DIGIT : TAG, DIGIT.
e) *range : COERCETY serial CLAUSE ; PROCEDURE denotation.

(Examples:
b) x ; xx ; x/ ; amsterdam )

(Rule b, together with 1.2.2.t and 1.2.1.1 gives rise to an infinity
of production rules of the strict language, one for each pair of terminal
productions of 'MAEBEL' and 'TAG'. For example,
'real identifier : letter a letter b.'
is one such production rule. From rule c and 3.0.2.b, one obtains
'letter a letter b : letter a, letter b. ',
'letter a : letter a symbol.' and
'letter b : letter b symbol. ',
yielding
'letter a symbol, letter b symbol'
as a terminal production of 'real identifier'.
See also 7.1.1.g and 8.6 for additional insight into the function of
rules c and d. )

4.1.2. Identification of identifiers

a) A given occurrence of an identifier defines if
i) it follows a formal-declarer (5.1.1.e, 7.4.1.a),
ii) within some range, it is the textually first occurrence of that
identifier in a constituent flexible-lower-bound or flexible-upper-
bound (7.1.1.u) of that range, or
iii) it is contained in a label (6.1.1.g);
otherwise, it "is applied".
4.1.2. continued

b) If a given occurrence of an identifier is applied, then it may identify a defining occurrence found by the following steps:
Step 1: The given occurrence is called the "home" and Step 2 is taken;
Step 2: If there exists a smallest range containing the home, then this range, with the exclusion of all ranges contained within it, is called the home and Step 3 is taken; otherwise, there is no defining occurrence which the given occurrence identifies;
Step 3: If the home contains a defining occurrence of the identifier, then the given occurrence identifies it; otherwise, Step 2 is taken.

(In the closed-expression \((\texttt{bits } x(101); \texttt{abs } x[3] = 0)\), the first occurrence of \(x\) is a defining occurrence of a reference-to-row-of-boolean-identifier. The second occurrence of \(x\) identifies the first and, in order to satisfy the identification condition (4.4.1), is also a reference-to-row-of-boolean-identifier.)

(Identifiers have no inherent meaning. The defining occurrence of an identifier either is in a label (6.1.1.g) or is made to possess a value (2.2.3) by the elaboration of an identity-declaration (7.4).)

4.2. Indications

4.2.1. Syntax

a)* indication: MODE mode indication; ADIC indication.
b) MODE mode indication: mode standard; other indication.
c) mode standard: string symbol;
   long symbol sequence option, complex symbol;
   long symbol sequence option, bits symbol.
d)* priority indication: PRIORITY indication.
e) PRIORITY indication: long symbol sequence option, operator token;
   long symbol sequence option, equals symbol; other indication.
f) monadic indication: long symbol sequence option, operator token;
   other indication.
g)* adic indication: ADIC indication.
4.2.1. continued

(Examples:
b) primitive; compl;
c) string; long compl; bite;
e) +; =; ?;
f) +; ?; long abs)

{For other indications see 1.1.5. Step 3 and for operator-tokens see 3.0.4.b.}

4.2.2. Identification of indications

a) A given occurrence of an indication indication-defines if it precedes the constituent equals-symbol in a mode-declaration (7.2) or priority-declaration (7.3); otherwise it is "indication-applied".

b) If a given occurrence of an indication is indication-applied, then it may identify an indication-defining occurrence of the indication found using the steps of 4.1.2.b with Step 3 replaced by:
"Step 3: If the home contains an indication-defining occurrence of the indication, then the given occurrence identifies it; otherwise, Step 2 is taken."

{Indications have no inherent meaning. The indication-defining occurrence of an indication establishes that indication as a terminal production of 'MODE mode indication' (7.2) or 'PRIORITY indication' (7.3). Monadic-indications have no indication-defining occurrence.}

4.3. Operators

4.3.1. Syntax

a) operator: procedure with PARAMETERS ADIC operator.
b) procedure with PARAMETERS DELIVERY ADIC operator:
   procedure with PARAMETERS ADIC operator.
c) procedure with a LMODE parameter and a RMODE parameter PRIORITY operator:
   PRIORITY indication.
d) procedure with a RMODE parameter monadic operator: monadic indication.
e) priority operator: procedure with PARAMETERS PRIORITY operator.

{Examples:
c) +;
d) abe}
4.3.2. Identification of operators

a) A given occurrence of an operator operator-defines if it precedes the constituent equals-symbol in an operation-declaration \((7.5)\); otherwise, it is "operator-applied".

b) If a given occurrence of an operator is operator-applied, then it may identify an operator-defining occurrence of the operator found using the steps of \(4.1.2.b\), with Step 3 replaced by:

"Step 3: If the home contains an operator-defining occurrence of an operator which is the same adic-indication as the given occurrence, and which \((in\ view of the identification condition \((4.4.1))\) could be an operator-defining occurrence of that operator, then the given occurrence identifies that operator-defining occurrence of the operator; otherwise, Step 2 is taken."

(Operators have no inherent meaning. The operator-defining occurrence of an operator is made to possess a routine \((2.2.3.4)\) by the elaboration of an operation-declaration \((7.5)\).

A given occurrence of an indication may be both a priority indication and a priority-operator. As a priority-indication, it identifies its indication-defining occurrence. As a priority-operator, it may identify an operator-defining occurrence, which possesses a routine. Since the occurrence of an indication in an operation-declaration is an indication-application and an operator-definition (but not an operator-application), it follows that the set of those occurrences which identify a given priority-operator is a subset of those occurrences which identify the same priority-indication.

In the closed-statement

\[
\begin{align*}
\text{begin} & \quad \text{real } x, y \left(1.5\right) ; \quad \text{priority min } = 6 ; \\
& \quad \text{op min } = \ (\text{real } a, b) \quad \text{real } : \ (a > b \mid b \mid a) ; \\
& \quad x := y \text{ min pi } / 2 \text{ end ,}
\end{align*}
\]

the first occurrence of \(\text{min}\) is an indication-defining occurrence of a priority-SIX-Indication. The second occurrence \(\text{min}\) is indication-applied and identifies the first occurrence, whereas, at the same textual position, \(\text{min}\) is also operator-defined as a \([prr]\)-priority-SIX-operator and hence is also a \([prr]\)-priority-SIX-operator \((4.3.1.b); \ i.e.\ ignoring the mode of the
4.3.2. continued

value, if any, which it delivers), where \([\text{prr}]\) stands for procedure-
with-a-real-parameter-and-a-real-parameter, and \([\text{prrr}]\) for \([\text{prr}]-\)delivering-
a-real. The third occurrence of \(\min\) is indication-applied and, as such,
identifies the first occurrence, whereas, at the same textual position,
\(\min\) is also operator-applied, and, as such, identifies the second occurrence;
this makes it (in view of the identification condition, 4.4.1) a \([\text{prrr}]-\)
priority-SIX-operator and hence, also because of the identification
condition, a \([\text{prrr}]-\)priority-SIX-operator. This identification of the
priority-operator is made because

i) \(\min\) occurs in an operation-declaration,

ii) \(y\) could be an adjusted-real-priority-SIX-operand,

iii) \(\pi/2\) could be an adjusted-real-priority-SEVEN-operand
    (since it is a priority-SEVEN-formula),

iv) \(\min\) is a \([\text{prrr}]-\)priority-SIX-operator, and

v) this combination of possibilities satisfies the identification
    condition.

With this identification of the priority-operator accomplished, we know that
\(y\) is an adjusted-real-priority-SIX-operand and that \(\pi/2\) is an adjusted-
real-priority-SEVEN-operand. If the identification condition were not
satisfied, then the search for another defining occurrence would be
continued in the same range, or failing that, in a surrounding range. }

{Though this be madness, yet
there is method in't.

Hamlet, William Shakespeare.}

4.4. Context conditions

A "proper" program is any program satisfying the context conditions;
a "meaningful" program is a proper program whose elaboration is defined
by this Report. Whether all programs, only proper programs, or only
meaningful programs are "ALGOL 68 programs" is a matter for individual
taste. (If one chooses only proper programs, then he must consider the
context conditions as syntax which is not written as production rules. }
4.4.1. The identification condition

In a proper program, each applied occurrence of an identifier (each indication-applied occurrence of an indication, each operator-applied occurrence of an operator) which is a terminal production of one or more notions ending with 'identifier' ('indication', 'operator') is a terminal production of all those same notions at the defining (indication-defining, operator-defining) occurrence, if any, of that identifier (indication, operator). {See the remarks after 4.1.2 and 4.3.2.}

4.4.2. The mode conditions

a) No proper program contains a declarer \{7.1\} specifying a mode united from \{2.2.4.1.h\} two modes related \{2.2.4.1.i\} to one another, or from a mode related to that mode.

{e.g., neither the declarer \texttt{union(real, ref real)}

nor the mode-declaration \{7.2\} \texttt{mode a = union(real, proc a)}
is contained in any proper program.}

b) No proper program contains a declarer specifying a mode structured from \{2.2.4.1.j\} itself.

{e.g., no proper program contains the mode-declaration
\texttt{strut a = (aa, real r).}
}

c) No proper program contains a declarer the constituent field-selectors \{7.1.1.h\} of two of whose constituent field-declarators \{7.1.1.g\} are the same sequence of symbols.

{e.g., the declarer \texttt{strut(int i, bool i)}
is not contained in any proper program, but
\texttt{strut(int i, strut(int i, bool j) j)} may be.}

4.4.3. The uniqueness conditions

a) A "reach" is a range \{4.1.1.e\} with the exclusion of all its constituent ranges.

b) A given mode-indication \{4.2.1.b\} is "connected to" a second mode-indication if the actual-declarer following the equals-symbol following the indication-defining occurrence of the given indication ends with an indication which identifies the indication-defining occurrence of the second indication, or, otherwise is connected to the second indication.

{e.g., in the context of
\texttt{mode a = ref b ; mode b = proc a },
the indication \texttt{a} is connected to \texttt{b} and hence to \texttt{a}.}
4.4.3. continued

c) No proper program contains a reach containing two defining occurrences of a given identifier nor two indication-defining occurrences of a given indication.

\[ (\text{real } x ; \text{real } x ; \sin(3.14)) , \]
\[ (\text{real } y ; \text{int } y ; \sin(3.14)) , \]
\[ (\text{real } p ; \text{proc } p ; \sin(3.14)) , \]
\[ (\text{mode } a = \text{real} ; \text{mode } a = \text{bool} ; \sin(3.14)) \text{ and} \]
\[ (\text{mode } b = \text{real} ; \text{priority } b = 6 ; \sin(3.14)) \]
is contained in a proper program. 

d) No proper program contains a reach containing two operation-declarations whose first constituent operators are the same indication and all corresponding constituent virtual-declarers \((7.1.1.b)\) of whose first constituent tails \((7.1.1.w, x, z)\) specify related \((2.2.4.1.i)\) modes.

\[ \text{e.g., neither the closed-expression} \]
\[ \text{op max} = (\text{int } a, \text{int } b) \text{ int} : (a > b | a | b) ; \]
\[ \text{op max} = (\text{int } a, \text{int } b) \text{ int} : (a > b | a | b) ; \sin(3.14)) \]
nor \[ \text{op max} = (\text{int } a, \text{ref int } b) \text{ int} : (a > b | a | b) ; \]
\[ \text{op max} = (\text{ref int } a, \text{int } b) \text{ int} : (a > b | a | b) ; \sin(3.14)) \]
is contained in any proper program, but
\[ \text{op max} = (\text{int } a, \text{int } b) \text{ int} : (a > b | a | b) ; \]
\[ \text{op max} = (\text{real } a, \text{real } b) \text{ real} : (a > b | a | b) ; \sin(3.14)) \]
may be. 

e) No proper program contains a mode-indication which is connected to \((4.4.3,b)\) itself.

\[ \text{e.g., neither of the mode-declarations} \]
\[ \text{mode } a = a \text{ and} \]
\[ \text{mode } b = \text{ref } b \text{ nor the pair of declarations} \]
\[ \text{mode } a = \text{ref } d ; \text{mode } d = \text{proc } c \]
is contained in any proper program.

f) No proper program contains an applied occurrence of an identifier (indication-applied occurrence of a mode-indication or priority-indication, operator-applied occurrence of an operator) which does not identify a defining (an indication-defining, an operator-defining) occurrence.
5. Denotations

5.0.1. Syntax

a) denotation : PLAIN denotation ; BITS denotation ; STRING denotation ;
   PROCEDURE denotation ; format denotation.

   {Examples:
   a) 3.14 ; 101 ; "algol_report" ; (bool a, b) bool : (a | b | false) ; f5df }

   {For plain-denotations see 5.1, for row-of-boolean-denotations see 5.2,
   for row-of-character-denotations see 5.3, for routine-denotations see 5.4
   and for format-denotations see 5.5. }  

5.0.2. Semantics

a) A denotation possesses a value; a given denotation always possesses the
   same value; its elaboration involves no action.

b) The mode of the value possessed by a given denotation is obtained by
   deleting 'denotation' from that direct production of the notion 'denotation',
   of which the given denotation is a terminal production. {e.g. The value of
   "algol_report", which is a production of 'row of character denotation',
   is of the mode 'row of character'.}

5.1. Plain denotations

5.1.0.1. Syntax

a) plain denotation : PLAIN denotation.

b) long INTHEAL denotation : long symbol, INTHEAL denotation.

   {Examples:
   a) 4098 ; 3.14 ; true ;
   b) Long 4096 ; Long Long 3.141592653589793 }

   {For integral-denotations see 5.1.1, for real-denotations see 5.1.2
   and for boolean-denotations see 5.1.3. }

5.1.0.2. Semantics

a) A plain-denotation possesses a plain value {2.2.3.1}, but plain values
   possessed by different plain-denotations are not necessarily different.
5.1.0.2. continued

b) The value of a denotation consisting of a number (possibly zero) of long-symbols followed by an integral-denotation (real-denotation) is the "a priori" value of that integral-denotation (real-denotation) provided that it does not exceed the largest integer \(10.1.3\) (largest real number \(10.1.d\)) of length number one more than that number of long-symbols \{; otherwise, the value is undefined\}.

5.1.1. Integral denotations

5.1.1.1. Syntax

a) integral denotation : digit zero ; natural numeral.
b) natural numeral : digit FIGURE, digit token sequence option.

{Examples:
a) 0 ; 4096 ;
b) 1 ; 2 ; 3 ; 123 ; (Note that 00123 and -1 are not integral-denotations.)}

5.1.1.2. Semantics

The a priori value of an integral-denotation is the integer which in decimal notation is written as that integral-denotation in the representation language \(1.1.8\).

{See also 5.1.0.2.b}

5.1.2. Real denotations

5.1.2.1. Syntax

a) real denotation : variable-point numeral ; floating-point numeral.
b) variable-point numeral : integral part option, fractional part ; integral part, point symbol.
c) integral part : integral denotation.
d) fractional part :
point symbol, digit zero sequence option, integral denotation.
e) floating-point numeral : stagnant part, exponent part.
f) stagnant part : integral denotation ; variable-point numeral.
g) exponent part : times ten to the power symbol, power of ten.
h) power of ten : plusminus option, integral denotation.
5.1.2.1. continued

Examples
a) 0.000123 ; 1.23e-4 ; b) .723 ; .0723 ; .723 . ;
c) .723 ; d) .723 ; .000723 ;
e) 1.23e-4 ; 710+5f) 7 ; 1.23 ;
g) e-4 ; h) 3 ; +45 ; -678 }

5.1.2.2. Semantics

a) The a priori value of a fractional-part is the a priori value of its integral-denotation divided by ten as many times as there are digit-tokens in the fractional-part.

b) The a priori value of a variable-point-numeral is the sum in the sense of numerical analysis of zero, the a priori value of its integral-part, if any, and that of its fractional-part, if any (see also 5.1.0.2.b.).

c) The a priori value of an exponent-part is ten raised to the a priori value of the integral-denotation in its power-of-ten if that power-of-ten does not begin with a minus-symbol; otherwise, it is one-tenth raised to the a priori value of that integral-denotation.

d) The a priori value of a floating-point-numeral is the product in the sense of numerical analysis of the a priori values of its stagnant-part and exponent-part (see also 5.1.0.2.b.).

5.1.3. Boolean denotations

5.1.3.1. Syntax

a) boolean denotation : true symbol ; false symbol.

Examples:
a) true ; false }

5.1.3.2. Semantics

The value of a true-symbol (false-symbol) is true (false).

5.2. Row of boolean denotations

5.2.1. Syntax

a) BITS denotation : long symbol sequence option, flipflop sequence.
5.2.1. continued

(Examples:
  a) 101 ; Long 101 }

  (For flipflops see 3.0.3.e. )

5.2.2. Semantics

a) Let m stand for the number of flipflops in the denotation and n for the value of \( L \) bits width \( (10.1.g) \), \( L \) standing for as many times \( Long \) as there are long-symbols in the denotation.

b) If \( m \leq n \), then the value of the row-of-boolean-denotation is a multiple value \( (2.2.3.3) \) whose descriptor has an offset \( 1 \) and one quintuple

\( (1, n, 1, 1, 1) \)

and whose element with index \( i \) is a new instance of true (false) if the \( i \)-th constituent flipflop is a flip-symbol (a flop-symbol) for \( i = 1, \ldots, m \) and of false for \( i = m + 1, \ldots, n \) {; otherwise, the value is undefined}.

(If the value of \( bits \) width is, say, 5, then \( 101 \) possesses the same value as the collateral-expression \( \langle false, false, true, false, true \rangle \), but \( 101 \) is not a collateral-expression. )

5.3. Row of character denotations

5.3.1. Syntax

a) STRING denotation :

  quote symbol, string item sequence option, quote symbol.

b) string item : character token ; quote image ; other string item.

c) quote image : quote symbol, quote symbol.

(Now that, since the Syntax nowhere allows row-of-character-denotations to occur following one another, the quote-image can cause no ambiguities. )

(Examples:
  a) "" ; "a" ; "abode" ; "a_{+}b_{-}""c_{x}a_{formula}"

b) a ; "" ; ? ;

c) ""

(For character-tokens see 3.0.9.d and for other-string-items see 1.1.5. Step 4. )
5.3.2. Semantics

a) Each character-token and other-string-item, as well as the quote-symbol (not quote-image) possesses a unique character.
b) The value of a row-of-character-denotation is a multiple value \{2.2.3.3\} whose descriptor has an offset 1 and one quintuple \((1, n, 1, 1, 1)\), where \(n\) stands for the number of string-items contained in the denotation. For \(i = 1, \ldots, n\), the element with index \(i\) of that multiple value is a new instance of the character possessed by the \(i\)-th constituent string-item if that string-item is a character-token or other-string-item, and otherwise, \{if that string-item is a quote-image\} is a new instance of the character possessed by the quote-symbol.

5.4. Routine denotations

5.4.1. Syntax

a) routine denotation : PROCEDURE denotation.
b) procedure with PARAMETERS delivering a MODE denotation :
   formal PARAMETERS pack, virtual MODE declarer, parameter symbol,
   hip adapted MODE primary.
c) procedure with PARAMETERS denotation :
   formal PARAMETERS pack, parameter symbol, primary statement.
d) VICTAL PARAMETERS and a PARAMETER :
   VICTAL PARAMETERS, comma symbol, VICTAL PARAMETER.
e) formal MODE parameter : formal MODE declarer, MODE identifier.
f) procedure delivering a MODE denotation :
   virtual MODE declarer, expression symbol, hip adapted MODE primary.
g) procedure denotation : expression symbol, primary statement.

{Examples:
  b) \((\text{bool } a, b) \text{ bool} : (a \mid b \mid \text{false})\);
  c) \((\text{ref int } i) : (i > 0 \mid i := i - 1)\);
  d) \text{bool } a, b ; \text{ref int } i ;
     \[ \text{real } x \ ; [1 : 10] \text{real } y \ ; [\text{int } m : \text{int } n] \text{real } z \ ;
  e) \text{bool } a ; \text{ref int } i ;
  f) \text{real expr}(p \mid x \mid y) ;
  g) \text{expr}(n = 1986 \mid \text{vansav} \mid \text{sandvoort}) \}

{For hip-adapted-primaries see 8.3.1.a and for primary-statements see 6.2.1.c.}
5.4.2. Semantics

A routine-denotation possesses that routine which would be obtained from it by
i) placing an open-symbol before it and a close-symbol after it;
ii) inserting a denotes-symbol followed by a skip-symbol following the last identifier in each constituent formal-parameter;
iii) deleting the constituent virtual-declarer, if any, preceding the constituent parameter-symbol or expression-symbol;
iv) replacing the parameter-symbol, if any, by a go-on-symbol, and
v) deleting the expression-symbol, if any.

{For the use of routines, see 8.1 (formulas), 8.2.1 (unaccompanied-calls) and 8.7 (accompanied-calls). }

5.5. Format denotations

5.5.1. Syntax

a) format denotation :
   formatter symbol, format primary list, formatter symbol.

b) format primary : format item ; insertion option, replicator,
   format primary list pack, insertion option.

c) format item : MODE pattern, insertion option.

d) insertion : literal option, insert sequence ; literal.

e) insert : replicator, alignment, literal option.

f) replicator : replication option.

g) replication : dynamic replication ; integral denotation.

h) dynamic replication : letter n, fitted serial integral expression pack.

i) alignment : letter k ; letter x ; letter y ; letter l ; letter p.

j) literal : STRING denotation option, replicated literal sequence ;
   STRING denotation.

k) replicated literal : replication, STRING denotation.

{Examples:
  a) \texttt{f} \texttt{"table_of"x10a,n(lim-1)(2x8sd,3x10(2x+12de+2d)*j"si+.10de+2d))p};
  b) \texttt{p"table_of"x10a ; 3x10(2x+.12de+2d)*j"si+.10de+2d) ;
  c) \texttt{t20ka("mon","tues","wednes","thurs","fri","satur","sun")"day" ;
  d) \texttt{p"table_of"x ; "day" ;
  e) \texttt{p"table_of" ;
  f) \texttt{p"table_of" ;
  g) n(lim-1) ; 10 ;}
5.5.1. continued

h) \( n(lim-1) \);

j) \( "jx" \);

k) \( 20",_" \)

l) sign mould: loose replicable zero frame option, sign frame.

m) loose ANY frame: insertion option, ANY frame.

n) replicatable ANY frame: replicator, ANY frame.

o) zero frame: letter z.

p) sign frame: plusminus.

q) suppressible ANY frame: letter s option, ANY frame.

r) frame: ANY frame.

(Examples:

1) \( \text{"12z"} \);

m) \( \text{"12s"} \);

n) \( 12s \);

q) \( \text{si} \); 10a)

(Formats (see 5.5.2.a) are used by the formatted transput routines
(10.5.4,5) to control "transput", i.e. "input" from and "output" to a
"file" (10.5.1).

A format-item is used on output to control the "conversion" of a value
to a "string", i.e. a value of mode 'row of character', and, on input,
that of a string to a value.

The mode specified by a format-item is that obtained by deleting 'pattern'
from that notion ending with 'pattern' whose terminal production is the
constituent pattern of that format-item.

Formats have a complementary meaning on input and output; that is, under
control of one format-item:

i) it is possible to convert a given value to a string by means of a
formatted output routine, provided the mode specified by the format-
item is "output-compatible" with the mode of the given value, and
the number of characters specified by the format-item is sufficient
(10.5.4);

ii) it is possible to convert a given string to a value of a given mode,
provided the mode specified by the format-item is "input-compatible"
with the mode of the value, the number of elements of the string is
5.5.1. continued 2

the same as that specified by the format-item, and the individual
caracters of the string "agree" with the frames of the format-item
specifying them (10.5.5);

iii) if it is possible to convert a given value to a string and the
format-item does not contain a letter-k or letter-y as alignment,
and the format-item does not contain any digit-frames or character-
frames preceded by letter-s, then it is possible to convert the
resulting string (under control of the same format-item) into a
value; the resulting value is equal (approximately equal) to the
given value if the given value is a string, integer or truth value
(is a real value);

iv) if it is possible to convert a given value into a string and to
convert that string into a new value, then converting this new value
to a string yields the same string.

{The value of the empty replicator is one; the value of a replication
that is an integral-denotation is the value of that denotation; the value
of a dynamic-replication is the value of its constituent fitted-serial-
integral-expression if that value is positive, and zero otherwise.
The number of characters specified by a format-item is the sum of the
numbers of characters specified by its constituent frames and the number
specified by a frame is equal to the value of its preceding replicator.

A frame preceded by letter-s is "suppressed", and the characters
specified by it are also suppressed, i.e.:
on output, are deleted from the string that is output, and,
on input, are inserted in the string that is input, viz., by inserting
the character possessed by a point (times-ten-to-the-power, plus-i-times,
digit-zero, space) -symbol for a suppressed-point (exponent, complex,
digit, character) -frame.

A format-primary which is not a format-item can control the transput
of a number of values; this number is at most the value of the constituent
replicator times the sum of the numbers of values of which the transput
can be controlled by the constituent format-primaries of its constituent
format-primary-list-pack.

An insertion is "performed" by performing its constituent literals
and/or alignments one after the other.
5.5.1. continued 3

On output, a (replicated-) literal is "written" (10.5.4.k) on the file, starting from the current position on the line, as many times as the value of the replicator.

On input, a (replicated-) literal is "required" (10.5.5.b) on the file, starting from the current position on the line, as many times as the value of the replicator. If the string possessed by the literal is present, then it is skipped; otherwise, the further elaboration is undefined.

An alignment may change the current page count, line count and position on the line of the file as follows: (let n stand for the value of the preceding replicator)

a) letter-k causes the position on the line to be set to n;
b) letter-x causes the position to be incremented by n (10.5.1.2.m);
c) letter-y causes the position to be decremented by n (10.5.1.2.n);
d) letter-l causes the line count to be incremented by n and the position on the line to be reset to one (10.5.1.2.o);
e) letter-p causes the page count to be incremented by n and both line count and position on the line to be reset to one (10.5.1.2.p).

A format-item can be used to "edit" a value as follows:

i) The value is converted by an appropriate output routine (10.5.2.c, d, e) to a string of as many characters as specified by the format-item. If the format-item is an integral-pattern, then this conversion takes place to a base equal to the radix, if present, and base ten otherwise.

ii) If the format-item contains a sign-mould, then a character specified by the sign-frame will be used to indicate the sign, viz., if the sign-mould contains a minus-symbol and the value is positive (negative), then a space (minus), and, otherwise, a plus (minus). This character is shifted in that part of the string specified by the sign-mould as far to the right as possible across any leading zeroes and those zeroes are replaced by spaces;

   e.g., under the sign-mould $\pm$, the string possessed by "$+0003" is edited into that possessed by "$\pm+3". If the format-item does not contain a sign-mould and the value is negative, then the result is undefined.

iii) Leading zeroes in those parts of the string specified by any remaining zero-frames are replaced by spaces; e.g., under the
5.5.1. continued

format-item $\text{adadad}$, the integer possessed by 180168 is edited into
the string possessed by "18.168".

iv) Suppressed characters are deleted.
A format-item can be used to "indit" a string into a value of a
given mode as follows:
i) If the format-item contains a sign-mould, then the character specified
by the sign-frame is required as one of the characters specified by
that sign-mould. Only spaces may appear in front of this character
and no leading zeroes may appear after it. The leading spaces are
deleted, and if the character specified by the sign-frame is a space,
and the sign frame is a minus-symbol, then that character is replaced
by a plus.
i) Leading spaces in those parts of the string specified by any remaining
zero-frame are replaced by zeroes.
iii) For each suppressed digit, a zero is inserted into the string; for
each other suppressed character, a space is inserted.
iv) The string is converted by an appropriate input routine (10.5.3.b,
c, d) into a value of the given mode.

