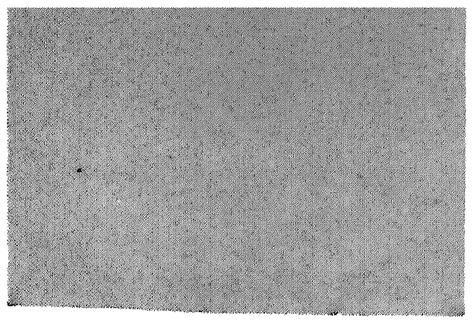
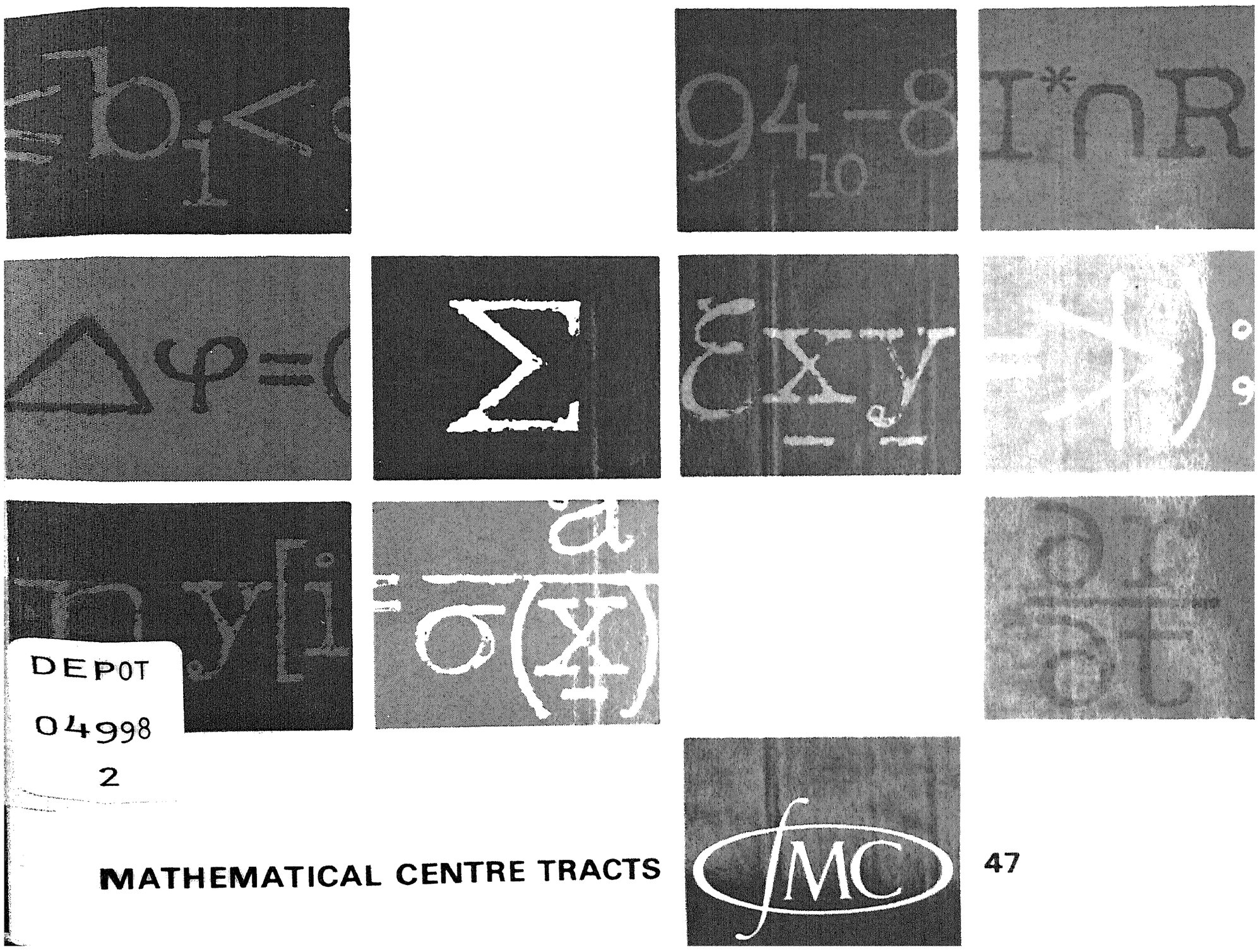