The insertion, if any, preceding the constituent format-primary-list-
pack of a format-primary that is not a format-item is performed before
the first constituent format-item is used to control the transput of a
value. The insertion, if any, following that format-primary-list-pack is
performed after all constituent format-items have been used. }

5.5.1.1. Integral patterns

a) integral pattern : radix mould option, sign mould option,
   integral mould ; integral choice pattern.
b) radix mould : radix, letter r.
c) radix : digit two ; digit four ; digit eight ; digit one, digit zero ;
   digit one, digit six.
d) integral mould : loose replicatable suppressible digit frame sequence.
e) digit frame : zero frame ; letter d.
f) integral choice pattern : insertion option, letter c, literal list pack.
5.5.1.1. continued

{Examples:
  a) \texttt{2r6d30sd ; 12sd ; sd"-sd"-19"2d ;
      l20ko("mon","tues","wednes","thurs","fri","satur","sun") ;}
  b) \texttt{2r ;}
  c) \texttt{3 ; 4 ; 8 ; 10 ; 16 ;}
  d) \texttt{sd"-sd"-19"2d ;}
  f) \texttt{l20ko("mon","tues","wednes","thurs","fri","satur","sun")} 

{If the integral-pattern is not an integral-choice-pattern, then,
  i) on output, the value to be output is edited into a string and
     "transcribed onto" the file by, for all frames occurring in the
     pattern, first performing the preceding insertion, if any, and then
     outputting to the file (10.5.1.2.k) that part of the string specified
     by the frame;
  ii) on input, a string is "transcribed from" the file, which string is
      obtained by, for all frames occurring in the pattern, first
      performing the preceding insertion, if any, and then, for a frame
      that is not suppressed, inputting (10.5.1.2.j) from the file as many
      characters as are specified by the frame; that string is indited into
      a value;
  iii) finally, the insertion, if any, following the last constituent
      frame is performed.

  If the integral-pattern is an integral-choice-pattern, then the
  insertion, if any, preceding the letter-c is performed, and,
  i) on output, letting n stand for the integral value to be output, if
     n > 0 and the number of literals in the constituent literal-list-
     pack is at least n, then the n-th literal is written on the file;
     otherwise, the further elaboration is undefined;
  ii) on input, one of the constituent literals of the constituent literal-
      list-pack is required on the file; if the i-th constituent is the
      first one present, then the value is i; if none of these literals
      is present, then the further elaboration is undefined;
  iii) finally, the insertion, if any, following the constituent literal-
      list-pack is performed. }
5.5.1.2. Real patterns

a) real pattern : sign mould option, real mould ; floating point mould.
b) real mould : integral mould, loose suppressible point frame,
   integral mould option ;
   loose suppressible point frame, integral mould.
c) point frame : point symbol.
d) floating point mould :
   stagnant mould, loose suppressible exponent frame,
   sign mould option, integral mould.
e) stagnant mould : sign mould option, INTREAL mould.
f) exponent frame : letter e.

{Examples:
a) +12d ; +d.11de+2d ;
b) d.11d ; .12d ;
d) +d.11de+2d ;
e) +d.11d }

{On output, under control of a real-pattern, a real or integral value
is edited into a string and transcribed onto the file;
on input, a string is transcribed from the file and indited into a real
value.}

5.5.1.3. Boolean patterns

a) boolean pattern :
   insertion option, letter b, boolean choice mould option.
b) boolean choice mould :
   open symbol, literal, comma symbol, literal, close symbol.

{Examples:
a) l"result"lxb ; b("","error") ;
b) ("","error") }

{If the boolean-pattern does not contain a choice-mould, then the
effect of using the pattern is the same as if the letter-b were followed
by ("","").
The insertion, if any, preceding the letter-b is performed.
On output, if the truth value to be output is true, then the first
constituent literal of the constituent choice-mould is performed, and,
otherwise, the second;
5.5.1.3. continued

On input, one of the constituent literals of the constituent choice-mould is required on the file; if the first literal is present, then the value true is found; otherwise, if the second literal is present, then the value false is found; otherwise, the further elaboration is undefined.

Finally, the insertion, if any, following the constituent choice-mould is performed. }

5.5.1.4. Complex patterns

a) COMPLEX pattern :
   real pattern, loose suppressible complex frame, real pattern.

b) complex frame : letter l.

   {Example:
   a) \(2x+.12de+2d"+f"si+.10de+2d}\}

   {On output, the complex or real or integral value is edited into
   a string and transcribed onto the file; on input, a string is transcribed
   from the file and indited into a complex value. }

5.5.1.5. String patterns

a) STRING pattern :
   loose replicatable suppressible character frame sequence.

b) character frame : letter a.

   {Example:
   a) \(p"table_of^a10a}\}

   {On output, a given string is edited into a string and transcribed
   onto the file;
on input, a string is transcribed from the file and indited into a string.
If the value to be transput is a character, then a string having one
element is transput.
A string to be output must have as many elements as the number of
characters specified by the format-item. }

5.5.1.6. Transforms

a) structured with a STRING named ALEPH transformat :
   hip adapted unitary format expression.

   {Example: \((x\geq0|f5df|f5d^n"f)\}
5.5.1.6. continued

(For unitary-expressions see Chapter 8. )

(Transormats are used exclusively as actual-parameters of out (10.5.4.a) and in (10.5.5.a); for reasons of efficiency, the programmer has deliberately been made unable to use them elsewhere by the choice of 'ALEPH' (1.2.5.d).

Although transformats are not denotations at all, they are handled here because of their close connection to formats. )

5.5.2. Semantics

a) The format {2.2.3.4} possessed by a given format-denotation is the same sequence of symbols as the given format-denotation.

b) A given transformat is elaborated in the following steps:
   Step 1: It is preelaborated {1.1.6.f} ;
   Step 2: It is replaced by the format obtained in Step 1, and the thereby resulting format-denotation is considered ;
   Step 3: All constituent dynamic-replications {5.5.1.h} of the considered format-denotation are elaborated collaterally {6.3.2.a}, where the elaboration of a dynamic-replication is that of its constituent serial-expression;
   Step 4: Each of those dynamic-replications is replaced by that integral-denotation {5.1.1} which possesses the same value as that dynamic-replication if that value is positive, and, otherwise, by a digit-zero ;
   Step 5: That row-of-character-denotation {5.3} is considered which would be obtained by replacing, in the considered format-denotation as modified in Step 4, each constituent quote-symbol by a quote-image {5.3.1.c} and each formatter-symbol by a quote-symbol ;
   Step 6: A new instance of the value of the considered row-of-character-denotation is made to be the {only} field of a new instance of a structured value {2.2.3.2} whose mode is that obtained by deleting 'transformat' from that notion ending with 'transformat' of which the given transformat is a terminal production ;
   Step 7: The considered format-denotation is replaced by the given transformat, and that transformat is made to possess the structured value obtained in Step 6.
6. Phrases

6.0.1. Syntax

a) phrase: COERCETY SOME PHRASE.
b) clause: COERCETY SOME CLAUSE.
c) expression: COERCETY SOME MODE expression.
d) declaration: SOME declaration.
e) statement: SOME statement.
f) SOME phrase: COERCETY SOME PHRASE.
g) SOME clause: COERCETY SOME CLAUSE.
h) SOME expression: COERCETY SOME MODE expression.

6.0.2. Semantics

a) The elaboration of a phrase begins when it is initiated, it may be "interrupted", "halted" or "resumed", and it ends by being "terminated" or "completed", whereupon, if the phrase "appoints" a unitary-phrase as its successor, the elaboration of that unitary-phrase is initiated, except in the case mentioned in 7.0.2.a.

b) The elaboration of a phrase may be interrupted by an action (e.g. overflow) not specified by the phrase but taken by the computer if its limitations do not permit satisfactory elaboration. (Whether, after an interruption, the elaboration of the phrase is resumed, the elaboration of some unitary-phrase is initiated or the elaboration of the program ends, is not defined in this Report.)

c) The elaboration of a phrase may be halted (10.4.b), i.e. no further actions constituting the elaboration of that phrase take place until the elaboration of the phrase is resumed (10.4.a), if at all.
6.0.2. continued

d) A given clause is "protected" in the following steps:

Step 1: If an occurrence of an identifier (Indication) which is the same as some identifier (indication) occurring outside the given clause defines \{4.1.2.a\} (indication-defines \{4.2.2.a\}) within it, then the defining (indication-defining) occurrence and all occurrences identifying it are replaced by occurrences of one same identifier (indication) which does not occur elsewhere in the program and Step 1 is taken; otherwise, Step 2 is taken;

Step 2: If an occurrence of an indication which is the same as some indication occurring outside the given clause is operator-defined within it, then the operator-defining occurrence and all occurrences identifying it are replaced by occurrences of one same new indication which does not occur elsewhere in the program and Step 3 is taken; otherwise, the protection of the given clause is complete;

Step 3: If the indication is a priority-indication then Step 4 is taken; otherwise, Step 2 is taken;

Step 4: A copy is made of the priority-declaration containing that occurrence of the indication which is identified by that operator; the occurrence of that indication in the copy is replaced by an occurrence of that new indication; the copy, thus modified, preceded by an open-symbol and followed by a go-on-symbol, is inserted preceding the given clause, a close-symbol is inserted following the given clause, and Step 2 is taken.

{Clauses are protected in order to allow unhampered definitions of identifiers, indications and operators within ranges and to permit a meaningful call, within a range, of a procedure declared outside it.}

{What's in a name? that which we call a rose
By any other name would smell as sweet.
Romeo and Juliet, William Shakespeare.}
6.1. Serial phrases

6.1.1. Syntax

a) serial declaration:
   chain of unitary declarations separated by go on symbols.
b) COERCENCY serial CLAUSE : declaration prelude option,
   chain of COERCENCY CLAUSE trains separated by completers.
c) declaration prelude : serial declaration, go on symbol.
d) COERCENCY CLAUSE train : label sequence option,
   statement prelude option, COERCENCY unitary CLAUSE.
e) statement prelude:
   chain of unitary statements separated by sequencers, sequencer.
f) sequencer : go on symbol, label sequence option.
g) label : label identifier, label symbol.
h) completer : completion symbol, label.

{Examples:
  a) \texttt{real} \; x \; ; \texttt{real} \; y(1) \; ; \texttt{int} \; n = \texttt{abs} \; j \; ;  
  b) \; l : \texttt{true} \; ; \; l1 : l2 : x := a + 1 \; ; \; (x > 0 \; | \; l3 \; | \; x := 1 - x) \; ; \texttt{false}.
      \quad l3 : y := y + 1 \; ; \texttt{true} ;  
  c) \texttt{real} \; x \; ; \texttt{int} \; i \; ;  
  d) l1 : l2 : x := a + 1 \; ; (x > 0 \; | \; l3 \; | \; x := 1 - x) \; ; \texttt{false} ;  
  e) x := a + 1 \; ; (x > 0 \; | \; l3 \; | \; x := 1 - x) \; ;  
  f) \; ; \; l ;  
  g) l ;  
  h) \; . \; l3 ; )

{For unitary-phrases see 6.2 and Chapters 7 and 8. }

6.1.2. Semantics

a) The elaboration of a serial-declaration is initiated by initiating
the elaboration of its first constituent unitary-declaration.

b) The elaboration of a serial-clause is initiated by protecting it
{6.0.2.d} and then initiating the elaboration of its first constituent
unitary-phrase.
6.1.2. continued

c) The completion of the elaboration of a unitary-phrase preceding a
go-on-symbol initiates the elaboration of the first unitary-phrase
textually after that go-on-symbol.
d) The elaboration of a serial-phrase is
   i) interrupted (halted, resumed) upon the interruption (halting,
      resumption) of a constituent unitary-phrase;
   ii) terminated upon the termination of the elaboration of a constituent
       unitary-phrase appointing a successor outside the serial-phrase,
       and that successor \{6.2.2.a\} is appointed the successor of the
       serial-phrase.
e) The elaboration of a serial-declaration is completed upon the
   completion of the elaboration of its last constituent unitary-declaration.
f) The elaboration of a serial-clause is completed upon the completion
   of the elaboration of its last constituent unitary-clause or of that of
   a constituent unitary-clause preceding a completer.
g) The value of a serial-expression is the value of that constituent
   unitary-constituent the completion of whose elaboration completed the
   elaboration of the serial-expression, provided that the scope \{2.2.4.2\}
   of that value is larger than the serial-expression \{; otherwise, the
   value of the serial-expression is undefined\}.

   \{In y := (x := 1.2 ; 2.3), the value of the serial-expression
   x := 1.2 ; 2.3 is the real number possessed by 2.3. In
   xx := (real r(0.7) ; r), the value of the serial-expression real r(0.7) ; r
   is undefined since the scope of the name possessed by r is the serial-
   expression itself. \}

6.2. Unitary statements

6.2.1. Syntax

a) unitary statement : formary statement ; MODE confrontation.
b) formary statement : ADIC formula ; called ADIC formula ;
   NONPROC ADIC formula ; called NONPROC ADIC formula ; primary statement.
c) primary statement : CLOSED statement ; cohesive statement ;
   called cohesion ; called NONPROC cohesion.
d) cohesive statement : jump ; skip ; statement call ; NONPROC cohesion.
e) skip : skip symbol.
f) jump : go to symbol option, label identifier.
6.2.1. continued

{Examples:
 a) goto warsaw; \( x := x + 1 \);
 b) up \( i;\) \( x + y;\) stop;
 c) \( \langle x := 1, y := 0 \rangle; \langle x := 1, y := 0 \rangle;\) \( \langle p \mid x := 1 \mid y := 0 \rangle;\)
   goto grenoble; stop; random;
 d) kootwijk; skip; setrandom \( x\); det(y2, i1); \( x;\)
 e) skip;
 f) goto amsterdam; zandvoort }
6.3.1. continued

{Examples:

a) \((\text{real } x, \text{real } y)\); (and, by 9.2.c, d) \text{real } x, y;

b) \((x := 0, y := 1)\); \((x := 0, y := 1, z := 2)\);

c) \((x, n); (1, 2.3, 4.5)\)

{For unitary-phrases see 6.2 and Chapters 7 and 8.}

6.3.2. Semantics

a) If a number of constituents of a given terminal production of a notion are "elaborated collaterally", then this elaboration is the collateral action \((2.2.5)\) consisting of the (merged) elaborations of these constituents, and is:

i) initiated by initiating the elaboration of each of these constituents;

ii) interrupted upon the interruption of the elaboration of any of these constituents;

iii) completed upon the completion of the elaboration of all of these constituents; and

iv) terminated upon the termination of the elaboration of any of these constituents, and if that constituent appoints a successor, then this is the successor of the given terminal production.

b) A collateral-phrase is elaborated in the following steps, where "\(m\)" stands for the number of its constituent unitary-phrases:

Step 1: Its constituent unitary-phrases are elaborated collaterally \((a)\);

if it is an expression, then Step 2 is taken; otherwise, its elaboration is complete;

Step 2: If the values of the constituent unitary-expressions of the collateral-expression are names \((2.2.3.5)\) one or more of which refers to an element or subvalue of a multiple value having one or more states \((2.2.3.3.b)\) equal to zero, or if the values of those unitary-expressions are multiple values \((2.2.3.3)\) not all of whose corresponding upper (lower) bounds are equal, then the further elaboration is undefined; otherwise, Step 3 is taken;
6.3.2. continued

Step 3: The value of the collateral-expression is a new instance of a
multiple value whose mode is that obtained by deleting 'collateral',
'expression' and the terminal production of 'COERCETY' from {the notion
which is} that direct production of 'collateral expression' of which
the given collateral-expression is a terminal production; this new
multiple value is established as follows:

if

the values obtained in Step 1 are not multiple values
then

its element with index "i" is a new instance of the value of the
i-th constituent unitary-expression and its descriptor consists of an
offset 1 and one quintuple (1, m, 1, 1, 1);

otherwise, those values are multiple values and the elements with
indices (i-1) x r + j, j = 1, ..., r of the new value, where r stands
for the number of elements in one of those values, are the elements of
the value of the i-th constituent unitary-expression and the descriptor
of the new value is a copy of the descriptor of the value of one of
the constituent unitary-expressions in which an additional quintuple
(1, m, r, 1, 1) has been inserted in front of the old first quintuple,
the offset has been set to 1, d_n has been set to 1, and, for
i = n, n - 1, ..., 2, the stride d_i-1 has been set to (u_i - l_i + 1) x d_i.

{The presence of a parallel-symbol makes it possible to control the
progress of the elaborations of the constituent unitary-phrases by means
of the synchronization operations of 10.4. }

6.4. Closed phrases

6.4.1. Syntax

a) COERCETY closed PHRASE :

  elementary symbol option, open, COERCETY serial PHRASE, close.

{Examples:

a) (real x = u) ; elem begin i := i + 1 ; j := j + 1 end increment }

{For serial-phrases see 6.1 and for opens and closes see 3.0.6.b, c. }
6.4.2. Semantics

a) The elaboration of a closed-phrase is that of its constituent serial-phrase.
b) The value of a closed-expression is that, if any, of its constituent serial-expression.
c) The elaboration of a closed-phrase which begins with an elementary-symbol is an elementary action \(2.2.5\).

6.5. Conditional clauses

6.5.1. Syntax

a) \texttt{COERCETY conditional CLAUSE :}
   
   \texttt{if symbol, COERCETY choice CLAUSE, fi symbol.}

b) \texttt{COERCETY choice CLAUSE :}
   
   \texttt{condition, COERCETY then CLAUSE, COERCETY else CLAUSE option.}

c) condition : fitted serial boolean expression.
d) \texttt{COERCETY THEELSE CLAUSE : THEELSE symbol, COERCETY serial CLAUSE.}

{Examples:}
a) \((x > 0 \mid x \mid 0)\) ("adapted" in \(y := (x > 0 \mid x \mid 0)\) ;
   \texttt{if overflow then exit fi ;}

b) \(x > 0 \mid x \mid 0 ; overflow \texttt{then exit ;}

b) \texttt{x > 0 ; overflow ;}
d) \(\{ x ; \mid 0 ; \texttt{then exit}\}

{For serial-clauses see 6.1.1.b.}

6.5.2. Semantics

a) A conditional-clause is elaborated in the following steps:

Step 1: Its constituent condition is elaborated ;

Step 2: If the value of that condition is true, then its constituent then-clause and otherwise its constituent else-clause, if any, is considered ;

Step 3: The clause following the then-symbol or else-symbol of the considered clause, if any, is elaborated ;

Step 4: If the conditional-clause is a conditional-expression, then its value is that of the clause elaborated in Step 3, if any; otherwise, its value is undefined.
6.5.2. continued

b) The elaboration of a conditional-clause is
i) interrupted (halted, resumed) upon the interruption (halting, resumption) of the elaboration of the condition or the considered clause;
ii) completed upon the completion of the elaboration of the considered clause, if any; otherwise, completed upon the completion of the elaboration of the condition; and
iii) terminated upon the termination of the elaboration of the condition or considered clause, and, if one of these appoints a successor, then this is the successor of the conditional-clause.
7. Unitary declarations

7.0.1. Syntax

a) unitary declaration : mode declaration ;
   priority declaration ; identity declaration ;
   operation declaration ; closed declaration ; collateral declaration.

   {Examples:
   a) mode bits = [1 : bits width] bool ;
      priority plus = 1 ;
      int m = 4096 ; real x ; bool complete(false) ;
      proc sgn = (real x) int : (x = 0 | 1 | sign x) ;
      op * = (real a, b) int : (round a * round b) ;
              (real x = u) ; real x, y }

7.0.2. Semantics

a) If, during the elaboration of an expression contained within a unitary-
   declaration, a jump is elaborated {6.2.2.a} whose successor is a unitary-
   clause outside that declaration but within the smallest range
   containing it, then the further elaboration is undefined.

b) An external object {2.2.1} which was caused to possess a value
   by the elaboration of a declaration ceases to possess that value
   upon termination or completion of the elaboration of the smallest range
   containing that declaration.

   {For mode-declarations see 7.2, for priority-declarations see 7.3,
   for identity-declarations see 7.4, for operation-declarations see 7.5,
   for closed-declarations see 6.3 and for collateral-declarations see 6.3.}
   {The elaboration of the closed-expression
      begin[1 : (go to e ; 5)] int a ; e : a[1] := 1 end
   is undefined, according to a. }
7.1. Declarers

7.1.1. Syntax

a) * declarer : VICTAL MODE declarer.
   b) VICTAL MODE declarer :
       VICTAL MODE declarator ; MODE mode indication.
   c) VICTAL PRIMITIVE declarator : PRIMITIVE symbol.
   d) VICTAL long INTREAL declarator :
       long symbol, VICTAL INTREAL declarator.

   {Examples:
   b) real ; bits ;
   c) int ; real ; bool ; char ; format ;
   d) long int ; long long real }

   e) VIRACT structured with FIELDS declarator :
       structure symbol, VIRACT FIELDS declarator pack.
   f) VIRACT FIELDS and a FIELD declarator :
       VIRACT FIELDS declarator, comma symbol, VIRACT FIELD declarator.
   g) VIRACT MODE named TAG declarator :
       VIRACT MODE declarer, MODE named TAG selector.
   h) MODE named TAG selector : TAG.
   i) * field SELECTOR : FIELD SELECTOR ; VIRACT FIELD SELECTOR.

   {Examples:
   e) struct (string name, real value) ;
   f) string name, real value ;
   g) string name ;
   h) name } 

   j) virtual reference to MODE declarator :
       reference to symbol, virtual MODE declarer.
   k) actual reference to MODE declarator : 
       reference to symbol, virtual MODE declarer.
   l) formal reference to NONREF declarator :
       reference to symbol, formal NONREF declarer.
   m) formal reference to reference to MODE declarator :
       reference to symbol, virtual reference to MODE declarer.
7.1.1. continued

(Examples:

j) ref [] real ;
k) ref [] real ;
l) ref[1 : int n] real ;
m) ref ref [] real }

n) VICTAL ROWS NONROW declarator : sub symbol, VICTAL ROWS rower,
    bus symbol, virtual NONROW declarer.

o) VICTAL row of ROWS rower :
    VICTAL row of rower option, comma symbol, VICTAL ROWS rower.

p) VICTAL row of rower :
    VICTAL lower bound, up to symbol, VICTAL upper bound.

q) formal LOWPER bound :
    flexible LOWPER bound ; strict LOWPER bound ; virtual LOWPER bound.

r) actual LOWPER bound : strict LOWPER bound ; virtual LOWPER bound.

s) virtual LOWPER bound : EMPTY.

t) strict LOWPER bound : hip fitted integral formary.

u) flexible LOWPER bound : integral symbol, integral identifier.

(Examples:

n) [1 : m, 1 : n] real ;

o) 1 : m, 1 : n ; , 1 : n ;

p) 1 : m

q) int n ; i + j ;

r) i + j ;

t) i + j ;

u) int n )

v) VICTAL PROCEDURE declarator : procedure symbol, PROCEDURE tail.

w) procedure tail : EMPTY.

x) procedure with PARAMETERS tail : virtual PARAMETERS pack.

y) virtual MODE parameter : virtual MODE declarer.

z) procedure PARAMETRY delivering a MODE tail :
    procedure PARAMETRY tail, virtual MODE declarer.
7.1.1. continued 2

(Examples:
\[\text{v)} \quad \text{proc} \ ; \ \text{proc}(\text{real, int}) \ ; \ \text{proc}(\text{real, int}) \ \text{bool} \ ;\]
\[\text{w)} \ ;\]
\[\text{x)} \ (\text{real, int}) \ ;\]
\[\text{y)} \ \text{real} \ ;\]
\[\text{z)} \ (\text{real, int}) \ \text{bool} \ ]\}

\[\text{aa)} \ \text{VICTAL union of MODES mode declarator} : \]
\[\text{union of symbol, virtual MODES declarer pack.} \]

\[\text{ab)} \ \text{virtual MODES and MODE declarer} : \]
\[\text{virtual MODES declarer, comma symbol, virtual MODE declarer}. \]

(Examples:
\[\text{aa)} \ \text{union}(\text{int, bool}) ;\]
\[\text{ab)} \ \text{int, bool} \ ]\}

{Rule g, together with 1.2.1.k, l, m, n, o, p and 4.1.1.c, d, leads to an infinity of production rules of the strict language, thereby enabling the Syntax to "transfer" the field-selectors (i) into the mode of structured values, and making it ungrammatical to use an "unknown" field-selector in a field-selection (8.6). Concerning the occurrence of a given field-selector more than once in a declarer, see 4.4.2, which implies that \(\text{struct(real x, int x)}\) is not a (correct) declarer, whereas \(\text{struct(real x, struct(int x, bool p)p)}\) is.

Notice, however, that the use of a given field-selector in two different declarers within a given range does not cause any ambiguity. Thus,
\[\text{mode cell} = \text{struct(string name, ref cell next )} \quad \text{and} \]
\[\text{mode link} = \text{struct(ref link next, ref cell value)} \]
may both be present in some range.

Rules j, k, l and m imply that, for instance, \(\text{ref}[l : \text{int n}] \ \text{real x}\) may be a formal-parameter (5.4.1.e), whereas \(\text{ref ref}[l : \text{int n}] \ \text{real x}\) may not. }
7.1.2. Semantics

a) A given declarer specifies that mode which is obtained by deleting 'declarer' and the terminal production of the metanotion 'VICTAL' from that direct production {1.2.2.b} of the notion 'declarer' of which the given declarer is a production.

b) A given declarer is "developed" as follows:
Step: If it is, or contains, a mode-indication which is either an actual-declarer not preceded by a reference-to-symbol, or a formal-declarer not preceded by two reference-to-symbols, then that indication is replaced by a copy of the constituent actual-declarer of that mode-declaration {7.2} which contains its indication-defining occurrence {4.2.2.b}, and the Step is taken again; otherwise, the development of the declarer is complete.

(A declarer is developed during the elaboration of an actual-declarer (c) or identity-declaration (7.4.2. Step 1). The exceptions concerning reference-to-symbols are made in order that the development of the actual-declarer in constructions like

\[
\text{struct person} = (\text{int age}, \text{ref person father})
\]

may be finite. }

c) A given actual-declarer is elaborated in the following steps:
Step 1: It is developed {b} ;
Step 2: If it now begins with a structure-symbol, then Step 4 is taken; otherwise, if it now begins with a sub-symbol, then Step 5 is taken; otherwise, if it now begins with a union-of-symbol, then Step 3 is taken; otherwise, a new instance of a value of the mode specified (a) by the given actual-declarer is considered, and Step 8 is taken ;
Step 3: Some mode is considered which does not begin with 'union of' and from which the mode specified by the given actual-declarer is united {2.2.4.1.h}, a new instance of a value of the considered mode is considered, and Step 8 is taken ;
Step 4: All its constituent actual-declarers are elaborated collaterally {6.3.2.a}; the values referred to by the values (names) of these actual-declarers are made, in the given order, to be the fields of a new instance of a structured value of the mode specified by the given actual-declarer, this structured value is considered, and Step 8 is taken ;
7.1.2. continued

Step 5: All its constituent strict-lower-bounds and strict-upper-bounds are elaborated collaterally;

Step 6: A descriptor \{2.2.3.3\} is established consisting of an offset 1 and as many quintuples as there are constituent actual-row-of-rowers in the given declarer; if the i-th of these actual-row-of-rowers contains a constituent strict-lower-bound (strict-upper-bound), then \( l_i(u_i) \) is set equal to its value and \( s_i(t_i) \) to 1, and otherwise \( s_i(t_i) \) is set to 0 (and \( l_i(u_i) \) is undefined);

Step 7: The descriptor is made to be the descriptor of a multiple value of the mode specified by the given actual-declarer; each of its elements is a new instance of some value of some mode \{not beginning with 'union of' and\} such that the mode specified by the last constituent virtual-declarer is or is united from \{2.2.4.1.h\} it;

this multiple value is considered;

Step 8: A name \{2.2.3.5\} different from all other names and whose mode is 'reference to' followed by the mode specified by the actual-declarer, is created and made to refer to the considered value; this name is then the value of the given actual-declarer upon the completion, if any, of its elaboration.

7.2. Mode declarations

7.2.1. Syntax

a) mode declaration : mode symbol, MODE mode indication, equals symbol, actual MODE declarer.

{Examples:
  a) mode bits = [1 : bits width] bool;
     struct compl = (real re, im) (see 9.2.b, c.);
     union primitive = (int, real, bool, char, format) (see 9.2b)
}

7.2.2. Semantics

The elaboration of a mode-declaration involves no action.

{See 4.4.2. concerning certain mode-declarations which are not contained in proper programs.}
7.3. Priority declarations

7.3.1. Syntax

a) priority declaration : priority symbol, priority NUMBER indication, equals symbol, NUMBER token.
b) one token : digit one symbol.
c) TWO token : digit two symbol.
d) THREE token : digit three symbol.
e) FOUR token : digit four symbol.
f) FIVE token : digit five symbol.
g) SIX token : digit six symbol.
h) SEVEN token : digit seven symbol.
i) EIGHT token : digit eight symbol.
j) NINE token : digit nine symbol.