ABC ALGOL

A PORTABLE LANGUAGE FOR FORMULA MANIPULATION SYSTEMS

PART 2 : THE COMPILER

R.P. VAN DE RIET



MATHEMATICAL CENTRE TRACTS 47

ACM - Computing Reviews - category: 4.22

Part 1 of this treatise is published as MC TRACT 46 and contains the Table of Contents and the Introduction pertinent to this second part.

```
1  begin comment
2  6. The ABC ALGOL compiler
3
4  6.0.    Preliminaries of translation process
5
6  Algorithm:;
7
8  integer preceding begin,begin;
9
10 comment:
11 The above integers are global in the translation process. Their values
12 point to the information cells of the last two treated begin's.
13
14 6.1.    Prerequisites for translation process
15
16 Syntactic definition:
17
18 <program>::= <block>|<compound statement>
19
20 A program may be preceded by comment.
21
22 Algorithm:;
23
24 procedure envelope of block(procedure body);
25 value procedure body; integer procedure body;
26 begin integer ptr to integer, ptr to formula, nr of array segments,
27       ptr to array segment, max dimension in array declarations;
28     Boolean formula block, dangerous inner block, snn necessary,
29       block contains labels,block contains gotos, block,
30       proc id ass stat, interested in proc id;
31
32 comment:
33 "envelope  of block" translates  a block,  a compound statement  or  a
34 statement and treats them all  as blocks.  It is called  from the main
35 program  to translate an ABC ALGOL program,  from a procedure body (in
36 which case  the value  of "procedure body" is ≠ 0 indicating where the
37 information about  the procedure  may be found) or for the translation
38 of a real block.
```

The procedure contains the declarations of the above block-administrative variables and all the syntax-translating procedures as "block or statement", "declaration" or "statement". The effect is that the above variables are global to these procedures, while they are local within the procedure "envelope of block".
Each block is translated by a call of "envelope of block", thus each block has attached to it a private set of the above variables, which are initialized by a call of "Open new block in information list".

6.2. Translation of a block

Syntactic definition:

```
<block>::= <block head> <compound tail>
<block head>::= begin <declaration with semicolon>|
        <block head> <declaration with semicolon>
<declaration with semicolon>::= <declaration>;
<compound tail>::= <statement> end | <statement>; <compound tail>
```

Algorithm:;

```
procedure block or statement;
begin integer lnr; block:= synt unit = begin symbol;
  Open new block in information list;
  PR string(‹begin ›); lnr:= line number;
  if ptr to array segment ≠ 0 then
  begin comment
    In this block formula arrays are declared. Therefore, it is
surrounded by another block in which the array bounds are evaluated;
    SAVE reading ptrs; array bounds; PR nlcr;
    PR string(‹begin ›); RESET reading ptrs
  end;
  comment
  The next statement serves to determine whether this block is the
procedure body of a formula procedure;
  if block then
  begin RE begin; for synt unit:= synt unit
  while is declarator(synt unit) do declaration
```

```
77    end;
78    interested in proc id:= if procedure body ≠ 0 then
79      contents of [procedure body - 4] : 32 =
80        formula symbol × 1024 + procedure symbol
81      else false;
82    if second scan then
83    begin SAVE reading ptrs;
84      if ptr to array segment ≠ 0 then
85      begin Declare formula arrays; Declare integers end else
86      begin Declare integers; PR string(≠lnr(≠);
87        PR int num(lnr); PR string(≠);≠)
88      end;
89      if interested in proc id then procedure block entry;
90      Introduce names for formulae;
91      Introduce names for formula array elements;
92      Initialize snn;
93      RESET reading ptrs
94    end else formula block:= ptr to formula + ptr to array segment ≠ 0;
95
96      proc id ass stat:= false;
97  L1: statement(block v formula block);
98      comment the actual parameter of "statement" indicates whether the
99      environment of the statement is such that it can be split into more
100     than one statements as e.g. in a block, or that it should be sur-
101     rounded by begin and end when it is split.;
102     if synt unit ≠ semicolon symbol ^ synt unit ≠ end symbol then
103     begin ERR(≠statement not properly closed≠);
104       SEEK(synt unit = semicolon symbol v synt unit = end symbol)
105     end;
106     if block then
107     begin L2: if synt unit = semicolon symbol then
108       begin PR and RE semicolon; goto L2 end;
109       if synt unit ≠ end symbol then
110       begin proc id ass stat:= false; goto L1 end
111     end;
112     Block exit; Close block in information list
113 end block or statement;
114
```

comment:
Each block has a certain amount of administration stored in the information list. The information is "initialized" upon a call of "Open new block in information list" and is "buried" upon a call of "Close block in information list".

The block: "begin d; s end" is translated into:
"begin D; integer fnn,snn; fnn:= gnn; D2; snn:= gnn; S
; ERASE(fnn) end",
where d and s stand for a declaration and a statement, respectively. D is the first half of the translation of the declaration d ("formula x:= f" is translated into "integer X").
D2 is the introduction of names for formula variables("DE(X,F)"). The locally introduced integers "fnn" and "snn" are being used for erasure of names and thus of formulae. The integer "gnn" is, in the translated program, a global integer which counts the number of names introduced. "ERASE" is a procedure which erases the last "gnn - fnn" introduced names. A labelled statement "l: s" is translated into:
"L: ERASE(snn); S",
and again "ERASE" erases the last "gnn - snn" introduced names.

6.3. Translation of a declaration

Syntactic definition:

```
<declaration>::= <formula declaration>|<formula array declaration>|
    <formula procedure declaration>|<procedure declaration>|
    <type declaration>|<array declaration>|<switch declaration>
```

The first four declarations are defined in sections 6.3.1, 6.3.2, 6.3.3 and 6.3.4 respectively. The other declarations are defined in the ALGOL 60 report [10] section 5.

```
Algorithm:;
procedure declaration;
if synt unit = formula symbol then
begin  if next synt unit = array symbol then formula array declaration
  else if next synt unit = procedure symbol then procedure declaration
```

```
153     else formula declaration
154  end else
155  if synt unit = real symbol v synt unit = integer symbol v
156    synt unit = Boolean symbol then
157  begin  if next synt unit = array symbol then array declaration
158    else if next synt unit = procedure symbol then procedure declaration
159    else type declaration
160  end else
161  if synt unit = array symbol then array declaration else
162  if synt unit = procedure symbol then procedure declaration else
163  begin CHECK(switch symbol); PR and RE; PR string(ǂZǂ); PR and RE;
164    PR and RE;
165  L: other expression; if synt unit = comma symbol then
166     begin PR and RE; goto L end; PR and RE semicolon
167  end declaration;
168
169  procedure type declaration;
170  begin integer su; su:= synt unit;
171  if su = integer symbol then
172  begin L1: RE; if first scan then
173    ptr to integer:= STORE into information list(st(st(st(st(0,
174    nr of ident),
175    ptr to first letgit),
176    integer symbol × t15 + declared as value),
177    ptr to integer));
178    RE; if synt unit = comma symbol then goto L1;
179    RE semicolon
180  end else
181  begin L2: PR and RE; if su ǂ Boolean symbol ^ first scan then
182    STORE into information list(st(st(st(0,
183    nr of ident),
184    ptr to first letgit),
185    su × t15));
186    PR string(ǂZǂ); PR and RE; if synt unit = comma symbol then goto L2;
187    PR and RE semicolon
188  end end type declaration;
189
190  procedure array declaration;
```

```
begin integer su,nsu; su:= synt unit; nsu:= next synt unit;
  if nsu = array symbol then PR and RE;
L1: PR and RE; if su ≠ Boolean symbol ^ first scan then
  STORE into information list(st(st(st(0,
    nr of ident),
    ptr to first letgit),
    (if nsu = array symbol then su else real symbol) × t15 +
    32 × array symbol));
  PR string(‹Z›); PR and RE;
  if synt unit = sub symbol then
  begin L2: PR and RE; other expression; CHECK(colon symbol);
    PR and RE;
    other expression; if synt unit = comma symbol then goto L2;
    CHECK(bus symbol); PR and RE
  end; if synt unit = comma symbol then goto L1; PR and RE semicolon
end array declaration;

comment:
```

The other declarations will be treated in the next sections.

6.3.1. Translation of a formula declaration

Syntactic definition:

```
<formula declaration>::= formula <formula list>
<formula list>::= <formula definition>|<formula list>,
<formula definition>
<formula definition>::= <simple variable><formula initialization>
<formula initialization>::= <empty>|:= <formula expression>|
                          = <formula expression>
<simple variable>::= <identifier>
```