(Example:
a) priority += 6 }

7.3.2. Semantics

The elaboration of a priority-declaration involves no action.

(For a summary of the standard priority-declarations, see the remarks in 8.1.2.)

7.4. Identity declarations

7.4.1. Syntax

a) identity declaration :
formal MODE parameter, equals symbol, actual MODE parameter.
b) actual MODE parameter : MODE transformat ;
    hip adapted unitary MODE expression ; local MODE generator.

(Examples:
a) \texttt{real } e = 2.718281828459045 \ ; \texttt{int } e = \texttt{abs } i ; \texttt{real } d = \texttt{re}(z \times \texttt{conj} \ z) ; \texttt{real } a[l] = a[\ , \ :k] ; \texttt{ref real } x[k] = x[k] ; \texttt{compl } \texttt{unit} = 1 ; \texttt{proc int } time = \texttt{a} \texttt{lock} + \texttt{cycles} ;
(The following declarations are given first without, and then with, the extensions of 9.2.)
7.4.1. continued

```
ref real x = loc real ; real x ;
ref int sum = loc int (0) ; int sum (0) ;
ref i real a = loc [1:m, 1:n] real (a2) ; [1:m, 1:n] real a(x2) ;
proc(real) real vers = (real x) real : (1 - cos(x)) ;
proc vers = (real x) real : (1 - cos(x)) ;
ref proc(real) real p = loc proc(real) real ; proc(real) real p ;
ref proc(real) real q = loc proc(real) real ((real x) real : (x > 0 | x | 1)) ;
proc q((real x) real : (x > 0 | x | 1)) ;
```

b) \[ \text{loc real } \]

(For formal-parameters see 5.4.1.e, for hip-adapted-unitary-expressions see 8.0.1.a, for local-generators see 8.5.1.b and for transformats see 5.5.1.6.)

7.4.2. Semantics

An identity-declaration is elaborated in the following steps:

Step 1: Its textually first constituent formal-declarer {in the formal-parameter} is developed {7.1.2.b} ;

Step 2: Its textually last constituent actual-parameter, and all strict-lower-bounds and strict-upper-bounds contained in that formal-declarer, as possibly modified by Step 1, but not contained in any constituent strict-lower-bound or strict-upper-bound of that formal-declarer, are elaborated collaterally {6.3.2.a} ;

Step 3: If the value of that actual-parameter refers to an element or subvalue of a multiple value \{2.2.3.3\} having one or more states equal to 0, then the further elaboration is undefined ;

Step 4: Each defining occurrence \{4.1.2.a\}, if any, of an identifier in a constituent flexible-lower-bound or flexible-upper-bound of that formal-declarer is made to possess a new instance of the value of the corresponding bound in the \{multiple\} value of that actual-parameter ;

Step 5: If the value of any constituent strict-lower-bound or strict-upper-bound, or the value of any identifier \{8.3.2.a\} in a constituent flexible-lower-bound or flexible-upper-bound of that formal-declarer is not the same as that of the corresponding bound in the value of that actual-parameter, then the further elaboration is undefined; otherwise, the identifier following that formal-declarer is made to possess a new instance of the value of that actual-parameter.
7.4.2. continued

According to Step 5, the elaboration of the declaration

\[ [1 : 2] \, \text{real} \, x = (1.2, 3.4, 5.6) \]

is undefined, as is that of

\[ [1 : \text{int} \, n, \, 1 : \text{int} \, n] \, \text{real} \, x = ((1.1, 1.2), (2.1, 2.2), (3.1, 3.2)) \].

7.5. Operation declarations

7.5.1. Syntax

a) operation declaration:

OPERATIVE caption, equals symbol, actual OPERATIVE parameter.

b) OPERATIVE caption:

operation symbol, OPERATIVE tail, OPERATIVE ADIC operator.

(Examples:

a) \( \text{op} \, \text{abe} = (\text{real} \, a) \, \text{real} : (a < 0 \mid -a \mid a) \) (see 9.2.f) ;

\( \text{op} \, \land = (\text{bool} \, a, b) \, \text{bool} : (a \mid b \mid \text{false}) \) ;

b) \( \text{op} \, (\text{real}) \, \text{real} \, \text{abe} ; \, \text{op} (\text{bool}, \, \text{bool}) \, \text{bool} \, \land \)

(For actual-parameters see 7.4.1.b, for tails see 7.1.1.w, \( x, z \) and for operators see 4.3.)

7.5.2. Semantics

An operation-declaration is elaborated in the following steps:
Step 1: Its constituent expression is elaborated ;
Step 2: The operator preceding its constituent equals-symbol is made to possess the \{routine which is the\} value obtained in Step 1.

(The formula (8.1) \( p \, \land \, q \), where \( \land \) identifies the operator-defining occurrence of \( \land \) in the operation-declaration

\( \text{op} \, \land = (\text{bool} \, \text{john}, \, \text{proc} \, \text{bool} \, \text{mccarthy}) \, \text{bool} : (\text{john} \mid \text{mccarthy} \mid \text{false}) \), possesses the same value as it would if \( \land \) identified the operator-defining occurrence of \( \land \) in the operation-declaration

\( \text{op} \, \land = (\text{bool} \, a, b) \, \text{bool} : (a \mid b \mid \text{false}) \),

except, possibly, when the elaboration of \( q \) involves side effects on that of \( p \).)
8. Unitary expressions

8.0.1. Syntax

a) COERCETY unitary MODE expression :
   COERCETY MODE formary ; COERCETY MODE confrontation.
b) COERCETY MODE formary :
   COERCETY MODE ADIC formula ; COERCETY MODE primary.
c) hip FORCED MODE ADIC formula : FORCED MODE ADIC formula.
d) hip FORCED MODE confrontation : FORCED MODE ADIC formula.
e) MODE confrontation : MODE assignment ;
   MODE conformity relation ; MODE identity relation.

   (Examples:
   a) \( k + 1 ; x := 3.14 ; \)
b) \( k + 1 ; x ; \text{nil} \); 
c) \( i + j \) (in \( x := i + j \)); 
e) \( x := 3.14 ; e \to e \) (see 11.11.q) ; \( \text{val} xx := x \text{ or } y \)

   (For formulas see 8.1, for primaries see 8.3, for assignments see 8.8,
   for conformity-relations see 8.9 and for identity-relations see 8.10.
   )

8.1. Formulas

8.1.1. Syntax

a)* COERCETY formula : COERCETY ADIC formula DELIVETY.
b) MODE ADIC formula : ADIC formula delivering a MODE.
c) PRIORITY formula DELIVETY : LMODE PRIORITY operand, procedure with a
   LMODE parameter and a RMODE parameter DELIVETY PRIORITY operator,
   RMODE PRIORITY plus one operand.
d)* operand : MODE ADIC operand.
e) MODE PRIORITY operand :
   adjusted MODE PRIORITY formula ; MODE PRIORITY plus one operand.
f) MODE priority NINE plus one operand : MODE monadic operand.
g) MODE monadic operand :
   adjusted MODE monadic formula ; hip adjusted MODE primary.
h) monadic formula DELIVETY : dep DELIVETY ; procedure with a RMODE
   parameter DELIVETY monadic operator, RMODE monadic operand.
i) dep delivering a MODE :
   value of symbol, peeled reference to MODE monadic formula ;
   value of symbol, hip peeled reference to MODE primary.
j)* depression : dep DELIVETY.
8.1.1. continued

{Examples:
 c) \( x + y \); \( a + b \downarrow -2 \); (priority 6, 6)
 e) \( b \times (a > 0 \mid a \mid \text{goto exit}) \); \( b \downarrow -2 \); (priority 7, 8)
 f) 2;
 g) \( (a > 0 \mid a \mid \text{goto exit}) \); 2;
 h) \text{val xx} \; -2;
 i) \text{val xx}
}

{For adjusted-formulas see 8.2.0.1.d, for hip-adjusted-primaries and peeled-primaries see 8.3.1.a and for peeled-formulas see 8.2.1.1.e.}

8.1.2. Semantics

a) A formula other than a depression is elaborated in the following steps:
 Step 1: The formula is replaced by a copy of the routine possessed by the constituent operator at its operator-defining occurrence \{7.5.2, 4.3.2.b\};
 Step 2: The copy (which is now a closed-expression) is protected \{6.0.2.d\};
 Step 3: The skip-symbol \{5.4.2.ii\} following the equals-symbol following the textually first constituent formal-parameter of the copy is replaced by a copy of the textually first constituent operand of the formula, and if the constituent operator is not a monadic-operator then the skip-symbol following the equals-symbol following the textually second constituent formal-parameter of the copy is replaced by a copy of the textually second constituent operand of the formula;
 Step 4: The elaboration of the copy is initiated; if this elaboration is completed or terminated then the copy is replaced by the formula before the elaboration of a successor is initiated.

b) A depression is elaborated in the following steps:
 Step 1: Its constituent peeled-formula or hip-peeled-primary is elaborated;
 Step 2: The value of the depression is a new instance of the value referred to by the name obtained in Step 1.
8.1.2. continued

(The following table summarizes the operator-tokens as declared in the standard-declarations (10.2.0).

<table>
<thead>
<tr>
<th>priority</th>
<th>monadic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>minus</td>
<td>(\lor) (\land) (=) (&lt;) (-) (-\times) (\wedge) (-) (+) (\uparrow)</td>
</tr>
<tr>
<td>plus</td>
<td>(\neq) (\leq) (+) (\div)</td>
</tr>
<tr>
<td>times</td>
<td>(\leq) (\div)</td>
</tr>
<tr>
<td>over</td>
<td>(\geq) (\div)</td>
</tr>
<tr>
<td>modb</td>
<td>(\times) (\div)</td>
</tr>
<tr>
<td>prue</td>
<td></td>
</tr>
<tr>
<td>abs</td>
<td>bin</td>
</tr>
<tr>
<td>repr</td>
<td>leng</td>
</tr>
<tr>
<td>odd</td>
<td>sign</td>
</tr>
<tr>
<td>round</td>
<td>enter</td>
</tr>
<tr>
<td>re</td>
<td>im</td>
</tr>
</tbody>
</table>

Observe that the value of \((-7 \times 2 + 4 = 5)\) and that of \((4 - 7 \div 2 = 3)\) both are true, since the first minus-symbol is a monadic-operator whereas the second is dyadic.

Although the Syntax defines the order in which formulas are elaborated, parentheses may well be used to improve readability; e.g. 
\[(a \land b) \lor (\neg a \land \neg b)\] instead of \(a \land b \lor \neg a \land \neg b\).

8.2. Coercends

8.2.0.1. Syntax

a)\* coerced :: FORCETYPE COERCEND.

b)\* FORCED coerced :: FORCED COERCEND.

c) adapted COERCEND :

\(\) adjusted COERCEND ; widened COERCEND ; arrayed COERCEND.

d) adjusted COERCEND :

\(\) fitted COERCEND ; expressed COERCEND ; united COERCEND.

e) fitted COERCEND : COERCEND ; called COERCEND ; depressed COERCEND.
8.2.0.1. continued

{Examples:
c) \( m ; n := m ; x := n := m \) (in \( \textit{real} \) \( x \) \( = (x := n := m) \) )
d) \( x ; x ; x \) (in \( \textit{union} (\textit{bool}, \textit{proc} \textit{real}) bpr = x \) )
e) \( 3.14 \) \( + \) \( \textit{random} \) \( ; x \) (in \( 3.14 + \text{random} + x \) )

{For called-coercends see 8.2.1, for expressed-coercends see 8.2.2, for depressed-coercends see 8.2.3, for united-coercends see 8.2.4, for widened-coercends see 8.2.5 and for arrayed-coercends see 8.2.6.}

(The coercion process may be illustrated by considering the analysis of \( \textit{random} \) in \( \textit{random} + x \). According to 10.2.3.i, 10.2.0.a and 8.1.1.b, \( \textit{random} + x \) is a real-priority-SIX-formula and \( \textit{random} \) must therefore be a real-priority-SIX-operand, which may be produced as a procedure-delivering-a-real-identifier (see 10.3.k and 7.4.1.a.) as follows:
real-priority-SIX-operand,
real-priority-SEVEN-operand (8.1.1.c),
real-priority-EIGHT-operand (8.1.1.c),
real-priority-NINE-operand (8.1.1.c),
real-priority-NINE-plus-one-operand (8.1.1.c),
real-monadic-operand (8.1.1.d),
hlp-adjusted-real-primary (8.1.1.e),
hlp-adjusted-real-cohesion (8.3.1.a),
adjusted-real-cohesion (8.3.1.c),
fitted-real-cohesion (8.2.0.1.d),
called-real-cohesion (8.2.0.1.e),
fitted-procedure-delivering-a-real-cohesion (8.2.1.1.b),
procedure-delivering-a-real-cohesion (8.2.0.1.e),
procedure-delivering-a-real-identifier (8.3.1.c).
A coercion is derived from the context and is passed on by the Syntax until it meets a coercend (i.e., formula, cohesion or confrontation), where it is activated (i.e., stripped, called, expressed, depressed, united, widened or arrayed). In the above example, the coercion was activated by a called-cohesion which resulted in an unaccompanied-call (8.2.1). The relevant Semantics appears in 8.2.1.2, where it is explained that the routine denoted by \( \textit{random} \) must be elaborated and deliver a real value as the value of the left operand of the operator \(+\).}
8.2.1. Unaccompanied calls

8.2.1.1. Syntax

a) unaccompanied call : called COERCEND ; stripped COERCEND.
b) called MODE FORM : fitted procedure delivering a MODE FORM.
c) called FORM : fitted procedure FORM.
d) stripped COERCEND : peeled procedure delivering a COERCEND.
e) peeled COERCEND : COERCEND ; stripped COERCEND.

{Examples:
b) random (in random < .5) ;
c) stop (in ; stop ;) ;
d) x or y (in x or y := a) ;
e) x ; x or y (in x :=: x or y) }

8.2.1.2. Semantics

An unaccompanied-call is elaborated in the following steps:
Step 1: It is preelaborated 1.1.6.f and a copy is made of {the routine
which is} the resulting value ;
Step 2: The unaccompanied-call is replaced by the copy obtained in Step 1,
and the elaboration of the copy is initiated; if this elaboration is
completed or terminated, then the copy is replaced by the unaccompanied-
call before the elaboration of a successor is initiated.
{See also 8.7.2, accompanied-calls. }

8.2.2. Expressed coercends

8.2.2.1. Syntax

a) expressed procedure delivering a COERCEND :

   COERCEND ; hip expressed COERCEND ; depressed COERCEND.
b) expressed procedure cohesion : cohesive statement.

{Examples:
a) 2 \times random - 1 \text{ (in proc real r1(2 \times random - 1)) ;}
b) sandvoort \text{ (in proc go to = sandvoort)} } {\text{ (For cohesive-statements see 6.2.1.d. )}

8.2.2.2. Semantics

An expressed-coercend is elaborated in the following steps:
Step 1: A copy is made of it {itself, not its value} ;
8.2.2.2. continued

Step 2: That routine (5.4.2) which is obtained from the copy by placing an open-symbol before it and a close-symbol after it is the value of the expressed-coercend; its mode is that obtained by deleting 'expressed' and the terminal production of 'FORM' from that notion as terminal production of which the expressed-coercend is elaborated.

[If e1, e2 and e3 are label-identifiers, then the reader might recognise the effect of the declaration []
[] proc switch = (e1, e2, e3)
and the unitary-statement switch[i] ;
however, the declaration [1:3]
[] proc switch(e1, e2, e3)
is perhaps more powerful, since the assignation switch[2] := e1.
is possible.
The elaboration of real expr(p | x | ¬x) yields the routine ((p | x | ¬x)), whereas that of the expressed-coercend (p | x | ¬x) yields either (x) or (¬x), depending on the value of p. Similarly, the elaboration of
real expr(¬x := x + 1 ; y) yields the routine ((x := x + 1 ; y)), whereas that of the expressed-coercend (x := x + 1 ; y) yields, apart from a change in the value of x, the routine (y). On the other hand, if C stands for e.g. a formula (8.1) or cohesion (8.3.1.b), then the elaboration of
real expr C and that of the expressed-coercend C both yield the routine (C).
]

8.2.3. Depressed coercends

"I ca'n't go no lower", said the Hatter, "I'm on the floor as it is".
Alice's Adventures in Wonderland,
Lewis Carroll.

8.2.3.1. Syntax

a) depressed COERCEND : fitted reference to COERCEND.

{Example:
a) x (in x + 2) }

8.2.3.2. Semantics

A depressed-coercend is elaborated in the following steps:
Step 1: It is preelaborated {} ;
Step 2: The value of the depressed-coercend is a new instance of the value referred to by the name obtained in Step 1.
8.2.4. United coercends

8.2.4.1. Syntax

a) united union of LMODESETY MODE RMODESETY mode FORM : adjusted MODE FORM.

{Examples:
a) one (in \( f + one \), see 11.11.bb) ; b (in \( b + x \), ibid.) ;
call (fdash, g) (in 11.11.af) }

{In a range containing
union \( \text{ib} \) = (int, bool) ; \( \text{rb} \) = (real, bool) ;
union \( \text{rib} \) = (real, \( \text{ib} \));
as declarations,
\( \text{ib} \) \( \text{ib}1(1) \), \( \text{ib}2(\text{true}) \) ; \( \text{rb} \) \( \text{rb}1(\text{true}) \);
\( \text{rib} \) \( \text{rib}1(1) \), \( \text{rib}2(\text{ib}2) \), \( \text{rib}3(1.5) \), \( \text{rib}4(p \mid 1 \mid \text{true}) \)
are initialised declarations, but
\( \text{rib} \) \( \text{rib}5(\text{rb}) \)
is not. }

8.2.5. Widened coercends

8.2.5.1. Syntax

a) widened LONGSETY real FORM : fitted LONGSETY integral FORM.
b) widened structured with a REAL named letter \( r \) letter \( e \) and a REAL
named letter \( i \) letter \( m \) FORM : fitted REAL FORM ; widened REAL FORM.

{Examples:
a, \( b \) \( j \) (in \( \text{compl}(1) \)) }

8.2.5.2. Semantics

A widened-coercend is elaborated in the following steps:
Step 1: It is preelaborated \( \{1.1.6.f\} \);
Step 2: If the value yielded by Step 1 is an integer, then the value of
the widened-coercend is a new instance of that real number which is
equivalent to that integer \( \{2.2.3.1.d\} \); otherwise, it is a new instance
of that structured \( \{\text{complex }(10.2.5)\} \) value composed of two fields,
whose field-selectors are letter-\( r \)-letter-\( e \) and letter-\( i \)-letter-\( m \), whose
modes are the same as that of the value yielded in Step 1 and which
are new instances of that value and zero respectively; its mode is that
obtained by deleting 'widened' and the terminal production of 'FORM'
from that notion as terminal production of which the widened-coercend
is elaborated.
8.2.6. Arrayed coercends

8.2.6.1. Syntax

a) arrayed REFETY row of MODE confrontation:
   adapted REFETY MODE confrontation.

b) arrayed REFETY row of MODE ADIC formula:
   adapted REFETY MODE ADIC formula.

c) arrayed REFETY row of MODE cohesion: adapted REFETY MODE cohesion option.

   (Examples:
   a) \( x := 3.74 \) (in \([1 : \text{ int } n]\) \texttt{real} \( a = x := 3.74 \)) ;
   b) \( x + y \) (in \([1 : \text{ int } n]\) \texttt{real} \( a = x + y \)) ;
   c) ; 1.2 ; (3.4, 5.6)
   (in \([1 : \text{ int } m, 1 : \text{ int } n]\) \texttt{real} \( x1 = \texttt{case } i \texttt{ in } 1.2, (3.4, 5.6) \texttt{ esac}\)

8.2.6.2. Semantics

An arrayed-coercend is elaborated in the following steps:

Step 1: If it is not empty, then it is preelaborated, and Step 3 is taken ;

Step 2: A new instance of a multiple value \([2.2.3.3]\) composed of zero elements and a descriptor consisting of an offset 1 and one quintuple \((1, 0, 1, 1, 1)\) is considered, and Step 6 is taken ;

Step 3: If the value obtained in Step 1 is a name, then the value referred to by this name, and, otherwise, the value itself obtained in Step 1 is considered; if the considered value is a multiple value, then Step 5 is taken ;

Step 4: A new instance of a multiple value composed of the considered value as only element, and a descriptor consisting of an offset 1 and one quintuple \((1, 1, 1, 1, 1)\) is considered instead, and Step 6 is taken ;

Step 5: A new instance of a multiple value is created, composed of the elements of the considered value and a descriptor which is a copy of the descriptor of the considered value into which the additional quintuple \((1, 1, 1, 1, 1)\) (the value of the stride is irrelevant) is inserted before the first quintuple, and in which all states have been set to 1, and this new multiple value is considered instead ;
8.2.6.2. continued

Step 6: The mode of the considered value is that obtained by deleting 'arrayed', the initial 'reference to', if any, and the terminal production of 'FORM' from that notion as terminal production of which the arrayed-coercend is elaborated; if that notion begins with 'arrayed row of', then the value of the arrayed-coercend is the considered value; otherwise, a name different from all other names and whose mode is 'reference to' followed by the mode of the considered value is created and made to refer to the considered value, and this name is then the value of the arrayed-coercend.

8.3. Primaries

8.3.1. Syntax

a) COERCETY MODE primary :
   COERCETY CLOSED MODE expression ; COERCETY MODE cohesion.

b) MODE cohesion : MODE denotation ; MODE identifier ; MODE slice ;
   nonlocal MODE generator ; MODE named TAG selection ; MODE expression call.

c) hip FORCED MODE cohesion :
   FORCED MODE cohesion ; MODE hop ; MODE nihil.

d) NONPROC hop : skip ; jump.

e) reference to MODE nihil : nil symbol.

   {Examples:
    a) (a | b | false) ; sin(b − a) ;
    b) true ; x ; x[i, j] ; compl(1, 0) ; father of algol ; sin(b − a) ;
    c) x (in y := x) ; skip ; nil ;
    d) skip ; goto grenoble ;
    e) nil
   }

   {For collateral-expressions see 6.3.1.c, for closed-expressions see 6.4,
   for conditional-expressions see 6.5, for denotations see 5, for identifiers
   see 4.1, for slices see 8.4, for generators see 8.5, for field-selections
   see 8.6, for expression-calls see 8.7, for skips see 5.2.1.d and for jumps
   see 6.2.1.e. }
8.3.2. Semantics

a) The value of an identifier is the value, if any, possessed by its defining occurrence (4.1.2, 7.4.2. Step 5).

The identifier \( p \) as declared in the standard declaration 10.3.a is a real-identifier (and not a reference-to-real-identifier). Its value cannot be changed by assignment. In fact, in this context, \( p := 3 \) is not a production of 'assignment' (6.8). Similarly, the identifier \( sin \) as declared in 10.3.g is a procedure-with-a-real-parameter-delivering-a-real-identifier (5.4.1.b) and \( sin := \text{real}(x) \text{real} : (x - x \downarrow 3/6) \) is also not an assignment. The initialised declaration \( \text{real} ppi(p) \) creates a name possessed by the reference-to-real-identifier \( ppi \), which name refers to the value of \( p \); moreover, another value may be assigned to that name.

b) The value of a skip is a new instance of some value whose mode is that obtained in the following steps:
Step 1: The mode obtained by deleting 'hop' from that notion ending with 'hop' of which the skip is a terminal production is considered;
Step 2: If the considered mode begins with 'union of' then some mode which does not begin with 'union of' and from which the considered mode is united (2.2.4.1.h) is considered instead; the considered mode is the mode of the value of the skip.

c) A jump (see also 6.2.2.b) does not possess a value.

d) The elaboration of a nilhil involves no action; its value is a new instance of nil (2.2.3.5.a) whose mode is that obtained by deleting 'nilhil' from that notion ending with 'nilhil' of which the nilhil is a terminal production.

(Skips play a role in the Semantics of routine-denotations (5.4.2.ii), formulas (8.1.2. Step 3) and accompanied-calls (8.7.2. Step 4).

Moreover, they are useful in a number of programming situations, like e.g.
i) Supplying an actual-parameter (7.4.1.b) or structure (8.5.1.f) whose value is irrelevant or is to be calculated later; e.g. \( f(3, \text{skip}) \) where \( f \) does not use its second actual-parameter if the value of its first actual-parameter is positive; see also 11.11.ax;

ii) Supplying a constituent unitary-expression of a collateral-expression, e.g. [1:] \( \text{real } x1(3.14, \text{skip}, 1.68, \text{skip}) \);
8.3.2. continued

iii) as a "dummy" statement (6.2.1.d) in those rare situations where the
use of a completer is inappropriate, e.g. \texttt{l : skip} in 10.4.b

A jump is useful as expression to terminate the elaboration of another
expression when certain requirements are not met, e.g.

\texttt{exit in y := if x > 0 then sqrt(x) else goto exit fi,
f in (j > a \mid f \mid j) from 10.2.3.r.}

A nilhil is useful particularly where structured values are connected to
one another in that a field of each structured value refers to another
one except for one or more structured values where that field does not
refer to anything at all; the value of such a field must then be nil, e.g.

\texttt{language(14, nil)} in the examples of 8.6.1.

Since the value of a nilhil, nil, is unique, an identity-relation, like

\texttt{father of father of algol := nil}

can be used to determine whether a field is nil or not. }

8.4. Slices

8.4.1. Syntax

a) \texttt{REFETY ROWSETY ROWSETY NONROW slice : REFETY ROWS ROWSETY NONROW whole,}
   \texttt{sub symbol, ROWS leaving ROWSETY indexcr, bus symbol.}

b) NONREF whole : NONREF primary ; called NONREF primary.

c) reference to NONREF whole : fitted reference to NONREF primary.

d) row of ROWS leaving row of ROWSETY indexer :
   \texttt{trimmer option, comma symbol, ROWS leaving ROWSETY indexcr ;
   subscript, comma symbol, ROWS leaving row of ROWSETY indexcr.}

e) row of ROWS leaving EMPTY indexcr :
   \texttt{subscript, comma symbol, ROWS leaving EMPTY indexcr.}

f) row of leaving row of indexer : trimmer option.

g) row of leaving EMPTY indexcr : subscript.

h) trimmer : actual lower bound, up to symbol,
   actual upper bound, new lower part option.

i) new lower part : at symbol, new lower bound.

j) new lower bound : hip fitted integral formary.

k) subscript : hip fitted integral formary.

l) trimscript : trimmer option ; subscript.
8.4.1. continued

{Examples:
 a) \( x[\cdot, \cdot] ; x[\cdot, j] ; x[\cdot, \cdot] ; x[\cdot, n:1] \);
 b) \( (1, 2, 3) \) (in \( (1, 2, 3)[\cdot] \));
 c) \( x[1] ; x[2] \);
 d) \( 2:n:1, j ; i, 2:n:1 \);
 e) \( i, j \);
 f) \( 2:n:1 \);
 g) \( i \);
 h) \( 2:n:1 \);
 i) \( :1 \);
 j) \( 1 \);
 k) \( \bar{i} \) }

{For primaries see 8.3 and for hip-fitted for primaries see 8.0.1.b.}

{In rule a, 'ROWS' reflects the number of trims in the slice,
'ROWSETY' the number of these which are trimmer-options and 'ROWSETY'
the number of 'row of' not involved in the indexer. In the slices
\( x[\cdot, \cdot] ; x[\cdot, j] ; x[\cdot, \cdot] \), these numbers are \( (2,0,0), (2,1,0) \) and \( (1,0,1) \)
respectively. Because of rules h and 7.1.1.r, s, 2:3:7 ; 2:n ; 2: ; :5
and \( ::2 \) are trimmers, while rules d and f allow trimmers to be omitted.}

8.4.2. Semantics

A slice is elaborated in the following steps:

Step 1: Its constituent whole, and all constituent subscripts, strict-
lower-bounds, strict-upper-bounds and new-lower-bounds of the constituent
indexer of the slice are elaborated collaterally (6.3.2.a);

Step 2: That multiple value which is, or is referred to by, the value of
the whole, is considered, a copy is made of its descriptor, and all
the states {2.2.3.3.b} in the copy are set to 1;

Step 3: The trims in the slice following the sub-symbol is considered, and a
pointer, "i", is set to 1;

Step 4: If the considered trimscript is not a subscript, then Step 5 is
taken; otherwise, letting "k" stand for its value, if \( l_i \leq k \leq u_i \), then
the offset in the copy is increased by \( (k - l_i) \times d_i \), the i-th quintuple
is "marked", and Step 6 is taken; otherwise, the further elaboration
is undefined;
8.4.2. continued

Step 5: The values "l", "u" and "l'" are determined from the considered
trimscript \{trimmer-option\} as follows:

if the considered trimscript contains a strict-lower-bound (strict-
upper-bound), then l (u) is its value, and otherwise l (u) is l_i (u_i);
if it contains a new-lower-bound then l' is its value, and otherwise
l' is l;
if now l_i ≤ l and u ≤ u_i, then the offset in the copy is increased by
(l - l_i) × d_i, and then l_i is replaced by l' and u_i by (l' - l) + u;
otherwise, the further elaboration is undefined;

Step 6: If the considered trimscript is followed by a comma-symbol, then
the trimscript following that comma-symbol is considered instead, i is
increased by 1, and Step 4 is taken; otherwise, all quintuples in the
copy which were marked by Step 4 are removed, and Step 7 is taken;

Step 7: If the copy now contains at least one quintuple, then the
multiple value composed of the copy and those elements of the considered
value which it describes and whose mode is that obtained by deleting
'slice' and the initial 'reference to', if any, from that notion ending
with 'slice' of which the slice is a terminal production, is considered
instead; otherwise, the element of the considered value selected by
that index equal to the offset in the copy is considered instead;

Step 8: If the value of the whole is a name, then the value of the slice
is a new instance of the name which refers to the considered value,
and, otherwise, is a new instance of the considered value itself.