Algorithm:;

```
procedure formula declaration;
begin L: RE; if first scan then
  ptr to formula:= STORE into information list(st(st(st(st(0,
        nr of ident),
```

```
229                 ptr to first letgit),
230                 formula symbol × t15 + (if next synt unit = equal
231                     symbol then declared as value else declared as name)),
232                     ptr to formula));
233     SKIP text until(synt unit = comma symbol v synt unit =
234                         semicolon symbol);
235     if synt unit = comma symbol then goto L;
236     RE semicolon
237 end formula declaration;
238
239 comment:
240 The following procedures declare all integers, introduce all names and
241 produce the initialization for snn.  note  that "formula f:= expr1,g =
242 expr2;" is translated into: "integer G,F;".
243 It  is necessary  that names  are introduced for  "F" and "G" and that
244 the initial  values  are  computed immediately  after  the  translated
245 declarations.
246
247 Algorithm:;
248
249 procedure Declare integers;
250 begin integer a,a0,a3,mode; Boolean first,reverse;
251   procedure PR int com;
252   if first then
253   begin  PR string(ǂinteger ǂ); first:= false end
254   else PR string(ǂ,ǂ);
255   first:= true; reverse:= false; a0:= 0;
256   for a:= ptr to integer, ptr to formula do
257   begin for a:= a while a ǂ 0 do
258     begin SET reading ptrs on(contents of [a + 2]);
259       a3:= contents of [a + 3]; mode:= a3 - a3 : 32 × 32;
260       if mode = with local v mode = specified as value then
261       begin PR int com; PR string(ǂYǂ); if operator identifier then
262         PR operator else PR synt unit
263       end else if mode ǂ without local then
264       begin PR int com; PR string(ǂZǂ); PR synt unit end
265       else operator identifier:= false;
266       a3:= contents of [a + 4]; if reverse then
```

```
267         begin contents of [a + 4]:= a0; a0:= a end; a:= a3
268       end; reverse:= true
269     end; ptr to formula:= a0;
270     if formula block then
271     begin PR int com; PR string(‡fnn‡);
272       if snn necessary then
273       PR string(‡,snn‡); PR string(‡; fnn:= gnn‡)
274     end; if ¬ first then PR string(‡;‡)
275   end Declare integers;
276
277   procedure Introduce names for formulae;
278   begin integer a,a3,mode; Boolean first,print NULL;
279     print NULL:= false; first:= true;
280   L: a:= ptr to formula; if a ≠ 0 then PR nlcr;
281     for a:= a while a ≠ 0 do
282     begin a3:= contents of [a + 3]; mode:= a3 - a3 : 32 × 32;
283       if first then
284     begin if mode ≠ specified as value then
285       begin PR string(‡Z‡); SET reading ptrs on (
286         contents of [a + 2]); PR and RE; print NULL:= true;
287         PR string(‡:= ‡)
288     end end else
289     begin if mode = specified as value v mode = declared as value then
290       PR string(‡DEVAL(‡) else PR string(‡DE(‡);
291       if mode = specified as value then PR string(‡Y‡) else
292       PR string(‡Z‡);
293       SET reading ptrs on (contents of [a + 2]); PR and RE;
294       PR string(‡,‡); if mode = specified as value then
295       begin PR string(‡Z‡); SET reading ptrs on (contents of [a + 2]);
296         PR synt unit
297       end else
298       if synt unit = becomes symbol v synt unit = equal symbol then
299         begin RE; formula expression end else PR string(‡NULL‡);
300         PR string(‡);‡)
301       end;
302       a3:= contents of [a + 4]; a:= a3
303     end;
304     if first then
```

```
305     begin first:= false; if print NULL then PR string(ǂNULL;ǂ);
306       goto L
307     end
308   end Introduce names for formulae;
309
310   procedure Initialize snn;
311   if formula block ^ snn necessary then
312     PR string(ǂ snn:= gnn; ǂ);
313
314   comment:
315
316   6.3.2. Translation of a formula array declaration
317
318   Syntactic definition:
319
320   <formula array declaration>::= formula array <array list>
321   For array list see the ALGOL 60 report [10] section 5.2.
322
323   Algorithm:;
324
325   procedure formula array declaration;
326   begin integer a,dimension; RE;
327   ARRAY SEGMENT: RE; if first scan then
328     begin ptr to array segment:= a:=
329       STORE into information list(st(st(st(st(st(0,
330         nr of ident),
331         ptr to first letgit),
332         formula symbol × t15 + 32 × array symbol),
333         ptr to array segment),0));
334       nr of array segments:= nr of array segments + 1
335     end;
336     dimension:= 1;
337   NEXT IDENTIFIER: RE;
338     if synt unit = comma symbol then
339     begin RE; if first scan then
340       STORE into information list(st(st(st(0,
341         nr of ident),
342         ptr to first letgit),
```

```
343         formula symbol × t15 + 32 × array symbol)); goto NEXT IDENTIFIER
344     end else
345     if synt unit = sub symbol then
346     begin BOUND PAIR: RE; SKIP text until(synt unit = comma symbol v
347       synt unit = bus symbol);
348       if synt unit = comma symbol then
349       begin dimension:= dimension + 1; goto BOUND PAIR end;
350       if first scan then
351       begin contents of[a + 5]:= dimension; if max dimension in array
352         declarations < dimension then
353         max dimension in array declarations:= dimension
354       end; RE;
355       if synt unit = comma symbol then goto ARRAY SEGMENT
356     end; RE semicolon·
357 end formula array declaration;
358
359 comment:
360 The translation of:
361     "formula array a,b[e1:e2],c,d[e3:e4,e5:e6];"
362 is:
363     "integer array C,D[low1c1:up1c1,low1c2:up1c2]],A,B[low2c1:up2c1];"
364 It is necessary that the bounds e1,e2,e3,e4,e5 and e6 are evaluated in