{A trimmer restricts the possible values of a subscript and changes
its notation: first, the value of the subscript is restricted to run
from the value of the strict-lower-bound up to that of the strict-upper-
bound, both given in the old notation; next, all remaining values of
that subscript are changed by adding the same amount to each of them,
such that the lowest value then equals the value of the new-lower-
bound. Thus, the assignations

\[ y'[1:n-1] := x'[2:n-1]; y'[n] := x'[n]; x' := y' \]

effect a cyclic permutation of the elements of \( x' \). }
8.5. Generators

{And as imagination bodies forth
The forms of things unknown, the poet's pen
Turns them to shapes, and gives to airy nothing
A local habitation and a name.
A Midsummer-night's Dream, William Shakespeare.}

8.5.1. Syntax

a)*) generator : local MODE generator ; nonlocal MODE generator.
b) local MODE generator : local symbol, nonlocal MODE generator.
c) nonlocal reference to MODE generator :
   actual MODE declarer, MODE initialisation option.
d) MODE initialisation :
   hip adapted CLOSED MODE expression ; MODE structure pack.
e) structured with FIELDS and a FIELD structure :
   structured with FIELDS structure, comma symbol,
   structured with a FIELD structure.
f) structured with a MODE named TAG structure :
   hip adapted unitary MODE expression ; MODE structure pack.

{Examples:
b) loc[1 : 3] real (1.2, 3.4, 5.6) ;
c) person ; compl(1, 0) ; compl(a) ; string("abs") ;
   (and in the context of
   struct nest = (int a, struct(real b, bool c) d) 
   nest(1, (2.3, true)) ;
da) (a) ; (1, 0) ;
e) 1, 0 ;
f) 1 ; (2.3, true) }

8.5.2. Semantics

a) A given structure is elaborated in the following steps:
Step 1: All constituent expressions and structures of the given structure
   are elaborated collaterally {6.3.2.a} ;
Step 2: The values obtained in Step 1 are made, in the given order,
   to be the fields of a new instance of a structured value {2.2.3.2} whose
   mode is obtained by deleting 'structure' from that notion ending with
   'structure' of which the given structure is a terminal production, and
8.5.2. continued

this structured value is the value of the given structure.

b) A generator is elaborated in the following steps:
Step 1: Its constituent actual-declarer {7.1.2.c} and initialisation,
   if any, are elaborated collaterally, the elaboration of a structure-
   pack being that of its constituent structure;
Step 2: If there is an initialisation, then its value is assigned
   {8.8.2.a} to the value {name} of the actual-declarer;
Step 3: The value of the generator is the value {name} of the actual-
   declarer.

c) The scope {2.2.4.2} of the value of a local-generator is the smallest
   range containing that generator; that of a nonlocal-generator is the
   program.

{Extension 9.2.a allows

ref real x = loc real

to be written

real x.

The closed-expression

(ref real xx ; (ref real x = real(pt) ; xx := x) ; xx = pt)
possesses the value true, but the closed-expression

(ref real xx ; (real x(pt) ; xx := x) ; xx = pt)
possesses an undefined value since the assignment xx := x
in this latter case violates the condition on scopes (8.8.2.a. Step 1).
The closed-expression

((ref real xx ; real x(pt) ; xx := x) = pt)
however, has the value true.}

{Though the value of the offset in the descriptor of a multiple
value is always initially 1, this may be changed by the action of a
trimmer (see 8.4.2. Step 5).}
8.5.2. continued 2

The generator
\[-2:3, 7: 0:4\] real
would result in the name of a multiple value, with undefined elements,
whose descriptor quintuples have the values

<table>
<thead>
<tr>
<th>i</th>
<th>l_i</th>
<th>u_i</th>
<th>d_i</th>
<th>s_i</th>
<th>t_i</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-2</td>
<td>3</td>
<td>?</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>?</td>
<td>?</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>4</td>
<td>?</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

The fact that \( t_2 = 0 \) means that the second upper bound is virtual and
its value in the descriptor may be changed by assignment (8.8.2.a).}

8.6. Field selections

8.6.1. Syntax

a) REFETY FIELD selection : FIELD selector, of symbol,
   REFETY structured with LFIELDSA FIELD RFIELDSETY whole.

(Examples: The following examples are assumed in a range with the declarations

```c
struct language = (int age, ref language father);
language algol(10, language(74, nil));
language pl1 = language(4, algol);
```

a) age of pl1 ; father of algol }

(Rule a ensures that the value of the whole has a field selected by
the field-selector in the field-selection (see 7.1.1.e, f, g, h, and the
remarks below 7.1.1. and 8.6.2). The use of an identifier which is the
same sequence of symbols as a field-selector in the same range creates
no ambiguity.)
8.6.1. continued

Thus $age \ of \ algol := age$ is a (possibly confusing to the human) assignment if the second occurrence of $age$ is also an adapted-unitary-integral-expression. }

8.6.2. Semantics

A field-selection is elaborated in the following steps
Step 1: Its constituent whole is elaborated, and the structured value which is, or is referred to by, the value of that whole is considered ;
Step 2: If the value of the whole is a name, then the value of the field-selection is a new instance of the name which refers to that field of the considered structured value selected by the constituent field-selector; otherwise, it is a new instance of the value which is that field itself.

{In the examples of 8.6.1, $age \ of \ algol$ is a reference-to-integral-named-[age]-selection, and, by 8.3.1.a, b, c, a reference-to-integral-primary, but $age \ of \ pl1$ is an integral-named-[age]-selection and an integral-primary. (Certain pieces of text within a notion have a prolixity out of proportion to the information they convey. Thus [age] stands for 'letter-a-letter-g-letter-e' and [language] is likewise short for 'structured-with-a-integral-named-[age]-and-a-reference-to-[language]-named-[father]'. That certain notions have infinite length is clear; however, the computer can recognise them without full examination (see 7.1.2.b.).)

It follows that $age \ of \ algol$ may appear as a destination (8.8.1.b) in an assignation but $age \ of \ pl1$ may not. Similarly, $algol$ is a reference-to-[language]-primary but $pl1$ is a [language]-primary and no assignment may be made to $pl1$.

The selection $father \ of \ pl1$, however, is a reference-to-[language]-named-[father]-selection, and thus a reference-to-[language]-primary whose value is the name denoted by $algol$. It follows that the identity-relation $father \ of \ pl1 := \ algol$ possesses the value true. If $father \ of \ pl1$ is used as a destination in an assignation, there is no change in the name which is a field of the structured value denoted by $pl1$, but there may well be a change in the [language] referred to by that name.
8.6.2. continued

By similar reasoning and because the operators \( \text{re} \) and \( \text{im} \) denote routines (10.25.b, c) which deliver values whose mode is 'real' and not 'reference-to-real', \( \text{re} \) of \( z := \text{im} \ w \) is an assignment, but \( \text{re} \ z := \text{im} \ w \) is not. } 

8.7. Accompanied calls

8.7.1. Syntax

a) \* accompanied call : CLAUSE call.

b) MODE expression call:
   fitted procedure with PARAMETERS delivering a MODE primary,
   actual PARAMETERS pack.

c) statement call : fitted procedure with PARAMETERS primary,
   actual PARAMETERS pack.

(Examples:

b) \textit{samealon} \((m, (\text{int } j) \text{ real : } x[j])\) (in the scope of
   \textbf{proc} \textit{samealon} \((\text{int } n, \text{ proc(int) real } f) \text{ real :} \)
   \begin{verbatim}
   begin long real s(long 0) ;
   for i to n do s plus leng f(i) ↓ 2 ;
   short long sqrt(s) end;
   \end{verbatim}

c) \textit{set random}(x) ; (see 10.3.1.) )

(For actual-parameters see 7.4.1.b and for fitted-primaries see
8.3.1.a. See also unaccompanied-calls, 8.2.1.)

8.7.2. Semantics

An accompanied-call is elaborated in the following steps:

Step 1: Its constituent fitted-primary is elaborated and a copy is made
   of \{the routine which is\} its value ;

Step 2: The accompanied-call is replaced by that copy ;
8.7.2. continued

Step 3: That copy (which is now a closed-clause) is protected (6.0.2.d);
Step 4: The copy as modified by Step 3 is further modified by replacing the
skip-symbols following the equals-symbol following the constituent
formal-parameters of the copy (5.4.2.ii) in the textual order by the
constituent actual-parameters of the accompanied-call taken in the
same order;
Step 5: The elaboration of the copy is initiated; if this elaboration is
completed or terminated, then the copy is replaced by the accompanied-
call before the elaboration of a successor is initiated.

(The expression-call samelesson(m, (int j) real : x1[j]) as given in the
examples of 8.7.1, is elaborated by first considering (Step 1) the closed-
expression

```plaintext
((int n = skip, proc(int) real f = skip)
begin long real s(Long 0);
for i to n do s plus leng f(i) \# 2;
short long sqrt(s) end).
```

Supposing that n, f, s and i do not occur elsewhere, this closed-
expression is protected (Step 3) without further alteration. The actual-
parameters are now inserted (Step 4) yielding the closed-expression

```plaintext
((int n = m, proc(int) real f = (int j) real : x1[j])
begin long real s(Long 0);
for i to n do s plus leng f(i) \# 2;
short long sqrt(s) end)
```

and this closed-expression is elaborated (Step 5). Note that, for the
duration of this elaboration, n possesses the same integer as that referred
to by the name possessed by m, and f possesses the same routine as that
possessed by the routine-denotation (int j) real : x1[j]. During the elaboration
of this and its inner nested closed-clauses (9.3), the elaboration
of f(i) itself involves the elaboration of the closed-expression

```plaintext
((int j = i) ; x1[j])
```

and, within this inner closed-expression, the first
occurrence of j possesses the same integer as that referred to by the name
possessed by i.}
8.8. Assignations

8.8.1. Syntax

a) MODE assignation:
reference to MODE destination, becomes symbol, MODE source.
b) reference to MODE destination : peeled reference to MODE formary.
c) MODE source : hip adapted unitary MODE expression.

{Examples:
  a) \( x := 0 \); \( x := y \); \( x := \text{random} \); \( xx := x \); \( \text{val} \ xx := 1.2 \);
  \( x[i] := y[i] := (i = j \mid 1 \mid 0) \); \( \text{random} < .5 \mid x \mid y \) := 7
  \( x \text{ or } y := 3.4 \) }

{For peeled-formaries see 8.0.1.b and for hip-adapted-unitary-expressions see 8.0.1.a }

8.8.2. Semantics

a) When a given instance of a value is superseded by another instance of a value, then the name which refers to the given instance is caused to refer to that other instance, and, moreover, each name which refers to an instance of a multiple or structured value of which the given instance is a component \( \{2.2.2.k\} \) is caused to refer to the instance of the multiple or structured value which is established by replacing that component by that other instance.

b) When an element (a field) of a given multiple (structured) value is superseded by another instance of a value, then the mode of the thereby established multiple (structured) value is that of the given value.

c) A value is assigned to a name in the following steps:
Step 1: If the given value does not refer to an element or subvalue of a multiple value having one or more states equal to zero \( \{2.2.3.3.b\} \), if the outer scope of the given name is not larger than the inner scope of the given value \( \{2.2.4.2.c, d\} \), and if the given name is not \text{nil}, then Step 2 is taken; \{otherwise, the further elaboration is undefined ; \}

Step 2: The value referred to by the given name is considered; if the mode of the given name does not begin with 'reference to union of' and the considered value is a multiple value or a structured value, then Step 3 is taken; otherwise, the considered value is superseded by a new instance of the given value and the assignment is complete ;
8.8.2. continued

Step 3: If the considered value is a structured value, then Step 5 is taken; otherwise, applying the notation of 2.2.3.3.b to its descriptor, then for \( i = 1, \ldots, n \), if \( s_i = 0 \) (\( t_i = 0 \)), then \( l_i \) \((u_i)\) is set to the value of the \( i \)-th lower bound (\( i \)-th upper bound) in the descriptor of the given value; moreover, for \( i = n, n-1, \ldots, 2 \), the stride \( d_{i-1} \) is set to \((u_i - l_{i-1}) \times d_i \); finally, if some \( s_i = 0 \) or \( t_i = 0 \), then the descriptor of the considered value, as modified above, is made to be the descriptor of a new instance of a multiple value which is of the same mode as the considered value, and this new instance is considered instead;

Step 4: If for all \( i, i = 1, \ldots, n \) the bound \( l_i \) \((u_i)\) in the descriptor of the considered value, as possibly modified in Step 3, is equal to \( l_i \) \((u_i)\) in the descriptor of the given value, then Step 5 is taken (; otherwise, the further elaboration is undefined);

Step 5: Each element (field) of the considered value is superseded by a new instance of the corresponding element (field) of the given value and the assignment is complete. (The order in which these elements (fields) are superseded is undefined.)

\( a \) An assignation is elaborated in the following steps:

Step 1: Its constituent source and destination are elaborated collaterally \((6.3.2.a)\);

Step 2: The value of the source is assigned to the value \( \{\text{name}\} \) of the destination;

Step 3: The value of the assignation is a new instance of the value of the source.

\{ Observe that \((x, y) := (7.2, 3.4)\) is not an assignation, since \((x, y)\) is not a destination; indeed, the mode of the value of a collateral-expression \((6.3.1.c)\) does not begin with 'reference to' but with 'row of'. \}

8.9. Conformity relations \( \{ \text{I would to God they would either conform, or be more wise, and not be caught!} \} \)

8.9.1. Syntax

\( a \) boolean conformity relation :

\text{peeled reference to LMODE formary, conformity relator, RMODE formary.}

\( b \) conformity relator :

\( \text{conforms to symbol ; conforms to and becomes symbol.} \)
8.9.1. continued

{Examples:
  a) \( es :: e \) (see 11.11.q) ; \( es ::= e \) (see 11.11.r) ;
  b) \( ::; ::= \}

  {For peeled-formaries and formaries see 8.0.1.b. }

8.9.2. Semantics

A conformity-relation is elaborated in the following steps:
Step 1: Its constituent peeled-formary and formary are elaborated
collaterally \([6.3.2.a]\) and the value of that formary is considered ;
Step 2: If the mode of the value of the peeled-formary is 'reference to' 
followed by a mode which is or is united from \([2.2.4.1.h]\) the mode of
the considered value, then the value of the conformity-relation is true
and Step 4 is taken; otherwise, Step 3 is taken ;
Step 3: If the considered value refers to another value, then this other
value is considered instead and Step 2 is taken; otherwise, the value
of the conformity-relation is false and Step 4 is taken ;
Step 4: If the constituent conformity-relator is a conforms-to-and-
becomes-symbol and the value of the conformity-relation is true, then
the considered value is assigned \([8.8.2.c]\) to the value of the peeled-
formary.

{Observe that if the considered value is an integer and the mode of the
value of the peeled-formary is 'reference to' followed by a mode which is
or is united from the mode 'real' but not from 'integral', then the value
of the conformity-relation is false. Thus, in contrast with the assignation,
no automatic widening from integral to real takes place. }

8.10. Identity relations

8.10.1. Syntax

  a) boolean identity relation : peeled reference to MODE formary, 
      identity relator, hip peeled reference to MODE formary.
  b) identity relator : is symbol ; is not symbol.
8.10.1. continued

Examples:
a) \( xx := yy \); \( \text{val} \ xx := x \ or \ y \);
b) \(:= ; :\neq \)}

{For peeled-formaries and hip-peeled-formaries see 8.0.1.b.}

8.10.2. Semantics

An identity-relation is elaborated in the following steps:
Step 1: Its constituent peeled-formary and hip-peeled-formary are elaborated
collaterally \(6.3.2.a\)};
Step 2: If the constituent identity-relator is an id-symbol (is not symbol),
then the value of the identity-relation is true (false) if the values
(names) obtained in Step 1 are the same and false (true) otherwise.

{Assuming the assigntion \( xx := yy := x \), the value of the identity-
relation \( xx := yy \) is false because \( xx \) and \( yy \), though of the same mode,
do not possess the same name. The value of the identity-relation
\( \text{val} \ xx := x \ or \ y \) has a \(1/2\) probability of being true because the value
possessed by \( \text{val} \ xx \) is the name possessed by \( x \), and the routine possessed
by \( x \ or \ y \) (see 1.3), when elaborated, yields either the name possessed
by \( x \) or, with equal probability, the name possessed by \( y \). In the identity-
relation, the programmer is usually asking a specific question concerning
names and thus the level of reference is of crucial importance. Since no
automatic depressing of the formaries is provided, it must be explicitly
specified, if necessary, through the use of \( \text{val} \) or an equivalent device.
Thus, \( xx := x \) is not an identity-relation but \( \text{val} \ xx := x \) and
\( (xx := xx) := x \) are. On the other hand, unaccompanied procedures will be
called automatically so that \( x := x \ or \ y \) is also an identity-relation.
Observe that the value of the formula \( 1 = 2 \) is false, whereas \( 1 := 2 \)
is not an identity-relation, since the values of its formaries are not
names. Also,

\[ f_{2d3d} := f_{5d} \]
is not an identity-relation, whereas

\[ f_{2d3d} = f_{5d} \]
is a formula, but involves an operation which is not included in the
standard-declarations.}
9. Extensions

a) An extension is the insertion of a comment between two symbols or the replacement of a certain sequence of symbols, possibly satisfying certain requirements, by another sequence of symbols.

b) No extension may be performed within a comment {3.0.9.b} or a row-of-character-denotation {5.3}.

c) Some extensions are described in the representation language, except that

$A$ stands for a unitary-expression {Chapter 8},
$B$ for a unitary-expression,
$C_1$ and $C_2$ for unitary-clauses {6.2.1.a, 8},
$D$ for the standard-declarations {2.1.b, 10} if the extension is performed outside the standard-declarations and otherwise for the empty sequence of symbols,
$E$ for a serial-expression {6.1.1.b},
$F$ for a unitary-expression,
$G$ for two or more unitary-clauses separated by comma-symbols,
$H$ for a declarer {7.1},
$I$, $J$, $K$ and $L$ for identifiers {4.1},
$L$ for zero or more long-symbols,
$M$ for an identifier,
$N$ for an indication {4.2},
$O$ for zero or one identifiers,
$P$ for a tail {7.1.1.w, x, z},
$Q$ for a choice-clause {6.5.1.b},
$R$ for a routine-denotation {5.4},
$S$ for a unitary-statement {6.2.1.a},
$T$ for a unitary-expression,
$U$ for zero or one virtual-declarers {7.1.1.b},
$V$ for a virtual-declarer,
$W$ for a unitary-expression, and
$Z$ for a formal-declarer {7.1.1.b} all of whose formal-row-of-rower-options {7.1.1.o} are empty.
9.1. Comments

{A source of innocent merriment.}

Mikado, W.S. Gilbert.

A comment {3.0.9.b} may be inserted between any two symbols {but see 9.b.}.

{e.g. \( (m > n \mid m \mid n) \) may be written

\( (m > n \mid m \text{ the larger of the two } a \mid n). \)

9.2. Contracted declarations

a) \texttt{ref } ZI = \texttt{loc } H \text{ where } Z \text{ and } H \text{ specify the same mode }{7.1.2.a} \text{ may be replaced by } NI.

{e.g. \texttt{ref real } x = \texttt{loc real } may be written \texttt{real } x \text{ and}
\texttt{ref bool } p = \texttt{loc bool(true) } may be written \texttt{bool } p(true).}

b) \texttt{mode } N = \texttt{struct} may be replaced by \texttt{struct } N = \texttt{and } mode \ N = \texttt{union} may be replaced by \texttt{union } N = .

{e.g. \texttt{mode compl} = \texttt{struct(real re, im)} \text{ (see also 9.2.c) may be written}
\texttt{struct compl} = \texttt{(real re, im).}

\texttt{c}) If a given unitary-declaration (formal-parameter \{5.4.1.e\}, field-declarator \{7.1.1.g\}) and another unitary-declaration (formal-parameter, field-declarator) following a comma-symbol following the given unitary-declaration (formal-parameter, field-declarator) both begin with an occurrence of the mode-symbol, of the structure-symbol, of the union-of-symbol, of the priority-symbol, of the operation-symbol, of one same actual-declarer, or of one same formal-declarer, then the second of these occurrences may be omitted.

{e.g. \texttt{real } x, \texttt{real } y(1.2) \text{ may be written } \texttt{real } x, y(1.2), \text{ but}
\texttt{real } x, \texttt{real } y = 1.2 \text{ may not be written } \texttt{real } x, y = 1.2, \text{ since the first occurrence of } \texttt{real} \text{ is an actual-declarer whereas the second is a formal-declarer.}

Note also that \texttt{mode } b = \texttt{bool, } mode \ r = \texttt{real } \texttt{may be written}
\texttt{mode } b = \texttt{bool, } r = \texttt{real}, \texttt{etc.}

\texttt{d}) If a collateral-declaration \{6.3.1.a\} does not begin with a parallel-symbol, is not a constituent unitary-declaration of another collateral-declaration, none of its constituent unitary-declarations is a collateral-declaration, and only its first constituent unitary-declaration \{after application of 9.2.c\} begins with an occurrence of a mode-symbol, structure-symbol, union-of-symbol, priority-symbol, operation-symbol or declarer, then its first open-symbol and last close-symbol may be omitted.

{e.g. \texttt{(real } x, y, z) \text{ may be written } \texttt{real } x, y, z.}
9.2. continued

e) \textit{proc } \textit{PI} = R \textit{ may be replaced by } \textit{proc } \textit{I} = R.

f) \textit{op } \textit{PN} = R \textit{ may be replaced by } \textit{op } \textit{N} = R.

g) \textit{proc } \textit{PO(R)} \textit{ may be replaced by } \textit{proc } \textit{O(R)}.

\{ \textit{e.g. } \textit{proc(ref int) inor = (ref int i) : (i := i + 1) may be written}
\textit{proc inor = (ref int i) : (i := i + 1)},
\textit{op(ref int) int dear = (ref int i) int : (i := i - 1) may be written}
\textit{op dear = (ref int i) int : (i := i - 1)} \textit{ and}
\textit{proc(real) int p((real x) int : (round x)), obtained from}
\textit{ref proc(real) int p = loc proc(real) int((real x) int : (round x))}
\textit{by 9.2.a, may be written } \textit{proc p((real x) int : (round x))}. \}

9.3. Repetitive statements

a) The unitary-statement

\begin{verbatim}
begin(int J(F), int K = B, L = T);
  M : if D(K > 0 | J ≤ L | K < 0 | J ≥ L | true) then
    int I = J ; (W | S ; (Dj := J + K) ; goto M)
  fi
end,
\end{verbatim}

where \( J, K, L \) and \( M \) do not occur in \( D, W \) or \( S \), and where \( I \) differs from
\( J \) and \( K \), may be replaced by \textit{for I from F by B to T while W do S},
and if, moreover, \( I \) does not occur in \( W \) or \( S \), then \textit{for I from} may be
replaced by \textit{from}.

b) The unitary-statement

\begin{verbatim}
begin(int J(F), int K = B);
  M : (int I = J ; (W | S ; (Dj := J + K) ; goto M))
end,
\end{verbatim}

where \( J, K \) and \( M \) do not occur in \( D, W \) or \( S \), and where \( I \) differs from \( J \)
and \( K \), may be replaced by \textit{for I from F by B while W do S},
and if, moreover, \( I \) does not occur in \( W \) or \( S \), then \textit{for I from} may be
replaced by \textit{from}.

c) \textit{from 1 by} may be replaced by \textit{by}.

d) \textit{by 1 to} may be replaced by \textit{to}, and \textit{by 1 while} may be replaced by \textit{while}.

e) \textit{while true do} may be replaced by \textit{do}.

\{ \textit{e.g. } \textit{for i from 1 by 1 to n while true do x := x + a} \textit{ may be written}
\textit{to n do x := x + a}. \}
9.3. continued

Note that to 0 do $S$ and while false do $S$ do not cause $S$ to be elaborated at all, whereas do $S$ causes $S$ to be elaborated repeatedly until it is terminated or interrupted. }

9.4. Contracted conditional clauses {The flowers that bloom in the spring,

\[ \text{Tra la,} \]

\[ \text{Have nothing to do with the case.} \]

\[ \text{Mikado, W.S. Gilbert.} \}

a) $\text{else if } q \text{ fi fi} \text{ may be replaced by } \text{else if } q \text{ fi fi} \text{ and}$

\[ \text{then if } q \text{ fi fi may be replaced by } \text{then if } q \text{ fi fi.} \]

\{e.g. $\text{if } p \text{ then princeton else if } q \text{ then grenoble else sandvoort fi fi} \}

may be written

\[ \text{if } p \text{ then princeton} \]

\[ \text{else if } q \text{ then grenoble else sandvoort fi fi} \]

or $(p | \text{princeton} ; q | \text{grenoble | sandvoort}).$

Many more examples are given in 10.5. }

b) $(\text{int } I = A ; \text{if } DI = 1 \text{ then } C_1 \text{ else if } D(I = 2 | \text{true}) \text{ then } C_2 \text{ fi})$,

where $I$ does not occur in $C_1, C_2$ or $D$, may be replaced by

\[ \text{case } A \text{ in } C_1, C_2 \text{ esac.} \]

c) $(\text{int } I = A ; \text{if } DI = 1 \text{ then } C_1 \text{ else case}(DI - 1) \text{ in } G \text{ esac fi})$,

where $I$ does not occur in $C_1, D$ or $G$, may be replaced by

\[ \text{case } A \text{ in } C_1, G \text{ esac.} \]

\{Examples of the use of such "case" clauses are given 11.11.w, ap. \}

9.5. Complex values

\[ \text{val}(\text{real } I = A, J = B ; (\text{DL compl}(I, J))) \]

where $I$ and $J$ do not occur in $D$, may be replaced by

$(A \perp B)$. \]
10. Standard declarations

a) A "standard declaration" is one of the constituent declarations of the standard-declarations \{2.1.b\} \{}; it is either an "environment enquiry" supplying information concerning a specific property of the implementation \{(2.3.c)\}, a "standard priority" or "standard operation", a "standard mathematical constant or function", a "synchronization operation" or a "transput declaration"\}.

b) A representation of the standard-declarations is obtained by altering each form in 10.1, 10.2, 10.3, 10.4 and 10.5 in the following steps:

Step 1: Each sequence of symbols between ✱ and ✱ in a given form is altered in the following steps:

Step 1.1: If D occurs in the given sequence of symbols, then the given sequence is replaced by a chain of a sufficient number of sequences separated by comma-symbols; the first new sequence is a copy of the given sequence in which copy D is deleted; the n-th new sequence, n > 1, is a copy of the given sequence in which copy D is replaced by a sub-symbol followed by n-2 comma-symbols followed by a bus-symbol.

Step 1.2: If, in the given sequence of symbols, as possibly modified in Step 1.1, \[\{L \text{ int} \} \{L \text{ real} \text { or } L \text{ compl}\} \text{ occurs, then that sequence is replaced by a chain of int lengths } \{10.1.a\} \{\text{real lengths } \{10.1.c\}\} \text{ sequences separated by comma-symbols, the n-th new sequence being a copy of the given sequence in which copy each occurrence of } L(L) \text{ has been replaced by } (n-1) \text{ times long(long).} \]

Step 2: Each occurrence of ✱ and ✱ in a given form, as possibly modified in Step 1, is deleted.

Step 3: If, in a given form, as possibly modified in Steps 1 and 2, \[L \text{ int } \{L \text{ real} \text{ or } L \text{ compl}\}; \text{ or } L \text{ bits} \text{ or } L \text{ abs}, \text{ both } L \text{ int and } L \text{ real or both } L \text{ int and } L \text{ compl} \text{ occurs, then the form is replaced by a sequence of int lengths } \{10.1.a\} \{\text{real lengths } \{10.1.c\}, \text{ bits widths } \{10.1.f\}, \text{ the minimum of int lengths and real lengths} \} \text{ new forms; the n-th new form is a copy of the given form in which copy each occurrence of } L(L, K, S) \text{ is replaced by } (n-1) \text{ times long(long, leng, short).} \]

Step 4: If F occurs in a given form, as possibly modified or made in the Steps above, then the form is replaced by four new forms obtained by replacing F consistently throughout the form by either - or + or • or / ;
10. continued

Step 5: If $Q$ occurs in a given form, as possibly modified or made in the Steps above, then the form is replaced by four new forms obtained by replacing $Q$ consistently throughout the form by either $\text{minus}$ or $\text{plus}$ or $\text{times}$ or $\text{over}$;

Step 6: If $R$ occurs in a given form, as possibly modified or made in the Steps above, then the form is replaced by six new forms obtained by replacing $R$ consistently throughout the form by either $<$ or $\leq$ or $=$ or $\neq$ or $\geq$ or $>$;

Step 7: Each occurrence of $F$ in any form, as possibly modified or made in the Steps above, is replaced by a representation of one same terminal production of a terminal production of 'ALEPH' {1.2.5.d, 5.5.1.6.a};

Step 8: If, in some form, as possibly modified or made in the Steps above, $\%$ occurs followed by the representation of an identifier (field-selector, indication), then that occurrence of $\%$ is deleted and each occurrence of the representation of that identifier (field-selector, indication) in any form is replaced by the representation of one same identifier (field-selector, indication) which does not occur elsewhere in a form, and Step 8 is taken;

Step 9: If a representation of a comment occurs in any form, as possibly modified or made in the Steps above, then this representation is replaced by a representation of an actual-declarer or closed-clause suggested by the comment;

Step 10: If, in any form, as possibly modified or made in the Steps above, a representation of a routine-denotation occurs whose elaboration involves the manipulation of real numbers, then this denotation may be replaced by any other denotation whose elaboration has approximately the same effect (The degree of approximation is not defined in this Report (see also 2.2.3.1.c).);

Step 11: The standard-declarations are that serial-declaration followed by a go-on-symbol whose representation is the same as the sequence of all the forms, as possibly modified or made in the Steps above.

(The declarations in this Chapter are intended to describe their effect clearly. The effect may very well be obtained by a more efficient method.)
10.1. Environment enquiries

a) \textit{int} \textit{int lengths} = \textit{a} the number of different lengths of integers \textit{a} ;

b) \textit{L int L max int} = \textit{a} the largest \textit{L} integral value \textit{a} ;

c) \textit{int} \textit{real lengths} =
\textit{a} the number of different lengths of real numbers \textit{a} ;

d) \textit{L real L max real} = \textit{a} the largest \textit{L} real value \textit{a} ;

e) \textit{L real L small real} = \textit{a} the smallest \textit{L} real value such that both
\textit{L1 + L small real > L1} and \textit{L1 - L small real < L1} \textit{a} ;

f) \textit{int bits widths} =
\textit{a} the number of different widths of standard bit rows \textit{a} ;

g) \textit{int L bits width} =
\textit{a} the number of bits in a standard \textit{L} bit row \textit{a} ; (10.2.6.a)

h) \textit{op abs} = \textit{(char a) int} :
\textit{a} the integral equivalent of the character 'a' \textit{a} ;

i) \textit{op repr} = \textit{(int a) char} :
\textit{a} that character 'x', if it exists, for which \textit{abs} \textit{x} = \textit{a} \textit{a} ;

10.2. Standard priorities and operations

10.2.0. Standard priorities

a) \textit{priority minus} = 1, \textit{plus} = 1, \textit{times} = 1, \textit{over} = 1, \textit{modb} = 1, \textit{prue} = 1,
\textit{v} = 2, \textit{=} = 3, \textit{=} = 4, \neq = 5, \leq = 5, \geq = 5, \rightarrow = 6,
\rightarrow = 6, \times = 7, \div = 7, \div = 7, \div = 7, \div = 7, \div = 8 ;

10.2.1. Operations on boolean operands

a) \textit{op} \textit{v} = \textit{(bool a, b) bool} : (a | true | b) ;

b) \textit{op} \textit{=} = \textit{(bool a, b) bool} : (a | b | false) ;

c) \textit{op} \textit{=} = \textit{(bool a) bool} : (a | false | true) ;

d) \textit{op} \textit{=} = \textit{(bool a, b) bool} : ((a \land b) \lor (\neg a \land \neg b)) ;

e) \textit{op} \textit{=} = \textit{(bool a, b) bool} : (\neg (a = b)) ;

f) \textit{op abs} = \textit{(bool a) int} : (a | 1 | 0) ;

10.2.2. Operations on integral operands

a) \textit{op} \textit{=} = \textit{(L int a, b) bool} : \textit{a} true if the value of 'a' is smaller than
that of 'b' and false otherwise \textit{a} ;

b) \textit{op} \textit{=} = \textit{(L int a, b) bool} : (\neg (b < a)) ;

c) \textit{op} \textit{=} = \textit{(L int a, b) bool} : (a \leq b \land b \leq a) ;

d) \textit{op} \textit{=} = \textit{(L int a, b) bool} : (\neg (a = b)) ;
10.2.2. continued

e) \( \text{op } \equiv = (\text{L int } a, b) \text{ bool } : (b \leq a) ; \)
f) \( \text{op } \equiv = (\text{L int } a, b) \text{ bool } : (b < a) ; \)
g) \( \text{op } \equiv = (\text{L int } a, b) \text{ L int } : \)
    \( a \) the value of 'a' minus that of 'b' \( a \);
h) \( \text{op } \equiv = (\text{L int } a) \text{ L int } : (L0 - a) ; \)
i) \( \text{op } \equiv = (\text{L int } a, b) \text{ L int } : (a - b) ; \)
j) \( \text{op } \equiv = (\text{L int } a) \text{ L int } : a ; \)
k) \( \text{op } \equiv = (\text{L int } a) \text{ L int } : (a < L0 \lor -a \lor a) ; \)
(l) \( \text{op } \equiv = (\text{L int } a, b) \text{ L int } : (\text{L int } s(L0), i(\text{abs } b) ; \)
    \text{while } i \geq L1 \text{ do} (s := s + a ; i := i - L1) ; \quad (b < L0 \lor -s \lor s)) ; \)
m) \( \text{op } \equiv = (\text{L int } a, b) \text{ L int } : \)
    \( b \neq L0 \lor (\text{L int } q(L0), r(\text{abs } a) ; \)
    \text{while } (r := r - \text{abs } b) \geq L0 \text{ do } q := q + L1 ; \)
    \( (a < L0 \land b \geq L0 \lor a \geq L0 \land b < L0 \lor -q \lor q)) ; \)
n) \( \text{op } \equiv = (\text{L int } a, b) \text{ L int } : (a - a \equiv b \times b) ; \)
o) \( \text{op } \equiv = (\text{L int } a, b) \text{ L real } : (\text{L real } (a) / \text{L real } (b)) ; \)
p) \( \text{op } \equiv = (\text{L int } a, \text{ int } b) \text{ L int } : \)
    \( b \neq 0 \lor (\text{L int } p(L1) ; \text{to } b \text{ do } p := p \times a ; p) ; \)
q) \( \text{op } \equiv = (\text{L int } a) \text{ long } \text{ L int } : a \text{ the L integral value equivalent} \)
    \text{to the value of 'a' } a ; \)
r) \( \text{op } \equiv = (\text{L int } a) \text{ long } \text{ L int } : a \text{ the L integral value, if it exists,} \)
    \text{equivalent to the value of 'a' } a ; \)
s) \( \text{op } \equiv = (\text{L int } a) \text{ bool } : (\text{abs } a \equiv L2 = L1) ; \)
t) \( \text{op } \equiv = (\text{L int } a) \text{ int } : (a > L0 \lor 1 \lor a < L0 \lor -1 \lor 0) ; \)

10.2.3. Operations on real operands

a) \( \text{op } \equiv = (\text{L real } a, b) \text{ bool } : a \text{ true if the value of 'a' is} \)
    \text{smaller than that of 'b' and false otherwise } a ; \)
b) \( \text{op } \equiv = (\text{L real } a, b) \text{ bool } : (-b < a) ; \)
c) \( \text{op } \equiv = (\text{L real } a, b) \text{ bool } : (a \leq b \land b \leq a) ; \)
d) \( \text{op } \equiv = (\text{L real } a, b) \text{ bool } : (-a = b)) ; \)
e) \( \text{op } \equiv = (\text{L real } a, b) \text{ bool } : (b \leq a) ; \)
f) \( \text{op } \equiv = (\text{L real } a, b) \text{ bool } : (b < a) ; \)
g) \( \text{op } \equiv = (\text{L real } a, b) \text{ L real } : a \text{ the value of 'a' minus that of 'b' } a \)
    \{2.2.3.1.c} \)
h) \( \text{op } \equiv = (\text{L real } a) \text{ L real } : (L0 - a) ; \)

\text{BIBLIOTHEEK MATHEMATISCH CENTRUM}
\text{AMSTERDAM}
10.2.3. continued

i) \( op + = (L \text{ real } a, b) \ L \text{ real } : (a - b) \) ;

j) \( op + = (L \text{ real } a) \ L \text{ real } : a ; \)

k) \( op \text{ abs } = (L \text{ real } a) \ L \text{ real } : (a < L0 \mid -a \mid a) ; \)

l) \( op \times = (L \text{ real } a, b) \ L \text{ real } : a \text{ the value of 'a' times that of 'b' } a ; \)  
   \{2.2.3.1.c\}

m) \( op / = (L \text{ real } a, b) \ L \text{ real } : a \text{ the value of 'a' divided by that of } \)
   \( b \ a ; \{2.2.3.1.c\} \)

n) \( op \text{ hyp } = (L \text{ real } a) \ L \text{ real } : a \text{ the long } \text{ real value equivalent to the value of 'a' } a ; \)

o) \( op \text{ short } = (L \text{ hyp } \text{ real } a) \ L \text{ real } : a \text{ the } \text{ real value, if it } \)
   \( \text{exists, equivalent to the value of 'a' } a ; \)

p) \( op \text{ round } = (L \text{ real } a) \ L \text{ int } : a \text{ a } \text{ integral value, if one exists, } \)
   \( \text{equivalent to a } \text{ real value differing by not more than one-half } \)
   \( \text{from the value of 'a' } a ; \)

q) \( op \text{ sign } = (L \text{ real } a) \int \colon (a > L0 \mid 1 : a < L0 \mid 0 ) ; \)

r) \( op \text{ entier } = (L \text{ real } a) \ L \text{ int } : (L \int j(L0) ; \)
   \( (j \leq a \mid e : j = j + L1 ; (j \leq a \mid e \mid j - L1) \mid \)
   \( f : j = j - L1 ; (j > a \mid f \mid j)) ; \)

10.2.4. Operations on arithmetic operands

a) \( op \text{ P } = (L \text{ real } a, L \text{ int } b) \ L \text{ real } : (a \text{ P } L \text{ real } (b)) ; \)

b) \( op \text{ P } = (L \text{ int } a, L \text{ real } b) \ L \text{ real } : (L \text{ real } (a) \text{ P } b) ; \)

c) \( op \text{ R } = (L \text{ real } a, L \text{ int } b) \text{ bool } : (a \text{ R } L \text{ real } (b)) ; \)

d) \( op \text{ R } = (L \text{ int } a, L \text{ real } b) \text{ bool } : (L \text{ real } (a) \text{ R } b) ; \)

e) \( op \text{ } k = (L \text{ real } a, \text{ int } b) \ L \text{ real } : (L \text{ real } p(L1) ; \)
   \( \text{to abe b do } p := p \times a ; (b \geq 0 \mid p \mid L1 / p)) ; \)

10.2.5. Complex structures and associated operations

a) \( \text{struct} \ L \text{ compl } = (L \text{ real } re, im) ; \)

b) \( op \text{ re } = (L \text{ compl } a) \ L \text{ real } : re \text{ of } a ; \)

c) \( op \text{ im } = (L \text{ compl } a) \ L \text{ real } : im \text{ of } a ; \)

d) \( op \text{ abs } = (L \text{ compl } a) \ L \text{ real } : L \text{ sqrt } (re a + im a + 2) ; \)

e) \( op \text{ conj } = (L \text{ compl } a) \ L \text{ compl } : (re a - im a) ; \)

f) \( op \text{ } e = (L \text{ compl } a, b) \text{ bool } : (re a = re b \wedge im a = im b) ; \)

g) \( op \neq = (L \text{ compl } a, b) \text{ bool } : (\neg (a = b)) ; \)

h) \( op \text{ + } = (L \text{ compl } a) \ L \text{ compl } : a ; \)
10.2.5. continued

i) \( \text{op} - = (L \text{compl} a) L \text{compl} : (-re a \downarrow -im a) ; \)

j) \( \text{op} + = (L \text{compl} a, b) L \text{compl} : (re a + re b \downarrow im a + im b) ; \)

k) \( \text{op} - = (L \text{compl} a, b) L \text{compl} : (re a - re b \downarrow im a - im b) ; \)

l) \( \text{op} \times = (L \text{compl} a, b) L \text{compl} : \)
   \( (re a \times re b - im a \times im b \downarrow re a \times im b + im a \times re b) ; \)

m) \( \text{op} / = (L \text{compl} a, b) L \text{compl} : \)
   \( (L \text{real} d = \text{re}(b \times \text{conj} b) ; L \text{compl} n = a \times \text{conj} b ; \)
   \( \text{re} n / d \downarrow \text{im} n / d) ; \)

n) \( \text{op} \text{len} = (L \text{compl} a) L \text{compl} : (\text{len} \text{re} a \downarrow \text{len} \text{im} a) ; \)

o) \( \text{op} \text{short} = (L \text{compl} a) L \text{compl} : (\text{short} \text{re} a \downarrow \text{short} \text{im} a) ; \)

p) \( \text{op} P = (L \text{compl} a, L \int b) L \text{compl} : (a P L \text{compl}(b)) ; \)

q) \( \text{op} P = (L \text{compl} a, L \text{real} b) L \text{compl} : (a P L \text{compl}(b)) ; \)

r) \( \text{op} P = (L \int a, L \text{compl} b) L \text{compl} : (L \text{compl}(a) P b) ; \)

s) \( \text{op} P = (L \text{real} a, L \text{compl} b) L \text{compl} : (L \text{compl}(a) P b) ; \)

t) \( \text{op} \text{abs} k = (L \text{compl} a, \int b) L \text{compl} : (L \text{compl} p(|k|) ; \)
   \( \text{to abs b do } p := p \times a ; (b \geq 0 \mid p \mid L^2 / p) ; \)

10.2.6. Bit rows and associated operations

a) \( \text{mode L bits} = [1 : L \text{bits width}] \text{bool} ; \{10.1.g} ; \)

b) \( \text{op} = = ([L : \int n] \text{bool} a, b) \text{bool} : \)
   \( \text{for i to n do}(a[i] \neq b[i] \mid i) ; \text{true} \downarrow \text{false} ; \)

c) \( \text{op} \neq = ([L \text{bool} a, b) \text{bool} : (\neg(a = b)) ; \)

d) \( \text{op} \lor = ([L : \int n] \text{bool} a, b) \text{bool} : ([L : n] \text{bool} c ; \)
   \( \text{for i to n do} a[i] := a[i] \lor b[i] ; c) ; \)

e) \( \text{op} \land = ([L : \int n] \text{bool} a, b) \text{bool} : ([L : n] \text{bool} c ; \)
   \( \text{for i to n do} a[i] := a[i] \land b[i] ; c) ; \)

f) \( \text{op} \leq = ([L \text{bool} a, b) \text{bool} : (a \lor b = b) ; \)

g) \( \text{op} \geq = ([L \text{bool} a, b) \text{bool} : (b \geq a) ; \)

h) \( \text{op} \uparrow = ([L : \int n] \text{bool} a, \int b) \text{bool} : ([L : n] \text{bool} c(a) ; \)
   \( e : (b > 0 \mid b := b - 1 ; \text{for i from 2 to n do} \)
   \( a[i - 1] := a[i] ; a[n] := \text{false} ; e \)
   \( \mid f : (b < 0 \mid b := b + 1 ; \text{for i from n by -1 to 2 do} \)
   \( a[i] := a[i - 1] ; a[1] := \text{false} ; f)) ; c) ; \)

i) \( \text{op} \text{abs} = (L \text{bits width} a) L \text{int} : (L \text{int c}(L0) ; \)
   \( \text{for i to L bits width do} c := L2 \times a + \text{abs}(a[i]) ; c) ; \)

j) \( \text{op} \text{bin} = (L \text{int} a) L \text{bits} : \text{if } a \geq L0 \text{ then } L \text{int aa}(a) ; L \text{bits c}(0) ; \)
   \( \text{for i to L bits width do}(c := c \uparrow -1 ; c[1] := \text{odd}(aa \div L2) ; \)
   \( aa := aa + L2) ; c fi ; \)
10.2.7. Operations on character operands

a) \( \text{op} < = \langle \text{char } a, b \rangle \text{ bool} : (a \leq b) \); \{1.1.h\}

b) \( \text{op} \leq = \langle \text{char } a, b \rangle \text{ bool} : (\neg (b < a)) \);

c) \( \text{op} = = \langle \text{char } a, b \rangle \text{ bool} : (a = b) \);

d) \( \text{op} \neq = \langle \text{char } a, b \rangle \text{ bool} : (\neg (a = b)) \);

e) \( \text{op} \geq = \langle \text{char } a, b \rangle \text{ bool} : (b \leq a) \);

f) \( \text{op} > = \langle \text{char } a, b \rangle \text{ bool} : (b < a) \);

10.2.8. String mode and associated operations

a) \( \text{mode string} = [1:] \text{ char} \);

b) \( \text{op} < = ([1:] \text{ int } m] \text{ char } a, [1:] \text{ int } n] \text{ char } b \) \text{ bool} :

\( \langle \text{int } i(1) ; \text{ int } p = (m < n | m | n) ; \text{ bool } c) ;

(p < 1 | n \geq 1 | e : (e := a[i] = b[i] ; i := i + 1) \leq p | e) ;

(c | m < n | a[i] < b[i])) \);

c) \( \text{op} \leq = \langle \text{string } a, b \rangle \text{ bool} : (\neg (b < a)) \);

d) \( \text{op} = = \langle \text{string } a, b \rangle \text{ bool} : (a \leq b) \);

e) \( \text{op} \neq = \langle \text{string } a, b \rangle \text{ bool} : (\neg (a = b)) \);

f) \( \text{op} \geq = \langle \text{string } a, b \rangle \text{ bool} : (b \leq a) \);

g) \( \text{op} > = \langle \text{string } a, b \rangle \text{ bool} : (b < a) \);

h) \( \text{op} R = ([1:] \text{ char } a, [1:] \text{ char } b) \) \text{ bool} :

\( (n = 1 \land a[i] R b) \);

i) \( \text{op} R = \langle \text{char } a, [1:] \text{ int } n] \text{ char } b \rangle \text{ bool} : (n = 1 \land a R b[1]) \);

j) \( \text{op} + = ([1:] \text{ int } m] \text{ char } a, [1:] \text{ int } n] \text{ char } b \) \text{ string} :

\( ([1 : m + n] \text{ char } c ;

a[1 : m] := a ; c[m + 1 : m + n : 1] := b ; c) \);

k) \( \text{op} + = \langle \text{string } a, \text{ char } b \rangle \text{ string} : (\text{string } s = b ; a + s) \);

l) \( \text{op} + = \langle \text{char } a, \text{ string } b \rangle \text{ string} : (\text{string } s = a ; s + b) \);

(The operation defined in b implies that if "a"[1] < "b"[1], then
"a" < "a" ; "c" < "b" ; "aa" < "ab" ; "aa" < "ba" ; "ab" < "b".)

10.2.9. Operations combined with assignations

a) \( \text{op minus} = \langle \text{ref } L \text{ int } a, L \text{ int } b \rangle \text{ int} : (a := a - b) \);

b) \( \text{op minus} = \langle \text{ref } L \text{ real } a, L \text{ real } b \rangle \text{ real} : (a := a - b) \);

c) \( \text{op minus} = \langle \text{ref } L \text{ compl } a, L \text{ compl } b \rangle \text{ compl} : (a := a - b) \);

d) \( \text{op plus} = \langle \text{ref } L \text{ int } a, L \text{ int } b \rangle \text{ int} : (a := a + b) \);

e) \( \text{op plus} = \langle \text{ref } L \text{ real } a, L \text{ real } b \rangle \text{ real} : (a := a + b) \);

f) \( \text{op plus} = \langle \text{ref } L \text{ compl } a, L \text{ compl } b \rangle \text{ compl} : (a := a + b) \);

g) \( \text{op times} = \langle \text{ref } L \text{ int } a, L \text{ int } b \rangle \text{ int} : (a := a \times b) \);
10.2.9. continued

h) \texttt{op \ times = (ref \ L \ real \ a, \ L \ real \ b) \ L \ real \ : (a := a \times b) ;}

i) \texttt{op \ times = (ref \ L \ compl \ a, \ L \ compl \ b) \ L \ compl \ : (a := a \times b) ;}

j) \texttt{op \ over = (ref \ L \ int \ a, \ L \ int \ b) \ L \ int \ : (a := a \div b) ;}

k) \texttt{op \ modb = (ref \ L \ int \ a, \ L \ int \ b) \ L \ int \ : (a := a \div b) ;}

l) \texttt{op \ over = (ref \ L \ real \ a, \ L \ real \ b) \ L \ real \ : (a := a / b) ;}

m) \texttt{op \ over = (ref \ L \ compl \ a, \ L \ compl \ b) \ L \ compl \ : (a := a / b) ;}

n) \texttt{op \ Q = (ref \ L \ real \ a, \ L \ int \ b) \ L \ real \ : (a \ Q \ L \ real(b)) ;}

o) \texttt{op \ Q = (ref \ L \ compl \ a, \ L \ int \ b) \ L \ compl \ : (a \ Q \ L \ compl(b)) ;}

p) \texttt{op \ Q = (ref \ L \ compl \ a, \ L \ real \ b) \ L \ compl \ : (a \ Q \ L \ compl(b)) ;}

q) \texttt{op \ plus = (ref \ string \ a, \ string \ b) \ ref \ string \ : (a := a + b ; a) ;}

r) \texttt{op \ plus = (ref \ string \ a, \ string \ b) \ ref \ string \ : (a := b + a ; a) ;}

s) \texttt{op \ plus = (ref \ string \ a, \ char \ b) \ ref \ string \ : (a := a + b ; a) ;}

t) \texttt{op \ plus = (ref \ string \ a, \ char \ b) \ ref \ string \ : (a := b + a ; a) ;}

10.3. Standard mathematical constants and functions

a) \texttt{L \ real \ L \ pi = \ o a L \ real \ value \ close \ to \ \pi ; \ see \ Math. \ of \ Comp. \ v. 18, 1962, pp. 80-93 a ;}

b) \texttt{proc \ L \ sqrt = (L \ real \ x) \ L \ real \ : o if x \geq 0, a L \ real \ value \ close \ to \ the \ square \ root \ of \ \sqrt{x} ;}

c) \texttt{proc \ L \ exp = (L \ real \ x) \ L \ real \ : o a L \ real \ value, \ if \ one \ exists, \ close \ to \ the \ exponential \ function \ of \ \exp(x) ;}

d) \texttt{proc \ L \ ln = (L \ real \ x) \ L \ real \ : o a L \ real \ value, \ if \ one \ exists, \ close \ to \ the \ natural \ logarithm \ of \ \ln(x) ;}

e) \texttt{proc \ L \ cos = (L \ real \ x) \ L \ real \ : o a L \ real \ value \ close \ to \ the \ cosine \ of \ \cos(x) ;}

f) \texttt{proc \ L \ arccos = (L \ real \ x) \ L \ real \ : o if \ abs(x) \leq L1, a L \ real \ value \ close \ to \ the \ inverse \ cosine \ of \ \arccos(x) ;}

g) \texttt{proc \ L \ sin = (L \ real \ x) \ L \ real \ : o a L \ real \ value \ close \ to \ the \ sine \ of \ \sin(x) ;}

h) \texttt{proc \ L \ arcsin = (L \ real \ x) \ L \ real \ : o if \ abs(x) \leq L1, a L \ real \ value \ close \ to \ the \ inverse \ sine \ of \ \arcsin(x) ;}

i) \texttt{proc \ L \ tan = (L \ real \ x) \ L \ real \ : o a L \ real \ value, \ if \ one \ exists, \ close \ to \ the \ tangent \ of \ \tan(x) ;}

j) \texttt{proc \ L \ arctan = (L \ real \ x) \ L \ real \ : o a L \ real \ value \ close \ to \ the \ inverse \ tangent \ of \ \arctan(x) ;}

abs L \ arctan(x) \leq L \ pi / L2 o ;}
10.3. continued

k) \[ \text{proc } L \text{ random } = L \text{ real expr } \alpha \text{ the next pseudo-random } \text{ real value from a uniformly distributed sequence on the interval } [L_0, L_1) \alpha ; \]

l) \[ \text{proc } L \text{ set random } = (L \text{ real } x) ; (\alpha \text{ the next call of } L \text{ random is made to deliver the value of } 'x' \alpha ; L \text{ random}) ; \]

10.4. Synchronization operations

a) \[ \text{op } \text{down } = (\text{ref int } \text{dijkstra}) : (\text{do elem(if } \text{dijkstra } \geq 1 \text{ then dijkstra minus } 1 ; \text{else } \alpha \text{ if the closed-statement replacing this comment is contained in a unitary-phrase which is a constituent unitary-phrase of the smallest collateral-phrase, if any, beginning with a parallel-symbol and containing this closed-statement, then the elaboration of that unitary-phrase is halted } \{6.0.2.c\} \text{; otherwise, the further elaboration is undefined } \alpha \text{ fi } ; l : \text{skip}) ; \]

b) \[ \text{op } \text{up } = (\text{ref int } \text{dijkstra}) : \text{elem(dijkstra plus } 1 ; \alpha \text{ the elaboration is resumed of all phrases whose elaboration is not terminated but is halted because the name possessed by 'dijkstra' referred to a value smaller than one } \alpha ) ; \]

{For insight into the use of down and up, see E.W. Dijkstra, Cooperating Sequential Processes, EWD123, Tech. Univ. Eindhoven, 1965.}
10.5. Transput declarations {"So it does!" said Pooh. "It goes in!"
"So it does!" said Piglet. "And it comes out!"
"Doesn't it?" said Eeyore. "It goes in
and out like anything."
Winnie-the-Pooh, A.A. Milne.}

10.5.0. Transput modes and straightening

10.5.0.1. Transput modes

a) $mode \% simplout = union(\{ L \ int \}, \{ L \ real \}, \{ L \ compl \},$
\{bool, char, string\});
b) $mode \% outtype = union(\{ D L \ int \}, \{ D L \ real \}, \{ D bool \},$
\{ D char \}, \{ D outstruct \});
c) $mode \% outstruct = \& an actual-declarer specifying a mode united
from \{2.2.4.1.h\} all modes structured from \{2.2.4.1.j\} only modes
from which the mode specified by outtype is united \&;
d) $mode \% intype = union(\{ ref D L \ int \}, \{ ref D L \ real \},$
\{ ref D bool \}, \{ ref D char \}, \{ ref D outstruct \});
e) $mode \% tamref = struct(string F); (See the remarks under 5.5.1.6.)