365 a surrounding  block and assigned  to the array elements  of "low" and
366 "up". For this example, the next procedure "array bounds" produces the
367 following text:
368   "integer low1c1,up1c1,low2c1,up2c1,i1,
369       low1c2,up1c2,low2c2,up2c2,i2;
370       low1c1:= E3; up1c1:= E4;
371       low1c2:= E5; up1c2:= E6;
372       low2c1:= E1; up2c1:= E2;"
373
374 In a case that the block is the body  of a procedure,  it is necessary
375 to treat the procedure parameters first,  i.e.  declaring integers and
376 producing names for the formal parameters.  This is done in a somewhat
377 tricky way  in that  the list  of formula variables  is split into two
378 lists:  one consisting of the parameters  and the other consisting  of
379 the ordinary variables  declared  in the heading  of  the block.  The
380 latter  list  has  to  be treated  together  with  the  formula  array
```

```
381  declaration,  i.e.  in the proper block.  The first list is treated in
382  this procedure. Note that the line number is treated also.
383
384  Algorithm:;
385
386  procedure array bounds;
387  begin integer dimension,a,index,m,ptf,pti,lnr; boolean sn;
388    lnr:= line number; a:= ptf:= ptr to formula;
389    ptr to formula:= index:= 0;
390    for a:= a while a ≠ 0 do
391    begin m:= contents of[a + 3]; m:= m - m : t15 × t15;
392      if m = declared as value v m = declared as name then
393      begin index:= a; a:= contents of [a + 4] end else
394      begin if index ≠ 0 then contents of [index + 4]:= 0;
395        ptr to formula:= a;a:= 0
396      end
397    end;
398    PR nlcr; PR string(≮integer ≯);
399    for a:= 1 step 1 until max dimension in array declarations do
400    begin for index:= 1 step 1 until nr of array segments do
401      PR sn(≮low≯,index,PR sn(≮c≯,a,
402      PR sn(≮,up≯,index,PR sn(≮c≯,a,PR string(≮,≯)))));
403      PR sn(≮i≯,a,if a < max dimension in array declarations then
404      PR string(≮,≯) else PR string(≮;≯)); PR nlcr
405    end;
406    sn:= snn necessary; snn necessary:= false;
407    pti:= ptr to integer; ptr to integer:= 0;
408    Declare integers; PR string(≮lnr(≯);
409    PR int num(lnr); PR string(≮);≯);
410    Introduce names for formulae;
411    ptr to formula:= ptf; ptr to integer:= pti; snn necessary:= sn;
412    a:= ptr to array segment; index:= 0;
413
414    for a:= a while a ≠ 0 do
415    begin PR nlcr; SET reading ptrs on(contents  of [a + 2]);
416      dimension:= contents of [a + 5]; index:= index + 1;
417      FIND SUB SYMBOL:
418      RE; if synt unit ≠ sub symbol then goto FIND SUB SYMBOL; RE;
```

```
419       for m:= 1 step 1 until dimension do
420       begin PR sn(‡low‡,index,PR sn(‡c‡,m,PR string(‡:= ‡)));
421         other expression; PR string(‡;‡); CHECK(colon symbol); RE;
422         PR sn(‡up‡,index,PR sn(‡c‡,m,PR string(‡:= ‡)));
423         other expression; PR string(‡;‡);
424         if m < dimension then CHECK(comma symbol) else
425         CHECK(bus symbol); RE
426       end; a:= contents of [a + 4]
427     end
428 end array bounds;
429
430 comment
431 In the following procedure the actual formula array declaration is
432 produced.
433
434 Algorithm:;
435
436
437 procedure Declare formula arrays;
438 begin integer dimension,a,n,m,index;
439     index:= 0; PR nlcr; PR string(‡ integer array ‡);
440     a:= ptr to array segment;
441     for a:= a while a ≠ 0 do
442     begin if a ≠ ptr to array segment then PR string(‡,‡);
443       SET reading ptrs on(contents of [a + 2]);
444       index:= index + 1;
445     L1: PR string(‡Z‡); PR and RE; dimension:= 1;
446       if synt unit = comma symbol then
447       begin PR and RE; goto L1 end else
448       if synt unit = sub symbol then
449       begin L2: PR and RE; SKIP text until
450         (synt unit = comma symbol v synt unit = bus symbol);
451         PR sn(‡low‡,index,PR sn(‡c‡,dimension,
452         PR sn(‡: up‡,index,PR sn(‡c‡,dimension,1))));
453         if synt unit = comma symbol then
454         begin dimension:= dimension + 1; goto L2 end;
455         CHECK(bus symbol); PR and RE
456       end; a:= contents of [a + 4]
```

```
457     end;
458     PR string(¢;¢); PR nlcr
459   end Declare formula arrays;
460
461   comment:
462   We finally  have to construct an algorithm for  the declaration of the
463   array elements and the introduction of names for them.  For  the above
464   example, this algorithm gives the following:
465     "for i1:= low1c1 step 1 until up1c1 do
466      for i2:= low1c2 step 1 until up1c2 do
467      begin DE(C[i1,12],NULL); DE(D[i1,i2],NULL) end ;
468      for i1:= low2c1 step 1 until up2c1 do
469      begin DE(A[i1],NULL); DE(B[i1],NULL) end ;"
470
471   Algorithm:;
472
473   procedure Introduce names for formula array elements;
474   begin integer dimension,a,m,index;
475     a:= ptr to array segment; index:= 0;
476     for a:= a while a ≠ 0 do
477     begin SET reading ptrs on(contents of [a + 2]);
478       dimension:= contents of [a + 5]; index:= index + 1;
479       for m:= 1 step 1 until dimension do
480       begin PR nlcr; PR sn(
481         ¢for i¢,m,PR sn(¢:= low¢,index,PR sn(
482         ¢c¢,m,PR sn(¢ step 1 until up¢,index,PR sn(
483         ¢c¢,m,PR string(¢ do¢))))))
484       end;
485       PR nlcr; PR string(¢begin ¢);
486     L3: PR string(¢DE(Z¢); PR and RE; PR string(¢[¢);
487       for m:= 1 step 1 until dimension do
488       PR sn(¢i¢,m,if m < dimension then PR string(¢,¢)
489             else PR string(¢],NULL)¢));
490       if synt unit = comma symbol then
491       begin PR string(¢;¢); RE; goto L3 end;
492       PR string(¢ end;¢); a:= contents of [a + 4]
493     end
494   end Introduce names for formula array elements;
```