10.5.0.2. Straightening

a) $op straightout = \{outtype x\} [] simplout :$
\& the result of "straightening" 'x' \&;
b) $op straightin = \{intype x\} [] ref simplout :$
\& the result of straightening 'x' \&;

The result of straightening a given value is obtained in the following
steps:

Step 1: If the given value is (refers to) a value from whose mode that
specified by simplout is united, then the result is a new instance of
a multiple value composed of a descriptor \{1, 1, 1, 1\} and the (the
name of the given value as its only element, and Step 4 is taken ;

Step 2: If the given value is (refers to) a multiple value, then, letting
n stand for the number of elements of the given value, and $y_i$ for the
result of straightening its i-th element, Step 3 is taken; otherwise,
letting n stand for the number of fields of the (of the value referred
to by the) given value, and $y_i$ for the result of straightening its i-th
field, Step 3 is taken ;
10.5.0.2. continued

Step 3: If the given value is not (is) a name, then, letting $m_i$ stand for the number of elements of $y_i$, the result is a new instance of a multiple value composed of a descriptor $(1, m_1 + \ldots + m_n, 1, 1, 1)$ and elements, the $l$-th of which, where $l = m_1 + \ldots + m_{k-1} + j$, is the (is the name referring to the) $j$-th element of $y_k$ for $k = 1, \ldots, n$ and $j = 1, \ldots, m_k$.

Step 4: If the given value is not (is) a name, then the mode of the result is 'row of' ('row of reference to') followed by the mode specified by `simplout`.

10.5.1. Channels and files

{"Channels", "backfiles" and files model the transput devices of the physical machine used in the implementation.

A channel corresponds to a device, e.g. a card reader or punch, a magnetic drum or disc, a piece of core memory, a tape unit or even a set-up in nuclear physics the results of which are collected by the computer. A channel has certain properties (10.5.1.1.d : 10.5.1.1.m).

Some devices may be seen as channels with properties in more than one way. The choice mode in an implementation is a matter for individual taste. Some possible choices are given in Table 1.

All information on a given channel is to be found in a number of backfiles. A backfile (10.5.1.1.b) comprises a reference to a three-dimensional array of integers (bytes of information), the book of the backfile, indexed by page, line and char; the lower bounds of the book are all one and the upper bounds are the maxpage, maxline and maxchar of the channel; furthermore, the backfile comprises the position of the "end of file", i.e. the page number, line number and character number up to which the backfile is filled with information.

On a given channel, a certain maximum number (10.5.1.1.m) of files (10.5.1.2.a) may be "opened" at any stage of the elaboration of the program. A file contains a reference to a backfile, to a current page number, line number and character number, and to the channel on which it has been opened.

After the elaboration of the declaration of `nextbfile` (10.5.1.1.c), all backfiles are part of the chains of backfiles referred to by `nextbfile`.
10.5.1. continued

Examples:

i) In a certain implementation, channel six is a line printer. It has no input information, nextbfile[6] is initialized to refer to a backfile the book of which is an integer array with upper bounds 2000, 60 and 144 (2000 pages of continuous stationery), with the end of file at position (1, 1, 1), and next equal to nil. All elements of the book are undefined.

ii) Channel four is a drum, divided into 32 segments each being one page of 256 lines of 256 bytes. It has 32 backfiles of input information (the previous contents of the drum), so nextbfile[4] is initialized to refer to the first element of a chain of 32 backfiles, each referencing the next, the last one having next equal to nil. Each of those backfiles has an end of file at position (2, 1, 1).

iii) Channel twenty is a tape unit, it can accommodate one tape at a time, one input tape is mounted, and another tape laid in readiness. Here, nextbfile[20] is initialized to refer to a chain of two backfiles.

Since it is part of the standard-declarations, all input is part of the program, though not of the particular-program.

In opening (10.5.1.2.c) a given file on a given channel, the first backfile is taken from the chain referenced by nextbfile of the channel and is made to be referred to by bfile of the file, obliterating the previous backfile, if any, of the file.

Apart from the possibility of being obliterated, at any stage in the elaboration of the particular-program, all backfiles are either part of the nextbfile chain of the channel, or referenced by a file opened on that channel, or part of the closedbfile chain (10.5.1.1.o) of that channel.

This models the part of a magnetic tape that, apart from the possibility of being left as a scratch tape, is either ready to be mounted on, in use on, or saved from the tape unit.

When a file is "closed" (10.5.1.2.q), its backfile is attached to the chain referenced by closedbfile of the channel; all files referencing the same backfile as that file are then unavailable for further transput.
10.5.1. continued 2

Example:

\begin{verbatim}
begin file tape1, tape2;
    open(tape1, 20); tape2 := tape1;
    out(tape2, fd.2df, pt); new page(tape1);
    close(tape2)
end
\end{verbatim}

The conv of a given file is used in conversion; if conv of the file is nil, then stand conv of the channel on which the file was opened is used as "conversion key", and, otherwise, the string to which conv of the file refers.

On output, if a character to be converted is not the same as some element of the conversion key, then the further elaboration is undefined; otherwise, the character is converted to an integer, viz. the lowest among the ordinal numbers of those elements of the key which are the same as that character.

On input, if an integer to be converted is larger than the number of elements of the conversion key, then the further elaboration is undefined; otherwise, the integer is converted to that character in the key whose ordinal number is that integer.

On all files opened on a channel for which set possible is false, and put possible and get possible both true, input and output may not be "alternated", i.e. after opening or resetting (10.5.1.2.e) such a file, either is possible, but, once one has taken place on the file, the other may not until the file has been reset again. Before the first output takes place on such a file, its book is filled with spaces. If, after output, such a file is reset, then an end of file is positioned at the current page, line and character number. (Such a file might be implemented with a buffer that holds one line.)

On all files opened on a channel for which set possible is false, binary and nonbinary transput may not be alternated.}
<table>
<thead>
<tr>
<th>properties</th>
<th>card reader</th>
<th>card punch</th>
<th>magnetic</th>
<th>tape</th>
<th>unit</th>
<th>line printer</th>
</tr>
</thead>
<tbody>
<tr>
<td>reset possible</td>
<td>false</td>
<td>false</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>set possible</td>
<td>false</td>
<td>false</td>
<td>false</td>
<td>false</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>get possible</td>
<td>true</td>
<td>false</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>put possible</td>
<td>false</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>true</td>
</tr>
<tr>
<td>bin possible</td>
<td>false</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>max page</td>
<td>1</td>
<td>1</td>
<td>very large</td>
<td>very large</td>
<td>very large</td>
<td>very large</td>
</tr>
<tr>
<td>max line</td>
<td>large</td>
<td>very large</td>
<td>16</td>
<td>large</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>max char</td>
<td>72</td>
<td>80</td>
<td>84</td>
<td>large</td>
<td>144</td>
<td>144</td>
</tr>
<tr>
<td>stand conv</td>
<td>a 48- or 64-character code</td>
<td>64-char code</td>
<td>some code</td>
<td>line-pr code</td>
<td>line-pr code</td>
<td></td>
</tr>
<tr>
<td>max rmb files</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>properties</th>
<th>magnetic disc</th>
<th>magnetic drum</th>
<th>paper</th>
<th>tape</th>
<th>reader</th>
<th>tape punch</th>
</tr>
</thead>
<tbody>
<tr>
<td>reset possible</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>false</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>set possible</td>
<td>true</td>
<td>false</td>
<td>true</td>
<td>false</td>
<td>false</td>
<td>false</td>
</tr>
<tr>
<td>get possible</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>true</td>
</tr>
<tr>
<td>put possible</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>false</td>
<td>false</td>
<td>true</td>
</tr>
<tr>
<td>bin possible</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>true</td>
<td>false</td>
</tr>
<tr>
<td>max page</td>
<td>200</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>max line</td>
<td>16</td>
<td>1</td>
<td>256</td>
<td>very large</td>
<td>very large</td>
<td>very large</td>
</tr>
<tr>
<td>max char</td>
<td>128</td>
<td>524288</td>
<td>256</td>
<td>80</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>stand conv</td>
<td>some code</td>
<td>some code</td>
<td>some code</td>
<td>5-hole code</td>
<td>7-hole code</td>
<td>lathe code</td>
</tr>
<tr>
<td>max rmb files</td>
<td>10</td>
<td>4</td>
<td>32</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**TABLE I: Properties of some possible channels**
10.5.1.1. Channels

a) \( \text{int } \text{nmb channels} = \text{a } \text{an integral-expression indicating the number of} \)
\( \text{transput devices in the implementation } \text{a} ; \)

b) \( \text{struct } \% \text{bfile} = ( \text{[.,}] \text{int book, int lpage, liine, lchar,} \)
\( \text{ref bfile next);} \)

c) \( \text{[1 : nmb channels]} \text{ref bfile } \% \text{nextbfile(a some appropriate} \)
\( \text{initialisation } \text{a);} \)

d) \( \text{[1 : nmb channels]} \text{bool reset possible = } \text{a } \text{a row-of-boolean-expression,} \)
\( \text{indicating which of the physical devices corresponding to the} \)
\( \text{channels allow resetting (e.g. rewinding of a magnetic tape) } \text{a;} \)

e) \( \text{[1 : nmb channels]} \text{bool set possible = } \text{a } \text{a row-of-boolean-expression,} \)
\( \text{indicating which devices can be accessed at random } \text{a;} \)

f) \( \text{[1 : nmb channels]} \text{bool get possible = } \text{a } \text{a row-of-boolean-expression} \)
\( \text{indicating which devices can be used for input } \text{a;} \)

g) \( \text{[1 : nmb channels]} \text{bool put possible = } \text{a } \text{a row-of-boolean-expression} \)
\( \text{indicating which devices can be used for output } \text{a;} \)

h) \( \text{[1 : nmb channels]} \text{bool bin possible = } \text{a } \text{a row-of-boolean-expression} \)
\( \text{indicating which devices can be used for binary transput } \text{a;} \)

i) \( \text{[1 : nmb channels]} \text{int max page = } \text{a } \text{a row-of-integral-expression} \)
\( \text{giving the maximum number of pages per file for the channels } \text{a;} \)

j) \( \text{[1 : nmb channels]} \text{int max line = } \text{a } \text{a row-of-integral-expression} \)
\( \text{giving the maximum number of lines per page } \text{a;} \)

k) \( \text{[1 : nmb channels]} \text{int max char = } \text{a } \text{a row-of-integral-expression} \)
\( \text{giving the maximum number of characters per line } \text{a;} \)

l) \( \text{[1 : nmb channels]} \text{ref string } \% \text{stand conv = } \text{a } \text{a row-of-reference-to-} \)
\( \text{row-of-character-expression giving the standard conversion keys for} \)
\( \text{the channels } \text{a;} \)

m) \( \text{[1 : nmb channels]} \text{int max nmb files = } \text{a } \text{a row-of-integral-expression} \)
\( \text{giving the maximum numbers of files the channels can accommodate } \text{a;} \)

n) \( \text{[1 : nmb channels]} \text{int } \% \text{opened files} \)
\( \text{(L7 : nmb channels] int zero ; for i to nmb channels do zero[i] = 0 ;} \)
\( \text{zero);} \)

o) \( \text{[1 : nmb channels]} \text{ref bfile } \% \text{closedbfile} \)
\( \text{([L : nmb channels] ref bfile nil ; for i to nmb channels do} \)
\( \text{nil[i] = nil ; nil);} \)
10.5.1.1. continued

p) \( \text{int stand in channel} = a \text{ an integral-expression whose value does not exceed nmb channels, such that get possible [stand in channel] is true, and stand conv [stand in channel] comprises, in some order, all character-tokens } a ; \)

q) \( \text{int stand out channel} = a \text{ an integral-expression whose value does not exceed nmb channels, such that put possible [stand out channel] is true, and stand conv [stand out channel] comprises, in some order, all character-tokens } a ; \)

r) \( \text{int stand back channel} = a \text{ an integral-expression whose value does not exceed nmb channels, such that reset possible [stand back channel], set possible [stand back channel], get possible [stand back channel], put possible [stand back channel] and bin possible [stand back channel] are true and stand conv [stand back channel] comprises, in some order, all character tokens } a ; \)

s) \( \text{proc file available} = (\text{int channel}) \text{ bool : } \)
\( \text{rmb opened files [channel]} < \text{max rmb files [channel]} ; \)

10.5.1.2. Files

a) \( \text{struct file} = (\text{ref bfile} \% \text{bfile}, \)
\( \quad \text{ref int} \% \text{page}, \% \text{line}, \% \text{char}, \% \text{chan}, \)
\( \quad \text{ref bool} \% \text{state def}, \% \text{state get}, \% \text{state bin}, \% \text{opened}, \)
\( \quad \text{ref string conv}) ; \)

b) \( \text{proc } \% \text{undefined} = \text{expr}((\text{false} | \text{true}) \text{ skip}) ; \)

c) \( \text{proc open} = (\text{ref file} \% \text{file}, \text{int} \% \text{ch}) : \)
\( \quad \text{if file available (ch)} \)
\( \quad \quad \text{then file} := \text{file}(\text{nextbfile[ch]} \% \text{1, 1, 1, ch, false, false, false, true, nil}) \text{ nextbfile[ch]} := \text{next of nextbfile[ch]} ; \)
\( \quad \quad \text{rmb opened files[ch]} \% \text{plus} 1 \)
\( \quad \text{else undefined} \)
\( \quad \text{fi} ; \)

d) \( \text{proc set} = (\text{file file}, \text{int} \% \text{p}, \text{int} \% \text{l}, \text{int} \% \text{a}) : \)
\( \quad \text{if set possible chan of file} \land \text{opened of file} \)
\( \quad \quad \text{then page of file} := \text{p} ; \text{line of file} := \text{l} ; \text{char of file} := \text{a} ; \)
\( \quad \quad \text{(outside(file) | undefined)} \)
\( \quad \text{else undefined} \)
\( \quad \text{fi} ; \)
10.5.1.2. continued

e) proc reset = (file file) :
   if reset possible[chang of file] \& opened of file
   then if state def of file \& \neg state get of file \&
   \neg set possible[chang of file]
   then lpage of bfile of file := page of file ;
      lline of bfile of file := line of file ;
      lchar of bfile of file := char of file
   fi ;
   page of file := line of file := char of file := 1 ;
   state def of file := false
   else undefined
   fi ;

f) proc % outside = (file file) bool : (opened of file |
   line ended(file) \lor page ended(file) \lor file ended(file)) ;

g) proc file ended = (file file) bool : (opened of file |
   int p = page of file, lp = lpage of bfile of file,
   l = line of file, ll = lline of bfile of file,
   c = char of file, lc = lchar of bfile of file ;
   (p < lp | false ; p > lp | true ; l < ll | false
   | l > ll | true ; c \geq lc)) ;

h) proc line ended = (file file) bool :
   (opened of file | char of file \geq max char[chang of file]) ;

i) proc page ended = (file file) bool :
   (opened of file | line of file \geq max line[chang of file]) ;

j) proc % get string = (file file, ref 1 : int n] char s) :
   if get possible[chang of file] \& opened of file
   then string conv = (conv of file := nil | stand conv[chang of file] |
   conv of file) ;
   int p = page of file, l = line of file ; ref int a = char of file ;
   if \neg set possible[chang of file] thef state def of file
   then(\neg state get of file \lor state bin of file | undefined)
   else state def of file := state get of file := true ;
   state bin of file := false
   fi ;
   for i to n do(outside(file) | undefined |
   s[i] := conv(book of bfile of file[p, l, a]] ; a plus 1)
   else undefined
   fi ;
10.5.1.2. continued 2

k) proc % put string = (file file,[1 : int n] char s) :
    if put possible[Chan of file] ^ opened of file
    then int ch = Chan of file, p = page of file, l = line of file ;
    string conv = (conv of file := nil | stand conv[ch] |
    conv of file) ; int space, h ; ref int c = char of file ;
    if ~ set possible[ch] then state def of file
    then(state get of file v state bin of file | undefined)
    else state def of file := true ; state get of file :=
    state bin of file := false ;
    (~ char in string(" ", space, conv) | undefined) ;
    for i to max page[ch] do for j to max line[ch] do
    for k to max char[ch] do
    book of bfile of file[i, j, k] := space
    fi ;
    for i to n do (~ char in string(s[i], h, conv) v outside(file) |
    undefined | book of bfile of file[p, l, o] := h ; o plus 1)
    else undefined
    fi ;

1) proc char in string = ([1 : 1] char a, ref int i, [1 : int w] char s) bool :
    (for k to w do (a = s[k] | i := k ; l) ; false, l : true) ;

m) proc space = (file file) :
    (char of file plus 1 ; outside(file) | undefined) ;

n) proc backspace = (file file) :
    (char of file minus 1 ; outside(file) | undefined) ;

o) proc new line = (file file) :
    (line of file plus 1 ; char of file := 1 ; outside(file) | undefined) ;

p) proc new page = (file file) :
    (page of file plus 1 ; line of file := char of file := 1 ;
    outside(file) | undefined) ;

q) proc close = (file file) :
    if opened of file
    then int ch = Chan of file ; (reset possible[ch] | reset(file)) ;
    next of bfile of file := closedbfile[ch] ;
    closedbfile[ch] := bfile of file ; opened of file := false ;
    mb opened files[ch] minus 1
    fi ;
10.5.1.2. continued 3

r) file stand in = (file f; open(f, stand in channel); f);
s) file stand out = (file f; open(f, stand out channel); f);
t) file stand back = (file f; open(f, stand back channel); f);

(Certain "standard files" (r, s, t) need not be opened by the
programmer, but are opened for him in the standard-declarations.
The procedure print (10.5.2.a) can be used for output on stand out,
read (10.5.3.a) for input from stand in, and write bin (10.5.6.a) and
read bin (10.5.7.a) for transput involving stand back.)

u) proc char number = (file f) int : (opened of f | char of f);
v) proc line number = (file f) int : (opened of f | line of f);
w) proc page number = (file f) int : (opened of f | page of f);

10.5.2. Formatless output

a) proc print = ([1] outtype x) : put(standout, x);
b) proc put = (file file, [1 : int n] outtype x) : (for i to n do
([1 : int l] s = straightout x[i]);
    for j to l do
      (string s ; bool b ; char c ;
       (* L int i ; (i := y[i] | s := L int string(i, L int width + 1, 10) ;
         sign supp zero(s[1 : w - 1]))) *)
      (* L real x ; (x := y[j] | s := L real string
        (x, L real width + L exp width + 4, L real width, L exp width) ;
         sign supp zero(s)) *)
      (* L compl x ; (x := y[j] | put(file, (re x, "", im x)); end) *)
      (b := y[j] | s := (b | "1" | "2");
      (a := y[j] | nextplo(file); put string(file, a); end);
      (s := y[j] | refl (int n) char t = s;
        for i to n do put(file, s[i]); end);
      (refl (int n) char t = s; int a1 = char of file;
        char of file := a1 + n; (line ended(file) | nextplo(file) |
          char of file := a1); put string(file, s);
        (!line ended(file) | space(file));
      end; skip)));
10.5.2. continued

c) \textbf{proc} \ L \ \textbf{int} \ \textbf{string} = (L \ \textbf{int} \ x, \ \textbf{int} \ w, \ r) \ \textbf{string} :
  (\textbf{string} \ a("\""\"\""\"\""\"\""\"\""\"\""\"\""\"\""\"\""\"\""\"\""\"\""\"\"""); \ \textbf{L} \ \textbf{int} \ n(ab\ e \ x); \ \textbf{L} \ \textbf{int} \ \textbf{lr} = x; r;
  \textbf{for} \ i \ \textbf{to} \ w - 1 \ \textbf{do} (a \ \textbf{prue dig char}(\textbf{S}(n + i : \textbf{lr})); \ \textbf{n over} \ \textbf{lr});
  (\textbf{n} = \textbf{L}0 | (x \ \textbf{L}0 | "\"" | "\""") + a));

a) \textbf{proc} \ L \ \textbf{real} \ \textbf{string} = (L \ \textbf{real} \ x, \ \textbf{int} \ w, \ d, \ e) \ \textbf{string} :
  (d \ \geq \ \textbf{0} \ \land \ e > \ \textbf{0} \ \land \ d + e + 4 \ \leq \ w | \ L \ \textbf{real} \ g = L10 \ \land (w - d - e - 4) ; \ L \ \textbf{real} \ h = g \ \times \ L1.1 ;
  \ L \ \textbf{real} \ y(ab\ e \ x); \ \textbf{int} \ p(0);
  \textbf{while} \ y \ \geq \ g \ \textbf{do} (y \ \textbf{times} \ L1.1; \ p \ \textbf{plus} \ 1);
  (y > L0 | \ \textbf{while} \ y < h \ \textbf{do} (y \ \textbf{times} \ L10; \ p \ \textbf{minus} \ 1));
  (y + L5 \ \times \ L1.1 \ \land \ \textbf{d} \ \geq \ g \ | \ y := h; \ p \ \textbf{plus} \ 1);
  \textbf{L} \ \textbf{dec} \ \textbf{string}((x \ \geq \ \textbf{0} \ | \ y \ \textbf{|} -y), \ w - e - 2, \ d) +
  "10" + \textbf{int} \ \textbf{string}(p, e + 1, 10));

d) \textbf{proc} \ L \ \textbf{dec} \ \textbf{string} = (L \ \textbf{real} \ x, \ \textbf{int} \ w, \ d) \ \textbf{string} :
  (\textbf{abs} \ x < L10 \ \land (w - d - 2) \ \land \ d \ \geq \ \textbf{0} \ \land \ d + 2 \ \leq \ w | \ \textbf{string} \ a("\""\"\""\"\""\"\""\"\""\"\""\"\""\"\""\"\""\"\""\"\""\"\""\"\""");
  \ L \ \textbf{real} \ y((\textbf{abs} \ x + L5 \ \times \ L1.1 \ \land \ \textbf{d}) \ \times \ L1.1 \ \land (w - d - 2));
  \textbf{for} \ i \ \textbf{to} \ w - 2 \ \textbf{do} \ \textbf{d plus dig char}((\textbf{int} \ c = \textbf{entier} \ \textbf{S}(y \ \textbf{times} \ L10); \ y \ \textbf{minus} \ \textbf{K}c | c));
  (x \ \geq \ \textbf{0} | "\"" | "\""") + \textbf{s}[1 : w - d - 2] + "." + \textbf{s}[w - d - 1 :: 1]);

e) \textbf{proc} \ % \ \textbf{dig char} = (\textbf{int} \ x) \ \textbf{char} = ("0123456789abcdef\"[x + 1]);

(\textbf{In connection with 10.5.2.c, d, e, see Table II.})

g) \textbf{proc} \ % \ \textbf{sign supp zero} = (\textbf{ref} [1 : \textbf{int} \ w] \ \textbf{char} \ a) :
  \textbf{for} \ i \ \textbf{from} \ 2 \ \textbf{to} \ w \ \textbf{while} \ a[i] = "0" \ \textbf{do}
  (a[i] := a[i - 1]; a[i - 1] := "."[1]);

h) \textbf{int} \ \textbf{L} \ \textbf{int} \ \textbf{width} = (\textbf{int} \ a(1));
  \textbf{while} L10 \ \land (a - 1) < L.1 \ \times \ \textbf{L} \ \textbf{max} \ \textbf{int} \ \textbf{do} \ a \ \textbf{plus} \ 1 | c);

i) \textbf{int} \ \textbf{L real width} = - \textbf{entier} \ (\textbf{L} \ \textbf{ln}(L \ \textbf{small real}) / \ \textbf{L} \ \textbf{ln}(L10));

j) \textbf{int} \ \textbf{L exp width} = 1 + \textbf{entier} \ (\textbf{L} \ \textbf{ln}(L \ \textbf{max real}) / \ \textbf{L} \ \textbf{ln}(L10));

k) \textbf{proc} % \ \textbf{nextplc} = (\textbf{file} \ \textbf{file}) :
  (((\textbf{line ended(file)} | \ \textbf{new line(file)}));
  (\textbf{page ended(file)} | \ \textbf{new page(file)});
  (\textbf{file ended(file)} | \ \textbf{undefined}));
\[
\begin{align*}
L \text{ int string} : & \quad +\overline{\text{DDDDDDDDDD}} \\
& \quad w \\
L \text{ dec string} : & \quad +\overline{\text{DDDDDD.DDDDDDDDD}} \\
& \quad w \\
L \text{ real string} : & \quad +\overline{\text{DDDDDDDDD.DDDDDDD10\cdotDDD}} \\
& \quad w
\end{align*}
\]

**TABLE II:** Display of the values of 
L int string, L dec string and L real string

---

frame

- type (1 = integer, 2 = real fixed, 3 = real floating, 4 = complex fixed, 5 = complex floating, 6 = string, 7 = integer choice, 8 = boolean)
- radix (2, 4, 8, 10 or 16)
- sign (0 = no sign frame, 1 = sign frame '+', 2 = sign frame '-')
- number of digits before point; if type = 1 then \( w-7 \), else if type = 2 or 4 then \( w-d-2 \) else if type = 3 or 5 then \( w-d-e-4 \), or, if type = 6, then number of characters in string
- number of digits after point; if type = 2, 3, 4 or 5 then \( d \)
- sign of exponent; if type = 3 or 5 then as [3]
- number of digits of exponent; if type = 3 or 5 then \( e \)

**TABLE III:** Significance of the elements of frame
10.5.3. Formatless Input

a) \texttt{proc read} = (\texttt{intype x}) : \texttt{get(stand in, x)} ;

b) \texttt{proc get} = (\texttt{file file, [1 : int w] intype x}) :
   \begin{verbatim}
   begin char k ;
   op ? = (\texttt{string s}) bool :
   (outside(file) | false | : get string(file, k) ;
    char \texttt{in string(k, loc int, s)} | 
    true | backspace(file) ; false) ;
   \end{verbatim}
   \texttt{proc read num = string expr}
   \texttt{(skip spaces ; ? "+" | k + (skip spaces ; read dig) | 
    "+" + read dig) ;}

\texttt{proc skip spaces = expr while(nextplc(file) ; ? ",") do skip} ;
\texttt{proc read dig = string expr}
\texttt{(string t(""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""""") ; while ? "0123456789" do t plus k ; t) ;}
\texttt{proc read real = string expr}
\texttt{(read num + (? "," | "," + read dig | "") + 
   (? "0" | "1" + (? "+" - | k | "+") + read dig | ")")) ;}
\texttt{for i to w do}
\texttt{[1 : int i] ref simplout y = straightin x[i] ;}
\texttt{for j to l do}
\texttt{(ref bool bb ; ref string ss ; ref char cc ;}
\texttt{(\# (ref L int ii ; (ii := y[j] | 
   val ii := L string int(read num, 10))) \#) ;}
\texttt{(\# (ref L real xx ; (xx := y[j] | 
   val xx := L string real(read real))) \#) ;}
\texttt{(\# (ref L compl ss ; (ss := y[j] | get(file, re of ss) ; 
   (skip spaces ; ? "," | get(file, im of ss) | undefined))) \#) ;}
\texttt{(bb := y[j] | skip spaces ; val bb := (? "1" | k = ",") ;}
\texttt{(cc := y[j] | nextplc(file) ; get string(file, cc) ; end) ;}
\texttt{(ss := y[j] | ref[ : int n] char t = ss ;}
\texttt{for i to n do get(file, ss[i]) ; end) ;}
\texttt{(-line ended(file) ; get(file, cc) ; cc \neq "," | undefined) ;}
\texttt{end: skip end) ;}

c) \texttt{proc L string int = ([1 : int w] char x, int r) L int :}
\texttt{(L int n(lo) ; L int lr = kr ; for i from 3 to w do}
\texttt{n := n \times lr + k(int d = char dig(x[i]) ; (d < r \mid d)) ;}
\texttt{(x[1] = "+" | n : x[1] = "+" | \neg n) ;}
10.5.3. continued

d) proc L string real = (string x) L real :
   (int e ; (char in string("." + e, x)) |
   L string dec(x[1 : e - 1]) × L10 * string int(x[e + 1 : 1], 10) |
   L string dec(x)))

e) proc L string dec = ([1 : int w] char x) L real :
   (L real r(L0) ; int p ; (char in string("--", p, x)) |
   for i to w - 2 do r := L w × r +
   (int d = char dig(x[i])) ; (d < 10 | d)) ;
   L string dec(x + ").")

f) proc % char dig = (char x) int :
   (int i ; (char in string(x, i, "0123456789abcdef") | i - 1)) ;