comment:

6.3.3. Opening and closing a block.

During the first scan of the translation process, information cells (IC) in the information list are reserved for each block begin and for each block end.
In these IC's the values of the block-administrative variables declared in section 6.1 and to which values are assigned in sections 6.3.1 and 6.3.2, are stored together with pointers for the linkage of the block IC's. During the second scan the stored values are used for:
a) Outputting the correct "block begin".
b) Searching the IC of an identifier used in a statement.

Let the begin's of the program being enumerated in the order in which they occur in the program: b[i], i = 1,... ,n.
Let the corresponding end's be: e[i], i = 1,... ,n.
Let the IC of b[i] be: IC(b[i]) and the IC of e[i] be IC(e[i]), i = 1,... ,n.
Let the blocks be b[i], i = 1,... ,n, such that the begin of b[i] is b[i].
Let us define a surrounding block b[j] of b[i] as a block in which b[i] is contained. Obviously, we have j < i.

The immediately surrounding block b[j] of b[i] is the surrounding block of b[i] for which i-j is minimal. Define s(i) to be this j. Obviously, for each i > 1, s(i) exists.

We are now able to describe information stored in IC(b[i]) and IC(e[i]).
IC(b[i]) contains, after the first scan is executed:
1. A reference to IC(e[i]).
2. A reference to IC(b[i + 1]), in case i < n.
3. The values of the block-administrative variables.
4. The block-administrative variables as mentioned in section 6.1.

IC(e[i]) contains, after the first scan is executed:
1. A reference to IC(b[s(i)]), provided i > 1.

Between IC(b[i]) and IC(e[i]), the IC's of the identifiers, declared in b[i], are stored in the information list. Upon entry of a new block, during the second scan, we can now find the corresponding IC(b[i]), since we know IC(b[i - 1]), provided i > 1. Hence, the block- administrative variables can be found and, during the translation of a statement, the IC of an identifier can be found by means of the following simple algorithm:

Step1: Choose IC(b[i]). Take Step2.

Step2: Choose the next IC.

If this IC is the IC of a begin, namely IC(b[j]), then choose IC(e[j]) and take Step2 again.

If this IC is the IC of an end, namely IC(e[j]), then, if j = 1, the process is finished and no IC is found for the identifier, otherwise choose IC(b[s(j)]) and take Step2 again.

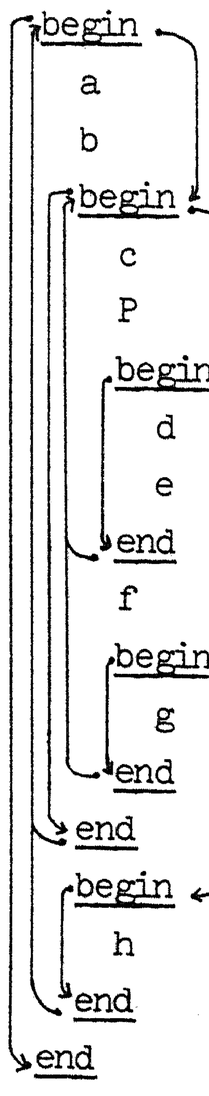
If this IC is the IC of an identifier, then check whether this is the identifier we looked for, in which case the process is finished, otherwise take Step2 again.

As we will see later, another process will be followed for the standard identifiers.

Example: The program:

```
"begin formula a,b; S1;
  begin formula c;
    procedure P(d); formula d ;
    begin formula e; S2 end ;
    formula f; S3;
    begin formula g; S4 end ;
  end ; S5;
  begin formula h; S6 end
end"
```

gives rise to the following information list in which the references are made visible by means of arrows:



```
571  begin                    = IC(b[1])
572    a
573    b
574    begin                  = IC(b[2])
575      c
576      P
577      begin                = IC(b[3])
578        d
579        e
580      end                  = IC(e[3]) s(3) = 2
581      f
582      begin                = IC(b[4])
583        g
584      end                  = IC(e[4]) s(4) = 2
585    end                    = IC(e[2]) s(2) = 1
586    begin                  = IC(b[5])
587      h
588    end                    = IC(e[5]) s(5) = 1
589  end                      = IC(e[1])
590    information list
591
592  A search  for the IC of an identifier in S2 leads to the inspection of
593  the IC's of the following identifiers: e,d,c,P,f,a,b. A search for the
594  IC of  an identifier  in S4 leads to the inspection of the IC's of the
595  following identifiers: g,c,P,f,a,b.
596
597  We give  now the algorithm for searching the IC of an identifier given
598  by the global integers: "nr of ident" and "ptr to first letgit". These
599  integers have obtained  values by means of the reading procedures "RE"
600  and "PR and RE".
601
602  The global integer  "block depth" decreases by one each time the block
603  depth of the block in which the identifier is sought diminishes.
604
605  Algorithm:;
606
607  Boolean procedure Search for identifier (IC); integer IC;
608  begin integer p,j;
```

```
609     p:= begin; Search for identifier:= false;
610     for p:= p while p ≠ 0 do
611     begin p:= p + contents of [p]; if p ≥ ptr of inf list then goto OUT;
612       j:= contents of [p + 1];
613       if j = -end symbol then
614       begin block depth:= block depth - 1;
615         p:= contents of [p + 2]
616       end else
617       if j = - begin symbol then p:= contents of [p + 2]
618       else if j = nr of ident
619       then begin Search for identifier:= true; IC:= p; goto OUT end
620     end;
621  OUT: end Search for identifier;
622
623  comment:
624  We give now the block-administrative procedures.
625
626  Algorithm:;
627
628  procedure Open new block in information list;
629  if first scan then
630  begin ptr to integer:= ptr to formula:= ptr to array segment:=
631    nr of array segments:= max dimension in array declarations:= 0;
632    block contains labels:= block contains gotos:= false;
633    if procedure body ≠ 0 then
634    begin ptr to integer:= contents of [procedure body + 4];
635      ptr to formula:= contents of [procedure body + 5]
636    end else
637    begin begin:= contents of [preceding begin]:=
638        STORE into information list(st(st(st(st(st(st(st(st(st(0,
639          - begin symbol),
640          begin),
641          0),
642          ptr to integer),
643          ptr to formula),
644          ptr to array segment),
645          nr of array segments),
646          max dimension in array declarations),
```

```
647           0));
648         preceding begin:= begin + 3
649     end
650   end else
651
652   begin Boolean array b[0:5];
653     if procedure body = 0 then
654     begin begin:= contents of [preceding begin];
655       preceding begin:= begin + 3
656     end;
657     ptr to integer:= contents of [begin + 4];
658     ptr to formula:= contents of [begin + 5];
659     ptr to array segment:= contents of [begin + 6];
660     nr of array segments:= contents of [begin + 7];
661     max dimension in array declarations:= contents of [begin + 8];
662     get bits(contents of [begin + 9],b);
663     formula block:= b[0];
664     block contains labels:= b[1];
665     block contains gotos:= b[2];
666     dangerous inner block:= b[3];
667     snn necessary:= if dangerous procedures then b[5] else b[4]
668   end;
669
670   procedure Close block in information list;
671   if first scan then
672   begin integer prec begin; Boolean array e,b[0:5];
673     prec begin:= contents of [begin + 2];
674     contents of [begin + 2]:=