10.5.4. Formatted output

a) proc out = (file file, tamrof tamrof, [1 : int n] outtype x) :
   begin
   string format = format primary list pack
   ("("+ F of tamrof +")") , loc int(1) ; int p(1) ;
   for k to n do
   (1 : int l) simpout y = straightout x[k] ;
   for j to l do
   (1 : 14] int frame ; int q(p) ; pattern(format, p, frame) ;
   (frame[1] | int, real, real, compl, compl, string, intoh, bool) ;
   int: (+ (L int i ; (i := y[j] |
   trans.edit L int(file, i, format, q, frame) ; end)) +) ;
   undefined.
   real: (+ (L real x ; (x := y[j] |
   trans.edit L real(file, x, format, q, frame) ; end)) +) ;
   (+ (L int i ; (i := y[j] |
   trans.edit L real(file, i, format, q, frame) ; end)) +) ;
   undefined.
   compl: (+ (L compl x ; (x := y[j] |
   trans.edit L compl(file, x, format, q, frame) ; end)) +) ;
   (+ (L real x ; (x := y[j] |
   trans.edit L compl(file, x, format, q, frame) ; end)) +) ;
   (+ (L int i ; (i := y[j] |
   trans.edit L compl(file, i, format, q, frame) ; end)) +) ;
   undefined.
10.5.4. continued

    string: ([1 : frame[4]] char s ; char c ;
    (s ::= y[j] |
        trans edit string(file, s, format, q, frame) ; end) ;
    (c ::= y[j] |
        trans edit string(file, c, format, q, frame) ; end)) ; undefined.

    intch: (int i ; (i ::= y[j] |
        trans edit choice(file, i, format, q) ; end)) ; undefined.

    bool: (bool b ; (b ::= y[j] |
        trans edit bool(file, b, format, q) ; end)) ; undefined.

    end: do insertion(file, format, q) ; p plus 1
    )

end ;

b) proc % format primary list pack = (string s, ref int p) string :
    (string t(format primary(s, p)) ;
    while s[p] = ""," do t plus "," + format primary(s, p) ; p plus 1 ; t) ;

c) proc % format primary = (string s, ref int p) string :
    (int n, q ; string f(p plus 1 ; insertion(s, p)) ;
    q ::= p ; replicator(s, p, n) ;
    (s[p] = "(" | string t = format primary list pack(s, p) ;
      to n do f plus t | p ::= q ; f plus pattern(s, p, loc[1 : 14] int)) ;
    f + insertion(s, p)) ;

a) proc % insertion = (string s, ref int p) string :
    (int q = p ; skip insertion(s, p) ; s[q : p - 1 : 1]) ;

e) proc % skip insertion = ([1 : int l] char s, ref int p) :
    while(p > l | false | : skip align(s, p) | true |
      skip lit(s, p)) do skip ;

f) proc % skip align = (string s, ref int p) bool :
    (int q = p ; replicator(s, p, loc int) ;
    (char in string(s[p], loc int, "x y p l k") |
    p plus 1 ; true | p ::= q ; false)) ;

g) proc % replicator = (string s, ref int p, n) :
    (string t("" ; while char in string
    (s[p], loc int, "0123456789") do t plus s[p] ;
    n ::= (t = "" | 11 | string int("+" + t, 10))) ;
10.5.h, continued 2

h) proc % skip lit = (string s, ref int p) bool : 
   (int q = p ; replicator(s, p, loop int) ; 
   s[p] = """" | while(e[p plus 1] = """" | s[p plus 1] = """" | 
   true) do skip ; true | p := q ; false)) ;
i) proc % pattern = ([1 : int m] char format, ref int p, 
   ref[] int int frame) string : 
   begin int n ;
   op ? = (string s) bool :
      (skip insertion(format, p) ; p > m | false | 
      int q = p ; replicator(format, p, n) ; 
      (format[p] = "s" | p plus 1) ;
      (char in string(format[p], loop int, s) | true | p := q ; false)) ;
   proc intreal pattern = (ref[1 : ?] int frame) bool :
      ((num mould(frame[2 : 4 : 1]) | frame[1] := 1 ; l) ;
       (? "." | num mould(frame[3 : 5 : 1]) | frame[1] := 2 ; l) ;
       (? "e" | num mould(frame[5 : 7 : 1]) | frame[1] := 3 ; l) ;
       false, l : true) ;
   proc num mould = (ref[1 : 3] int frame) bool :
      ((? "n" | frame[1] := n) ; (? "n" | frame[2] plus n) ;
      while ? "as" do frame[3] plus n ;
       format[p] = "," | format[p] = "(n)" ;
   proc string mould = (ref[] int frame) bool :
      (while ? "a" do frame[4] plus n ; format[p] = ",") ;
   for i to 14 do frame[i] := 0 ;
      (intreal pattern(frame[1 : ?]) | ( ? "i" | p plus 1 ; 
       frame[1] plus 2 ; intreal pattern(frame[8 : 14 : 1])) ; end) ;
   (string mould(frame) | frame[1] := 6 ; end) ;
   (format[p] = "(" | 
   while ? "," do skip lit(format, p) ; p plus 1) ;
end: skip insertion(format, p)
end ;
10.5.4. continued 3

j) proc % trans edit L int = (file f, L int i, string format,
   ref int p, [ ] int fr) :
   trans edit string(f, L int string(i, fr[4] + 1, fr[3]), format, p, fr) ;

k) proc % trans edit L real = (file f, L real x, string format,
   ref int p, [ ] int fr) :
   trans edit string(f, stringed L real(x, fr), format, p, fr) ;

l) proc % stringed L real = (L real x, [ ] int fr) string :

m) proc % trans edit L compl = (file f, L compl s, [ ] int frame) :
   trans edit string(f, ([1 : 14] int g(fr) ; g[1] minus 2 ;
    stringed L real(re s, g[1 : ?]) + "\n" + stringed L real
    (im s, f[8 : 14 : 1]))), format, p, fr) ;

n) proc % trans edit string = (file f, string x, [1 : int m] char format,
   ref int p, [ ] int frame) :
   begin int p1(1), n ; bool supp, string s(x) ;
   op ? = (string s) bool :
     (do insertion(file, format, p) ; p > m | false |
      int q = p ; replicator(format, p, n) ;
      (supp := format[p] = "e" | p plus 1) ;
      (char in string(format[p], loc int, s) | true | p := q ; false)) ;
   proc copy = expr((-sup | put string(f, s[p1]) ; p1 plus 1) ;
   proc inreal mould = expr
     (? "x" | sign mould(frame[3]) ; int mould ;
     (? "." | copy ; int mould |: s[p1] = "." | p1 plus 1) ;
     (? "e" | copy ; sign mould(frame[6]) ; int mould)) ;
   proc sign mould = (int sign) : (sign = 0 | p1 plus 1 | s[p1] := (s[p1] = "+" | (sign | "+", "-") | "-")) ;
   (? "x" | sign supp zero(s[p1 : p1 + n : 1]) | n := 0) ;
   put string(file, s[p1 : p1 + n : 1]) ; p plus 1) ;
   proc int mould = expr
     (l : (? "a" | bool as (true) ; to n do
        (a[p1] = "0" ^ as | put string(file, ",") ;
        p1 plus 1 | as := false ; copy) ; l)) ;
     (? "d" | to n do copy ; l)) ;
10.5.4. continued 4

    proc string mould = expr while ? "a" do to n do copy ;
    tes: (frame[1] = 6 | string mould |: intreal mould ;
        frame[1] > 3 | p plus 1 ; copy ; intreal mould)
    end ;

o) proc % trans edit choice = (file f, int c, string format, ref int p) :
    (c > 0 | do insertion(f, format, p) ; p plus 2 ;
    to c - 1 do (skip lit(format, p) ; format[p] = "," | p plus 1 | undefined) ;
    do lit(f, format, p) ;
    while format[p] ≠ "," do (p plus 1 ; skip lit(format, p)) ;
    p plus 1 | undefined) ;

p) proc % trans edit bool = (file f, bool b, string format, ref int p) ;
    (do insertion(f, format, p) ; (format[p] = ")" | p plus 2 ;
    b | do lit(f, format, p) ; p plus 1 ; skip lit
    (format, p) | skip lit(format, p) ; p plus 1 ; do lit(f, format, p)) |
    put string(f, (b | "1" | "0")) ; p plus 1) ;

q) proc % do insertion = (file f, (l : int l) char s, ref int p) :
    while(p > l | false) | do align(f, s, p) | true |
    do lit(f, s, p) | do skip ;

r) proc % do align = (file f, string s, ref int p) bool :
    (int q = p ; int n ; replicator(s, p, n) ;
    (s[p] = "w" | to n do space(f) ; l |:
    s[p] = "y" | to n do backspace(f) ; l |:
    s[p] = "p" | to n do new page(f) ; l |:
    s[p] = "m" | to n do new line(f) ; l |
    s[p] = "k" | char of f := n ; l) ; p := q ; false.
    l : p plus 1 ; true) ;

s) proc % do lit = (file f, string s, ref int p) bool :
    (int q = p ; int n ; replicator(s, p, n) ; (s[p] = "" | while(s[p plus 1] = "" | s[p plus 1] = "" | true) do put string(f, s[p]) ; true | p := q ; false) ;
10.5.5. Formatted input

a) \texttt{proc in = (file file, \texttt{tamrof} tamrof, \{1 : int n\} inttype x) :}

\begin{verbatim}
begin string format =
  format primary list pack("""4 F of tamrof +""", loc int(1)) ;
  int p(1) ;
  for k to n do
  (\{1 : int l\} simplout y = straightout x[k] ;
  for j to l do
  (\{1 : int 1\} int frame ; int q(p) ; pattern(format, p, frame) ;
  (frame[1] | int, real, real, compl, compl, string, intoh, bool) ;
  int: (\{ (ref \& int ii ; (ii ::= y[j] |
  trans indit L int(file, ii, format, q, frame) ; end)) \} ;
  undefined.
  real: (\{ (ref \& real xx ; (xx ::= y[j] |
  trans indit L real(file, xx, format, q, frame) ; end)) \} ;
  undefined.
  compl: (\{ (ref \& compl zz ; (zz ::= y[j] |
  trans indit L compl(file, zz, format, q, frame) ; end)) \} ;
  undefined.
  string: (ref string ss ; ref char oc ; [1 : frame[4]] char t ;
  trans indit string(file, t, format, q, frame) ;
  (ss ::= y[j] | val ss := t ; end | oc ::= y[j] |
  val oc := t[l] ; end)) ;
  undefined.
  intoh: (ref int ii ; (ii ::= y[j] |
  trans indit choice(file, ii, format, q) ; end)) ;
  undefined.
  bool: (ref bool bb ; (bb ::= y[j] |
  trans indit bool(file, bb, format, q) ; end)) ;
  undefined.
end: req insertion(file, format, q) ; p plus 1 ))
end ;
\end{verbatim}
10.5.5. continued

b) proc % trans indinit L int =

(file f, ref L int i, string format, ref int p, [] int fr) :
(string t ; trans indinit string(f, t, format, p, fr) ;
 i := L string int(t, 10)) ;

c) proc % trans indinit L real =

(file f, ref L real x, string format, ref int p, [] int fr) :
(string t ; trans indinit string(f, t, format, p, fr) ;
 x := L string real(t)) ;

d) proc % trans indinit L compl =

(file f, ref L compl x, string format, ref int p, [] int fr) :
(string t ; int i ; trans indinit string(f, t, format, p, fr) ;
 x := (char in string("_", i, t) |
 (L string real(t[i : i - 1]) L string real(t[i + 1 : : i]))) ;

e) proc % trans indinit string =

(file f, ref string t, [1 : int m] char format,
 ref int p, [] int frame) :

begin int n ; bool supp ; char k ; string x(""") ;
 op ? = (string s) bool :

 (req insertion(format, p) ; p > m | false |
 int q = p ; replicator(format, p, n) ;
 (supp := format[p] = "e" | p plus 1) ;
 (char in string(format[p], loc int, s) | true |
 p := q ; false)) ;

op ! = (char a) : (x plus(supp | a : next = a | a)) ;
 proc next = char expr(get string(f, k) ; k) ;
 proc intreal mould = expr
 ("_" ; sign mould(frame[3]) ; int mould ;
 ("_" | ! "_" ; int mould) ;
 (? "$" | ! "10" ; sign mould(frame[6]) ; int mould)) ;
 proc sign mould = (int sign) : (sign > 0 |
 (? "$" | bool as(true), sk(false) ; string t(""")) ;
 to n + 1 do(next = "_" | sk := true ; (!as | undefined) !
 as := false ; t plus k) ;
 x plus(sign = 2 ^ sk ^ t[7] # "$" | "$" + t | t) |
 x plus(sign = 2 ^ next = "$" | "$" | k)) ;
 p plus 1) ;
10.5.5. continued 2

```
proc int mould = expr
(l : (? "a" | bool zs (true)) ; to n do x plus
  (supp | "0" | next = "," \& zs | "0" | zs := false ; k) ; l |:
  ? "d" | to n do x plus(supp | "0" | next) ; l)) ;
proc string mould = expr while ? "a" do to n do x plus
  (supp | "," | next) ;
tis: (frame[1] = 6 | string mould | : intreal mould ; frame[1] > 3 | ! "1" ; intreal mould) ;
t := x
end ;

f) proc % trans indit choice =
  (file f, ref int a, string format, ref int p) :
  (req insertion(f, format, p) ; p plus 2 ; a := 1 ;
    while ¬ ask lit(f, format, p) do
      (a plus 1 ; format[p] = "," | p plus 1 | undefined) ;
      while format[p] ≠ "," do(p plus 1 ; skip lit(format, p)) ;
      p plus 1 ; req insertion(f, format, p)) ;

g) proc % trans indit bool =
  (file f, ref bool b, string format, ref int p) :
  (req insertion(f, format, p) ; (format[p + 1] = "," | p plus 2 ; (b := ask lit(f, format, p) |
    p plus 1 ; skip lit(format, p) | ¬ ask lit(f, format, p) | undefined) |
    char k ; get string(f, k) ; b := (k = "," | true |:
    k = "," | false)) ;
    p plus 1 ; req insertion(f, format, p)) ;

h) proc % req insertion = (file f, [1 : int l] char s, ref int p) :
  while(p > 1 | false | : do align(f, s, p) | true |
    req lit(f, s, p)) do skip ;
i) proc % req lit = (file f, string s, ref int p) bool :
  (int q = p ; int n ; replicator(s, p, n) ;
    (s[p] = """" | int r = p ; to n do(p := r ;
      while(s[p plus 1] = """" | s[p plus 1] = """" | true) do
        (char k ; get string(f, k) ; k ≠ s[p] | undefined)) ; true |
        p := q ; false)) ;
```
10.5.5. continued 3

j) proc % ask lit = (file f, string s, ref int p) bool:
   (int c = char of f ; int n ; replicator(s, p, n) ;
   s[p] = """" | int r = p ; to n do(p := r ;
   while(s[p plus 1] = """" | s[p plus 1] = """" | true) do
   (char k ; get string(f, k) ; k ≠ s[p] | l)) ; true.
   l: while(s[p plus 1] = """" | s[p plus 1] = """" | true) do skip ;
   char of f := c ; false)) ;

10.5.6. Binary output

a) proc write bin = ([] outtype x) : put bin(stand back, x) ;
b) proc put bin = (file file, [1 : int n] outtype x) :  
   if bin possible[chan of file] ∧ opened of file
   then if ¬ set possible[chan of file] then state def of file
      then(state get of file ∧ ¬ state bin of file | undefined)
      else state def of file := state bin of file := true ;
      state get of file := false
   fi ;
   for k to n do
   ([1 : int l] simplout y = straight out x;k) ;
   for i to l do
   ([1 : int m] int bin = to bin(file, y[i]) ;
   for i to m do(next plo(file) ;
   book of bfile of file(page of file, lines of file,
   char of file) := bin[i]))
   else undefined
   fi ;
c) proc % to bin = (file f, simplout x) [] int :
   a value of mode 'row of integral' whose lower bound is one,
   and whose upper bound depends on the value of 'f' and on the
   mode of the value of 'x'; furthermore,
   k = from bin(f, to bin(f, x)) c ;
d) proc % from bin = (file f, [] int y) simplout :
   a value, if one exists, of a mode from which that specified by
   simplout is unfolded, such that y = to bin(f, from bin(f, y)) c ;
10.5.7. Binary input

a) `proc` `read` `bin` = ([ ] `intype` `x`) : `get` `bin`(stand back, `x`); 

b) `proc` `get` `bin` = (`file` `file`, [1 : `int` `n`] `intype` `x`): 
- `if` `bin` possible[chan of file] ^ opened of file 
  `then` `if` ¬ set possible [chan of file] `then` state def of file 
  `then` (¬ state get of file v ¬ state bin of file | undefined) 
  `else` state def of file := state bin of file := 
  state get of file := `true` 

`fi` ;

`for` `k` `to` `n` `do`
- ([1 : `int` `l`] `ref` `simplout` `y` = `straightin` `s[k]`); 
- `for` `j` `to` `l` `do`
- ([1 : `int` `m`] `int` `bin` = `to` `bin`(file, `y[.j]`); `simplout` `r`;
- `for` `i` `to` `m` `do` (next `plot`(file);
- `bin[i]` := `book of bfile of file[page of file, line of file,` 
  `char of file]`;
- `r` := `from` `bin`(file, `bin`);

  `{ L `ref` `int` `ii` ; (`ii` ::= `y[j]`) : 
  `val` `ii` ::= `r` | `l` | undefined} `}`;
  `{ L `ref` `real` `xx` ; (`xx` ::= `y[j]`) : 
  `val` `xx` ::= `r` | `l` | undefined} `}`;
  `{ L `ref` `compl` `as` ; (`as` ::= `y[j]`) : 
  `val` `as` ::= `r` | `l` | undefined} `}`;
  `(` `ref` `string` `ss` ; (`ss` ::= `y[j]`) : 
  `val` `ss` ::= `r` | `l` | undefined) `}`;
  `(` `ref` `char` `cc` ; (`cc` ::= `y[j]`) : `val` `cc` ::= `r` | `l` | undefined) `}`;
  `(` `ref` `bool` `bb` ; (`bb` ::= `y[j]`) : `val` `bb` ::= `r` | `l` | undefined) `}`;

`else` undefined
`fi` ;

{But Eeyore wasn't listening. He was 
  taking the balloon out, and putting it 
  back again, as happy as could be. ... 
  Winnie-the-Pooh, A.A. Milne.}
11. Examples

11.1. Complex square root

A declaration in which \texttt{compsqrt} is a procedure-with-a-[complex]-
parameter-delivering-a-[complex]-identifier (Here [complex] stands for
structured-with-a-real-named-letter-r-letter-e-and-a-real-named-
letter-1-letter-m.):

\begin{itemize}
\item[a)] \texttt{proc compsqrt \equiv (compl \; x) \; compl \; : \; \text{the square root whose real part
\text{is nonnegative of the complex number } x \; \text{a}}}
\item[b)] \texttt{begin real \; x = \text{re} \; x, \; y = \text{im} \; x ;}
\item[c)] \texttt{real \; rp = \text{sqrt}((\text{abs} \; x + \text{sqrt}(x + 2 + y + 2))/2) ;}
\item[d)] \texttt{real \; ip = (rp = 0 \; | \; 0 \; | \; y/(2 \times rp)) ;}
\item[e)] \texttt{(x \geq 0 \; | \; (rp \downarrow \; ip) \; | \; (\text{abs} \; ip \downarrow \; (y \geq 0 \; | \; rp \; | \; -rp)))}
\item[f)] \texttt{end compsqrt}
\end{itemize}

[complex]-expression-calls \{8.7.1.b\} using \texttt{compsqrt}:

\begin{itemize}
\item[g)] \texttt{compsqrt(x)}
\item[h)] \texttt{compsqrt(-3.14)}
\item[i)] \texttt{compsqrt(-1)}
\end{itemize}
11.2. Innerproduct1

A declaration in which \textit{innerproduct1} is a procedure-with-a-integral-parameter-and-a-procedure-with-a-integral-parameter-delivering-a-real-parameter-and-a-procedure-with-a-integral-parameter-delivering-a-real-parameter-delivering-a-real-identifier:

\begin{itemize}
  \item[a)] \texttt{proc innerproduct1} = (\texttt{int n}, \texttt{proc(int) real x, y}) \texttt{real} :
  \begin{itemize}
    \item comment the innerproduct of two vectors, each with \texttt{n} components,
    \item \texttt{x(i), y(i), i = 1, \ldots, n}, where \texttt{x} and \texttt{y} are arbitrary mappings from integer to real number \texttt{comment}
  \end{itemize}
  \\
  \item[b)] \texttt{begin long real s(long 0);}
  \\
  \item[c)] \texttt{for i to n do s plus leng x(i) \times leng y(i);}
  \\
  \item[d)] \texttt{short s}
  \\
  \item[e)] \texttt{end innerproduct1}
\end{itemize}

Real-expression-calls \{8.7.1.b\} using \textit{innerproduct1}:

\begin{itemize}
  \item[f)] \texttt{innerproduct1(m, (int j) : x[j], (int j) : y[j])}
  \\
  \item[g)] \texttt{innerproduct1(n, nsin, noos)}
\end{itemize}

11.3. Innerproduct2

A declaration in which \textit{innerproduct2} is a procedure-with-a-reference-to-row-of-real-parameter-and-a-reference-to-row-of-real-parameter-delivering-a-real-identifier:

\begin{itemize}
  \item[a)] \texttt{proc innerproduct2} = (\texttt{ref1 : int n}) \texttt{real a, b}) \texttt{real} :
  \begin{itemize}
    \item comment the innerproduct of two vectors \texttt{a} and \texttt{b} with \texttt{n} elements \texttt{a}
  \end{itemize}
  \\
  \item[b)] \texttt{begin long real s(long 0);}
  \\
  \item[c)] \texttt{for i to n do s plus leng a[i] \times leng b[i];}
  \\
  \item[d)] \texttt{short s}
  \\
  \item[e)] \texttt{end innerproduct2}
\end{itemize}

Real-expression-calls using \textit{innerproduct2}:

\begin{itemize}
  \item[f)] \texttt{innerproduct2(x1, y1)}
  \\
  \item[g)] \texttt{innerproduct2(y2[2], y2[, 3])}
\end{itemize}
11.4. Innerproduct3

A declaration in which innerproduct3 is a procedure-with-a-reference-to-integral-parameter-and-a-integral-parameter-and-a-procedure-delivering-a-real-parameter-and-a-procedure-delivering-a-real-parameter-delivering-a-real-identifier:

a) \textit{proc innerproduct3} = \texttt{(ref int} \ i, \ \texttt{int} \ n, \ \texttt{proc real} \ x_{i}, \ \texttt{yi}) \ \texttt{real} : \\
\texttt{begin} \ \texttt{comment the innerproduct of two vectors whose} \ n \ \texttt{elements} \ \texttt{are} \ \texttt{the} \\
\texttt{values of the expressions} \ x_{i} \ \texttt{and} \ \texttt{yi} \ \texttt{and which depend, in general,} \\
\texttt{on the value of} \ i \ \texttt{comment} \\
b) \ \texttt{begin long real} \ s(\texttt{long} \ 0) ; \\
c) \ \texttt{for k to} \ n \ \texttt{do} (i := k ; \ \texttt{s plus leng} \ x_{i} \ \times \ \texttt{leng} \ y_{i}) ; \\
d) \ \texttt{short s} \\
e) \ \texttt{end innerproduct3} \\

A real-expression-call using innerproduct3:

f) \texttt{innerproduct3}(j, \ \texttt{8}, \ x[\texttt{j}], \ y[\texttt{j} + 1]) \\

11.5. Largest element


a) \textit{proc abemax} = \texttt{(ref} \ i : \ \texttt{int} \ m, \ 1 : \ \texttt{int} \ n) \ \texttt{real} \ a, \\
b) \ \texttt{a result a ref real} \ y, \ \texttt{a subscripts a ref int} \ i, \ \texttt{k} : \\
\texttt{comment the absolute value of the element of greatest absolute value} \\
\texttt{of the} \ m \ \texttt{by} \ n \ \texttt{matrix} \ a \ \texttt{is assigned to} \ y, \ \texttt{and the subscripts of this} \\
\texttt{element to} \ i \ \texttt{and} \ k \ \texttt{comment} \\
c) \ \texttt{begin y := -1 ;} \\
d) \ \texttt{for p to} \ m \ \texttt{do for} \ q \ \texttt{to} \ n \ \texttt{do} \\
e) \ \texttt{if abs a[p, q] > y then} \ \texttt{y := abs a[i := p], (k := q)] fi} \\
f) \ \texttt{end abemax} \\

Statement-calls \texttt{8.7.1.c} using abemax:

\begin{itemize}
\item \texttt{abemax(x8, x, i, j)}
\item \texttt{abemax(x8, x, loc int, loc int)}
\end{itemize}
11.6. Euler summation

a) \textit{proc euler = (proc(int) real f, real eps, int tim) real :}
   \textit{comment the sum for i from 1 to infinity of f(i), computed by means of a suitably refined euler transformation. The summation is terminated when the absolute values of the terms of the transformed series are found to be less than eps tim times in succession. This transformation is particularly efficient in the case of a slowly convergent or divergent alternating series comment}

b) \begin{verbatim}
begin int n(1), t; real mn, ds(eps); [1 : 16] real m ;
real sum((m[1] := f(1))/2) ;
for i from 2 while(t := (abs ds < eps | t + 1 | 1)) \leq \text{tim} do
begin mn := f(t) ;
for k to n do begin mn := ((ds := mn) + m[k])/2 ;
m[k] := ds end ;
sum plus(ds := (abs mn < abs m[n] \wedge n < 16 |
   n plus 1 ; m[n] := mn ; mn/2 | mn))
end ;
sum
end euler
\end{verbatim}

An expression-call using euler:

m) euler((int i) : (odd i | -1/i | 1/i), 1, 10, 5, 2)

11.7. The norm of a vector

a) \textit{proc norm = (ref[1 : int n] real a) real :}
   \textit{a the euclidean norm of the vector a with n elements a}

b) \begin{verbatim}
(long real s(long 0) ;
for k to n do s plus leng a[k] \& 2 ;
short long sqrt(s))
\end{verbatim}

For a use of norm as an expression-call, see 11.8.c.
11.8. Determinant of a matrix

a) \text{proc det} = (\text{ref} [1 : \text{int} n, 1 : \text{int} n] \text{real} a,

b) \text{ref} [1 : \text{int} n] \text{int} p) \text{real}:

\begin{comment}
the determinant of the square matrix \(a\) of order \(n\) by the
method of Crout with row interchanges: \(a\) is replaced by its triangular
decomposition \(L \times U\) with all \(u[k, k] = 1\). The vector \(p\) gives as
output the pivotal row indices; the \(k\)-th pivot is chosen in the \(k\)-th
column of \(L\) such that \(\abs{L[i, k]} / \text{row norm is maximal} \end{comment}

c) \begin{align*}
\text{begin} & 1 : n \text{ real} v; \text{ real} d(1), r(-1), s, \text{ pivot} ; \\
\text{for} & i \text{ to} n \text{ do } v[i] := \text{norm}(a[i]) ; \\
\text{for} & k \text{ to} n \text{ do } \\
\text{begin} & \text{int} k1 = k - 1 ; \text{ref} \text{ int} pk = p[k] ; \\
\text{ref} & [1, 1 : k1], au = a[1 : k1] ; \\
\text{ref} & [1, \text{ real} ak = a[k], ka = a[, k], apk = a[pk], \\
\text{for} & i \text{ from} k \text{ to} n \text{ do } \\
\text{begin} & \text{ref} \text{ real} aik = ka[i] ; \\
\text{if} & (s := \text{abs}(aik \times \text{innerproduct} 2(au[i], ka))/v[i]) > r \\
\text{then} & r := s ; pk := i \text{ fi} \\
\text{end} & \text{for} i ; \\
\text{v[pk]} := v[k] ; \text{ pivot := ka[pk] ;} \\
\text{for} & j \text{ to} n \text{ do } \\
\text{begin} & \text{ref} \text{ real} akj = ak[j], apkj = apk[j] ; \\
\text{r} := & akj ; akj := \begin{cases} & \text{if} j \leq k \text{ then} apkj \\
& \text{else}(apkj - \text{innerproduct} 2(alk, au[, k1, j]))/\text{pivot} \text{ fi} ; \\
\text{if} & pk \neq k \text{ then} apkj := -r \text{ fi} \\
\text{end} & \text{for} j ; \\
\text{d times pivot} \\
\text{end} & \text{for} k ; \\
d & \\
\text{end det}
\end{align*}

An expression-call using det:

z) \text{det}(y2, i1)
11.9. Greatest common divisor

An example of a recursive procedure:

a) \texttt{proc \textit{gcd} = (int \ a, \ b) \ int :}
   
c the greatest common divisor of two integers \ c
b) \ (b = 0 \mid abs \ a \mid \textit{gcd}(b, \ a + 1 : b))

An expression-call using \textit{gcd}:

c) \ \textit{gcd}(n, \ 124) .

11.10. Continued fraction

An example of a recursive operation:

a) \texttt{op / = ([1 : int \ n] \ real \ a, \ b) \ real :}
   
\textit{comment} the value of \ a/b \ is \ that \ of \ the \ continued \ fraction
   
\( a_1/(b_1 + a_2/(b_2 + \ldots + a_n/b_n)) \ldots \) \textit{comment}
   
b) \ (n = 1 \mid a[1]/b[1] \mid a[1]/(b[1] + a[2 :: 1]/b[2 :: 1]))

A formula using \texttt{/}:

c) \ x/y \texttt{1}.

{The use of recursion may often be elegant rather than efficient
as in 11.9 and 11.10. See, however, 11.11 for an example in which
recursion is of the essence.}
11.11. Formula manipulation

a) \texttt{begin union form = (ref const, ref var, ref triple, ref call);} \\
b) \texttt{struct const = (real value);} \\
c) \texttt{struct var = (string name, real value);} \\
d) \texttt{struct triple = (form left operand, int operator, form right operand);} \\
e) \texttt{struct function = (ref var bound var, form body);} \\
f) \texttt{struct call = (ref function function name, form parameter);} \\
g) \texttt{int plus = 1, minus = 2, times = 3, by = 4, to = 5;} \\
h) \texttt{const zero (0), one (1);} \\
i) \texttt{op = = (form a, ref const b) bool :} \\
\hspace{1cm} \texttt{(ref const ea ; (ea ::= a | val ea ::= b | false)) ;} \\
j) \texttt{op + = (form a, b) form :} \\
\hspace{1cm} \texttt{(a = zero | b | b = zero | a | triple(a, plus, b));} \\
k) \texttt{op - = (form a, b) form :} \\
\hspace{1cm} \texttt{(b = zero | a | triple(a, minus, b));} \\
l) \texttt{op \times = (form a, b) form :} \\
\hspace{1cm} \texttt{(a = zero \lor b = zero | zero | a = one | b | b = one | a |} \\
\hspace{2cm} \texttt{triple(a, times, b));} \\
m) \texttt{op / = (form a, b) form :} \\
\hspace{1cm} \texttt{(a = zero \land b = zero | zero | b = one | a | triple(a, by, b));} \\
n) \texttt{op \& = (form a, ref const b) form :} \\
\hspace{1cm} \texttt{(a = one \lor b ::= zero | one | b ::= one | a | triple(a, to, b));} \\
o) \texttt{proc derivative of = (form e, a with respect to a ref var x) form :} \\
p) \texttt{begin ref const ec ; ref var ev ; ref triple et ; ref call ef ;} \\
q) \texttt{if ec ::= e then zero} \\
r) \texttt{else ev ::= e then(val ev ::= x | one | zero)} \\
s) \texttt{else et ::= e then} \\
t) \texttt{form u = left operand of et, v = right operand of et,} \\
u) \texttt{udash = derivative of (u, a with respect to a x),} \\
v) \texttt{vdash = derivative of (v, a with respect to a x);} \\
w) \texttt{case operator of et in} \\
x) \texttt{udash + vdash, udash - vdash,} \\
y) \texttt{u \times vdash + udash \times v, (udash - et \times vdash)/v,} \\
z) \texttt{v \times u \& const(ec ::= v ; value of ec - 1) \times udash} \\
\texttt{esac}
11.11. continued

aa) \texttt{else ef ::= e then}

ab) \texttt{ref function f = function name of ef;}

ac) \texttt{form g = parameter of ef;}

ad) \texttt{ref var y = bound var of f;}

ae) \texttt{function fdash(y, derivative of(body of f, y));}

af) \texttt{call(fdash, g) \times derivative of(g, x)}

ag) \texttt{fi}

ah) \texttt{end derivative;}

ai) \texttt{proc value of = (form e) real :}

aj) \texttt{begin ref const ec \& ref var ev \& ref triple et \& ref call \& ef;}

ak) \texttt{if ec ::= e then value of ec}

al) \texttt{else ev ::= e then value of ev}

am) \texttt{else et ::= e then}

an) \texttt{real u = value of(left operand of et),}

ao) \texttt{v = value of(right operand of et);}

ap) \texttt{case operator of et in}

aq) \texttt{u + v, u - v, u \times v, u / v, exp(v \times ln(u)) esac}

ar) \texttt{else ef ::= e then}

as) \texttt{ref function f = function name of ef;}

at) \texttt{value of bound var of f ::= value of(parameter of ef);}

au) \texttt{value of(body of f)}

av) \texttt{fi}

aw) \texttt{end value of;}

ax) \texttt{form f, g \& var a("a", skip), b("b", skip), x("x", skip);}

ay) \texttt{start here:}

az) \texttt{read((value of a, value of b, value of x));}

ba) \texttt{f ::= a + x / (b + x); g ::= (f + one) / (f - one);}

bb) \texttt{print((value of a, value of b, value of x,}

bc) \texttt{value of(derivative of(g, a with respect to x))))}

bc) \texttt{end example.
11.12. Information retrieval

a) \texttt{begin } \texttt{struct book = (string title, ref book next),}
\hspace{1em} \texttt{auth = (string name, ref auth next, ref book book);}
\texttt{ref book book; ref auth auth, first auth(nil), last auth;}
\texttt{string name, title; int i; file input, output;}
\texttt{format format = fx30al, 80alf;}
\texttt{proc update = expr if val first auth := nil}
\hspace{1em} \texttt{then auth := first auth := last auth := auth(name, nil, nil)}
\texttt{else auth := first auth; while val auth #: nil do}
\hspace{1em} \texttt{(name = name of auth | known | auth := next of auth);}
\texttt{last auth := next of last auth := auth :=}
\hspace{1em} \texttt{auth(name, nil, nil);}
\texttt{known: skip fi;}
\texttt{open(input, remote in); open(output, remote out);}
\texttt{out(output, fp}
\texttt{m) "to enter a new author, type ""author"",
\hspace{1em} a space, and his name."l}
\texttt{n) "to enter a new book, type ""book"", a space,
\hspace{1em} the name of the author, a new line and the title."l}
\texttt{o) "for a listing of the books by an author, type ""list"",
\hspace{1em} a space, and his name."l}
\texttt{p) "to find the author of a book, type ""find",
\hspace{1em} a new line and the title."l}
\texttt{q) "to end, type ""Sa",endif, ""end""nn);}
\texttt{r) client: in(input, fio("author", "book", "list", "find", "end", "")f, i);}
\texttt{s) case i in author, book, list, find, end, error esac;}
\texttt{t) author: in(input, format, name); update; client;}
\texttt{u) book: in(input, format, (name, title)); update;}
\hspace{1em} else book := book of auth; while val next of book #: nil do
\hspace{1em} (title = title of book | client | book := next of book);}
\texttt{x) fi; client;
11.12. continued

aa) list: in(input, format, name); update;
ab) out(output, fp"author: "30a1f, name);
ac) if val first of auth :=. nil
ad) then put(output, "no publications")
ae) else while val book :# nil do
af) begin if line number(output) = max line[remote out]
ag) then out(output, f41k"continued on next page"p
    "author: "30a41k"continued"lf, name)
ah) fi ; out(output, f30a1f, title of book);
ai) book := next of book
aj) end
ak) fi ; client;
al) find: in(input, f180a1f, title); auth := first auth;
am) while val auth :# nil do
an) begin book := book of auth; while val book :# nil do
ao) if title = title of book
ap) then out(output, f1"author: "30a1f,
    name of auth); client
aq) else book := next of book
ar) fi ; auth := next of auth
as) end ; to 2 do new line(output);
at) put(output, "unknown"); client;
au) end: new page(output); put(output, "signed off");
av) close(input); close(output).
aw) error: new line(output); (output, "mistake, try again.");
ax) new line(input); client
ay) end authors and titles enquiry system

{And what impossibility would slay
in common sense, sense saves another way.
All's well that ends well, W. Shakespeare.}
12. Glossary

Given below are the locations of the first, and sometimes other, instructive appearances of a number of words which, in Chapters 1 up to 10 of this Report, have a specific technical meaning. A word appearing in different grammatical forms (e.g. "conversion", "convert", "converted", "converting") is given once, usually as infinitive (e.g. "convert").

action 2.2 ; 2.2.5
adjusted from 2.2.4.1.h
agree 5.5.1
ALGOL-68 4.4
alternate 10.5.1
applied 4.1.2.a
appoint 6.0.2.a
arithmetic 2.2.3.1.a
assign 2.2.2.1; 8.8.2.c
asterisk 1.1.2.c
automaton 1.1.1.a
backfile 10.5.1
capital letter 1.1.3.a
case 9.4.c
channel 10.5.1
closed 10.5.1
collateral action 2.2.2.5
colon 1.1.2.c
comma 1.1.2.b
compile 2.3.c
completed 6.0.2.a
component of 2.2.2.h, k
composite 3.1.2.d
computer 1.1.1.a
connected to 4.4.3.b
constituent 1.1.6.d; 2.2.2.b
contain 1.1.6.b; 2.2.2.b
context conditions 4.4
conversion key 10.5.1
convert 5.5.1
define 2.2.2.c; 4.1.2.a, b
describe 2.2.3.3.b
descriptor 2.2.3.3.a
developed 7.1.2.b
direct production 1.1.2.c
divided by 2.2.3.1.c ; 10.2.3.medit 5.5.1
elaborate 1.1.6.e
elaborate collaterally 6.3.2.a
element 2.2.2.k; 2.2.3.3.a
elementary 2.2.5; 6.4.2.c
end of file 10.5.1
English language 1.1.1.b
environment enquiry 10.a; 10.1
equivalent to 2.2.2.h, j
extended language 1.1.1.a; 1.1.7
extension 1.1.7
external object 2.2.1
false 2.2.3.1.e
field 2.2.2.k ; 2.2.3.2
file 5.5.1; 10.5.1
follow 1.1.6.a
formal language 1.1.1.b
format 2.2.3; 2.2.3.4
halted 6.0.2.a; 10.4.a
hardware language 1.1.8.b
hold 2.2
home 4.1.2.b
human being 1.1.1.a
identification condition 4.4.1
of the same mode as 2.2.2.h, i
opened 10.5.1
operator-applied 4.3.2.a
operator-define 2.2.2.c; 4.3.2.a, b
outer scope 2.2.4.1.a, c, d
output 5.5.1; 10.5.2, 4, 6
output-compatible 5.5.1
paranotion 1.1.6.c
performed 5.5.1
permanent 2.2.2
plain value 2.2.3; 2.2.3.1
point 1.1.2.c
portrayal 2.2.4.1.d
possess 2.2.2.d, e, f
possibly intended 2.3.c
pragmatic 1.3
precede 1.1.6.a
preelaborate 1.1.6.f
production 1.1.2.e; 1.1.3.d
production rule 1.1.2.a
proper 4.4
protected 6.0.2.d
publication language 1.1.8.b
quintuple 2.2.3.3.b
reach 4.4.3.a
refer to 2.2.2.h, i
related to 2.2.4.1.i
relationship 2.2; 2.2.2
representation 1.1.8.a
representation language
1.1.1.a; 1.1.8
required 5.5.1
resumed 6.0.2.a; 10.0.4.b
routine 2.2.2; 2.2.3.4
scope 2.2.3.5.a; 2.2.4.2
select 2.2.3.2; 2.2.3.3.a
semicolon 1.1.4
serial action 2.2.5
smaller than 2.2.2.h, j
small letter 1.1.2.a
standard declaration 10; 10.a
standard file 10.5.1.2
standard mathematical constant
  or function 10.a; 10.3
standard operation 10.a; 10.2
standard priority 10.a; 10.2.0
straighten 10.5.0.2
strict language 1.1.1.a; 1.1.2.a
stride 2.2.3.3.b
string 5.5.1
structured from 2.2.4.1.j
structured value 2.2.3; 2.2.3.2
sublanguage 2.3.c
subvalue 2.2.2.k; 2.2.3.3.c
successor 6.0.2.a
supersede 2.2.3.3.b; 8.8.2.a
suppressed 5.5.1
symbol 1.1.2.d
synchronization operation 10.a; 10.4
terminal production
  1.1.2.f; 1.1.3.e; 1.1.6.a
terminate 6.0.2.a
textual order 1.1.6.a
times 2.2.3.1.c, 10.2.3.1
transcribed from 5.5.1.1
transcribed onto 5.5.1.1
transput 5.5.1
transput declaration 10.a; 10.5
true 2.2.3.1.e
undefined 1.1.6.g
uniqueness conditions 4.4.3
united from 2.2.4.1.h
upper bound 2.2.3.3.b
upper state 2.2.3.3.b
value 2.2.1; 2.2.2.e, f, g; 2.2.3
widen 2.2.3.1.d
written 5.5.1

{Denn eben, wo Begriffe fehlen,
Da stellt ein Wort zur rechten Zeit sich ein.
Faust, J.W. von Goethe.}
EE. Ephemeral Epilogue

EE.1. Errata

{Cuiusvis hominis est errare, nullius, nisi insipientis in errore perseverare. Orationes Philippicae, M.T. Cicero.}

EE.1.1. Syntax

a) errata : erratum sequence.
b) erratum : location list, change.
c) location : line number ; fragment.
d) line number : set off, shift option.
e) set off : section, paragraph option.
f) section : integral denotation, point symbol, section option.
g) paragraph : TAG.
h) shift : plusminus, integral denotation.
i) fragment : top, up to symbol, bottom.
j) top : line number.
k) bottom : line number.
l) change : instead of symbol, old text denotation, substitute symbol, new text, please symbol.
m) old text denotation : old text ; begin of old text, query symbol, query symbol, query symbol, end of old text.

EE.1.2. Representations

<table>
<thead>
<tr>
<th>symbol</th>
<th>representations</th>
</tr>
</thead>
<tbody>
<tr>
<td>instead of symbol</td>
<td>*</td>
</tr>
<tr>
<td>substitute symbol</td>
<td>+</td>
</tr>
<tr>
<td>please symbol</td>
<td>*</td>
</tr>
<tr>
<td>query symbol</td>
<td>?</td>
</tr>
</tbody>
</table>

{Examples:
  b) 15.2.3.c-7 * x.y + x.z * ;
      14.2., 14.2.+3, 14.2.+7, 15.2.3.c-7 * a → b * ;
      0.:11.11.bc = Introduction ?? example. → * ;
  c) 15.2.3.c-7 ; 0.:11.11.bc ;
  d) 14.2. ; 14.2.+3 ;
  e) 14.2. ; 15.2.3.c ;
  f) 14.2. ;
  g) c ;}
EE1.2. continued

h) \(+3 ; -7 ;\)
i) \(0.:11.11.bc;\)
j) \(* x.y \rightarrow x.z *;\)
k) \(x.y ;\) Introduction ?? example.

EE.1.3. Semantics

a) Errata are elaborated in the following steps:
Step 1: The errata are considered;
Step 2: If the considered errata contain a location-list containing a
comma-symbol, then other errata are considered instead which are the
same sequence of Report-tokens as would be obtained by replacing that
comma-symbol in the considered errata by the change following that
location-list, and Step 2 is taken;
Step 3: The constituent erratum of the considered errata are elaborated
collaterally.

b) An erratum whose constituent location-list does not contain a comma-
symbol is elaborated in the following steps:
Step 1: The erratum is considered;
Step 2: That erratum is considered instead which is the same sequence of
Report-tokens as would be obtained by replacing each empty constituent
shift-option in the considered erratum by a plus-symbol followed by a
zero-symbol;
Step 3: That erratum is considered instead which is the same sequence of
Report-tokens as would be obtained by replacing, in the considered
erratum, each location not containing an up-to-symbol by \(\{\text{the line-number which is}\}\) that location followed by an up-to-symbol followed by
\(\{\text{the line-number which is}\}\) that location;
Step 4: Letting \(lt(1b)\) stand for the line of the Report possessed by the
set-off contained in the top (bottom) contained in the considered
erratum, \(vt(vb)\) for the value of the integral-denotation and \(st(sb)\) for
the plus-minus contained in the shift contained in the top (bottom)
contained in the considered erratum, then an upper line (lower line)
is sought in the Report at a distance of \(vt(vb)\) lines from \(lt(1b)\) in
the direction of the end or begin of the Report depending upon whether
\(st(sb)\) is a plus-symbol or minus-symbol, and, if the upper line and
lower line are found and if the upper line is not closer to the end
EE.1.3 continued

of the Report than the lower line, then the set of consecutive lines
the first (last) of which is the upper line (lower line) is considered,
and Step 5 is taken; otherwise, the further elaboration is undefined.
Step 5: If the constituent old-text-denotation of the constituent change
of the considered erratum is an old-text and the considered set of lines
comprises exactly one sequence of Report-tokens which is the same as
that old-text, or if that old-text-denotation is not an old-text and
the considered set of lines comprises exactly one sequence of Report-
tokens which is the constituent begin-of-old-text of that old-text-
denotation followed by a nonempty sequence of Report-tokens followed
by the constituent end-of-old-text, then that sequence of Report-tokens
is replaced by a new appearance of the sequence of Report-tokens which
is the constituent new-text of the constituent change of the considered
erratum, and Step 6 is taken; otherwise, the further elaboration is
undefined;
Step 6: The title of the Report and all titles of the Chapter, Section
and paragraph comprising the considered lines are made to refer to the
Report, Chapter, Section and paragraph as modified in Step 5, and the
elaboration of the erratum is complete.

EE.2. Correspondence with the Editor

EE.2.1. Example of a letter to the Editor

Amsterdam, 16 Feb. 1968.

{Achève, petit Jean; c'est fort bien débuté.
Les Plaideurs, J. Racine.}

Dear Editor,

This morning I received with thanks the Draft Report on ALGOL 68 and
read it with interest. Please convey my feelings of deep appreciation
to your co-authors for the fine work that they achieved. I take the
liberty to suggest the following amendments, which are of a purely
descriptional nature, for the final Report:
EE.2.1. continued

1.2.1.u, 5.4.1.b, 7.1.1.z, 8.1.1.b, 8.1.1.1, 8.2.1.1.d, 8.2.2.1.a, 8.7.1.b+1
* delivering a = *

4.3.2. continued +2:3, 8.2.0.1. continued +12, 8.2.0.1. continued +24,
8.2.0.1. continued +26, 8.2.0.1. continued +27,
8.3.2.+8, 11.1.+2, 11.2.+2, 11.2.+3, 11.2.+4, 11.3.+3, 11.4.+4
* delivering-a- → *
11.4.3.+3 * delivering-a-??-delivering-a →
    real-parameter-and-a-procedure *
1.2.1.q, 1.2.1.u, 1.2.2.h, 1.2.4.n, 1.2.4.n+1, 4.3.1.b, 8.1.1.a, 8.1.1.c,
8.1.1.h+1, 8.1.1.j * DELIVETY → MODETY *
8.1.1.h * DELIVETY : dep DELIVETY → MODETY : dep MODETY *
1.2.2.k * k)???. → *
8.2.1.1.b * called???. →
    called MODETY FORM : fitted procedure MODETY FORM. *
8.2.1.1.c x c)???. → *

These amendments do not change the language at all, but do diminish
the number of rules by two and, moreover, delete over three hundred
meaningless letters. Of course, the deletion of rules 1.2.2.k and
8.2.1.1.c will cause some changes in the paragraphs of the rules
following them, in the examples and, possibly, in some cross references.
Would you be so kind to take care of this yourself if you accept these
amendments?

If you answer this letter at all, would you then tell me why you
did not unify statements and expressions by considering statements as
vanity-expressions like in Orthogonal Design [4]?

Yours sincerely,

A. van W.
EE.2.2. Reply by the Editor to the letter in EE.2.1

Amsterdam, 16 Feb. 1968.

Dear A. van W.,

Many thanks for your prompt reaction to the receipt of the Draft Report. As to your amendments, I fully agree with them; actually, I had also found these very changes myself, but too late for incorporation in the text. I shall do my best to have them incorporated in the final Report and, of course, to make the necessary changes you asked for in paragraphs, examples and cross references.

Now about the statements. We had much trouble understanding the coercion process, dear me; especially skip, jump and nihil caused us a lot of ambiguous parsings. At an early stage, we separated the statements from the expressions again because we thought that this alleviated the problem. Now that the tempest has passed, I see that you can very well unify them again to great advantage. I shall sketch it for you, since you seem so much interested in our work. The errata are assumed to be elaborated after yours:

6.0.1. h * . + .
1) SOME statement : SOME void expression. *
2.1. u * u)??i. + u) RESULT : MODE ; void. *
2.1. q , 1.2.4. a, 1.2.4. n, 1.2.4. n+1 * M O D E T Y → RESULT *
2.3. b * b)??i. + b) CLAUSE : RESULT expression. *
6.0.1. e * SOME statement. + SOME void expression. *
6.1.1. e+1 * statements + void expressions *
6.2.6.3. -1 * Unitary statements??6.3.2.a).} → *
7.1.1. w, 7.1.1. x, 7.1.1. z+1 * tail + void tail *
8.0.1. a:8.0.1. e+1 * a)??relation. →
a) COERCETY unitary RESULT expression:
   COERCETY RESULT formary ; COERCETY RESULT confrontation.
b) COERCETY RESULT formary :
   COERCETY RESULT ADIC formulation ; COERCETY RESULT primary.
c) COERCETY MODE ADIC formulation : COERCETY MODE ADIC formula.
d) void ADIC formulation : void ADIC formula ; called void ADIC formula ;
   NONPROC ADIC formula ; called NONPROC ADIC formula.
e) hip FORCED MODE ADIC formula : FORCED MODE ADIC formula.
EE.2.2. continued

r) void confrontation : MODE confrontation.
g) hip FORCED MODE confrontation : FORCED MODE confrontation.
h) MODE confrontation : MODE assignation;
   MODE conformity relation ; MODE identity relation. *
8.1.1.a:8.1.1.j * a)??dep MODETY. → 
a)* COERCETY formula : COERCETY RESULT ADIC formula.
b) RESULT PRIORITY formula : LMODE PRIORITY operand,
   procedure with a LMODE parameter and a RMODE parameter
   RESULT PRIORITY operator, RMODE PRIORITY plus one operand.
c)* operand : MODE ADIC operand.
d) MODE PRIORITY operand :
   adjusted MODE PRIORITY formula ; MODE PRIORITY plus one operand.
e) MODE PRIORITY NINE plus one operand : MODE monadic operand.
f) MODE monadic operand :
   adjusted MODE monadic formula ; hip adjusted MODE primary.
g) RESULT monadic formula : RESULT dep ; procedure with a RMODE
   parameter RESULT monadic operator, RMODE monadic operand.
h) MODE dep :
   value of symbol, peeled reference to MODE monadic formula ;
   value of symbol, hip peeled reference to mode primary.
i)* depression : MODE dep. *
8.2.1.1.b:8.2.1.1.d * b)??d) →
b) called COERCEND : fitted procedure COERCEND.
c) *
8.2.1.1.e * e) → d) *
8.2.2.1.b * b)??a. → *
8.3.1.a:8.3.1.a+1 * a)??cohesion. →
a) COERCETY RESULT primary : COERCETY CLOSED RESULT expression ;
   COERCETY RESULT cohesion ; RESULT call. *
8.3.1.e * e)??a. →
e) skip : skip symbol.
f) jump : goto symbol option, label identifier.
g) reference to MODE nil : nil symbol.
h) void cohesion : NONPROC cohesion ; void expression call ; skip ; jump.
i) void call : called void cohesion ; called NONPROC cohesion. *
EE.2.2. continued

Of course, some examples, cross references and section headings must be
modified appropriately, and the scanty Semantics of 6.2.2 must be inserted
into 8.3.2, where it fits much better.
The effect is quite satisfying: one rule less, a whole section {6.2} gone,
and a much cleaner set up. This is, of course, also for the final Report.

Yours for ever,
Editor.

EE.2.3. Second example of a letter to the Editor

Somewhere, 1 June 1968.

Sir,

it stinks,

yours,

A.N. Onymous.

EE.2.4. Reply option by the Editor to the letter in EE.2.3

{Empty (the letter was not received in time, see PP.3.b).}

EE.2.5. Third example of a letter to the Editor

From Amsterdam to Calgary, 30 Jan. 1968.

Dear Editor,

Please consider the following errata to have been elaborated:

1.2.4+h+3  * Rule c → Rule d *
2.2.+3    * Carroll → Carroll. *
2.2.+4    * "computer" → computer *
2.2.2.1+2 * (8.8.2.c) → (8.8.2.c) *
2.2.3.1+b+4, 2.2.3.5.a * called → *
2.2.3.1.c+6 * divided → "divided *
2.2.5.+3   * either → *
3.1.1.c+6  * # → # *
3.1.1.d-1  * #: → :: *
3.1.2.d+2  * capital → capital *
4.1.1.e+3  * 1.2.2.t → 1.2.2.s *
4.1.2.a+6  * "is → is" *
4.4.+4    * "ALGOL 68 programs" → "ALGOL-68" programs *
5.5. Step 5+3 * each to the first and last constituent *
6.0.2.a+3 * successor + "successor" *
6.0.2.c * 10.4.b + 10.4.a *
6.0.2.c+2 * 10.4.a + 10.4.b *
7.1.1.o+1 * option to *
7.1.1.p+1 * . ; EMPTY. *
7.1.2.b+1:3 * either symbols to an actual-declarer or formal-declarer *
7.2.2.-1 * 9.2b + 9.2.b *
8.0.1.d * ADIĆ formula to confrontation *
8.1.2. continued+1 * operator-tokens to operators *
8.2.0.1. continued+9 * 8.1.1.b, + 8.1.1.b, c *
8.2.0.1. continued+14, 8.2.0.1. continued+15, 8.2.0.1. continued+16, 8.2.0.1. continued+17 * 8.1.1.c to 8.1.1.e *
8.2.0.1. continued+18 * 8.1.1.d to 8.1.1.f *
8.2.0.1. continued+19 * 8.1.1.e to 8.1.1.g *
8.2.0.1. continued+26 * 8.3.1.c to 8.3.1.b *
8.2.2.2. continued+13 * coercend to conditional-expression *
8.2.2.2. continued+13 * (x) to the routine (x) or the routine *
8.2.2.2. continued+16 * coercend to serial-expression *
8.2.6.2.-1 * (esac) + (esac)) *
8.3.2.d+7 * structure (8.5.1.f) to veld (8.5.1.g) *
8.5.1.f * :
     : MODE veld.
   g) MODE veld ; *
8.5.2.-1 * f) to g) *
8.5.2.a+1 * expressions and structures to velds *
8.5.2.a+2 * ; , where the elaboration of a structure-pack
   is that of its constituent structure ; *
8.5.2.b+2:3 * , the??; ; *
9.0+c26 * empty. to empty.
   d) Each representation of a symbol appearing in Sections
      9.1 up to 9.5 may be replaced by any other representation,
   if any, of the same symbol. *
10.4.b.-1 * (skip) to (skip)) *
10.5.1.+8 * mode to made *
10.5.2.b+14, 10.5.3.c+4 * : int n + 1 : int n *
EE.2.5. continued 2

10.5.2.b+16  # 7 : int n + : int n *
10.5.3.b+18  # string * string *
10.5.3.c-2   # get???# → ¬? *
11.11.       # manipulation * manipulation *

We plan to submit, if necessary, (a) loose-leaf letter(s) comprising other errata.

Collegialiter,

The authors.

EE.2.6. Reply by the Editor to the letter in EE.2.5

Amsterdam, 31 Jan. 1968.

Dear Authors,

The errata comprised in your letter of 30 Jan. 1968 and also those, possibly, comprised in (an) other letter(s) by you if communicated to the readers of the ALGOL Bulletin, are considered to have been elaborated.

Ours,

Editor.