675     STORE into information list(st(st(0,
676       - end symbol),
677       prec begin));
678     contents of [begin + 4]:= ptr to integer;
679     contents of [begin + 5]:= ptr to formula;
680     contents of [begin + 6]:= ptr to array segment;
681     contents of [begin + 7]:= nr of array segments;
682     contents of [begin + 8]:= max dimension in array declarations;
683
684     comment:
```

```
685     The following can be understood in connection with section 4.6 only.
686  In the Boolean array b and e the properties: form, label,  goto, dang,
687  snn1 and snn2  are represented for the array elements  with subscripts
688  0,  1,  2, 3,  4 and 5, respectively. The array b gives the properties
689  for the block under consideration and the array e gives the properties
690  for the enveloping block.
691     Note  that  the transfer  of properties  from an inner block  to the
692  block  under consideration,  such  as described  in section  4.6,  is
693  implemented  as  the transfer  of  properties  from  the  block  under
694  consideration to its (unique) enveloping block (provided it is not the
695  outermost block in which  case prec begin = 0).  Therefore,  b[3] does
696  not obtain a value here, but e[3] does, if necessary.;
697
698    get bits(contents of [begin + 9],b);
699    b[0]:= formula block;
700    b[1]:= block contains labels;
701    if block contains gotos then b[2]:= true;
702    if b[1] ^ b[3] then b[4]:= true;
703    if b[1] then b[5]:= true;
704    store bits(contents of [begin + 9],b);
705    if prec begin ≠ 0 then
706    begin get bits(contents of [prec begin + 9],e);
707      if b[2] then e[2]:= true;
708      if b[0] ^ b[2] v b[3] then e[3]:= true;
709      if b[4] ^ ¬ b[0] then e[4]:= true;
710      if b[1] ^ ¬ b[0] then e[5]:= true;
711      store bits(contents of [prec begin + 9],e)
712    end; begin:= prec begin
713  end else begin:= contents of [contents of [begin + 2] + 2];
714
715  procedure procedure block entry;
716  comment the procedure is called during the second scan only, while the
717  block is the body of a formula procedure;
718  begin integer a; a:= procedure body - 7;
719    if contents of [a + 6] ≥ 1 then
720    begin  PR string(≠
721    if protect then ERR(≠protection error in form proc≠);≠);
722      SET reading ptrs on (contents of [a + 2]);
```

```
723       PR nlcr; PR string(‡Y‡); if operator identifier then
724       PR operator else PR synt unit;
725         PR string(‡:= NULL;‡)
726   end end procedure block entry;
727
728   procedure Block exit;
729   if first scan then
730   begin if block then RE end;
731     if interested in proc id then
732     begin if ¬ proc id ass stat then
733       contents of [procedure body - 1]:= 1
734       else contents of [procedure body - 4]:=
735             formula symbol × t15 + procedure symbol × 32 + without local
736   end end else
737   begin integer a,i; Boolean b; PR nlcr;
738     if formula block then PR string(‡; ERASE(fnn)‡);
739     a:= if interested in proc id then procedure body - 7 else 0;
740     if a ≠ 0 then
741     begin if contents of [a + 6] ≥ 1 then
742       begin PR string(‡; if Y‡); SAVE reading ptrs;
743         for i:= 1,2,3 do
744         begin SET reading ptrs on(contents of [a + 2]);
745           b:= operator identifier;
746           if b then PR operator else PR synt unit;
747           if i = 1 then
748           begin PR string(
749             ‡= NULL then ERR(‡no assignment to proc ident‡);‡);
750             if ¬ b then PR string(‡Z‡)
751           end else if i = 2 then PR string(‡:= Y‡)
752         end; RESET reading ptrs;
753         if contents of[a + 6] = 1 then
754         PR string(‡; protect:= false‡)
755   end end;
756     PR nlcr; PR string(‡end ‡); if block then RE end;
757     if ptr to array segment ≠ 0 then
758     begin PR nlcr; PR string(‡; ERASE(fnn) end‡) end
759   end Block exit;
760
```

761 comment:
762
763 6.3.4. Translation of a (formula or type) procedure declaration.
764
765 Syntactic definition 1:
766
767 <formula procedure declaration>::= formula <procedure heading>
768 <procedure body>
769 <procedure declaration>::= <procedure type><procedure heading>
770 <procedure body>
771 <procedure type>::= <empty>|<type>
772 <procedure heading>::= <procedure ident><formal parameter part>;
773 <value part><specification part>
774 <procedure ident>::= <procedure identifier>|<operator identifier>
775 <operator identifier>::= dyadic +|dyadic -|
776 dyadic ×|dyadic /|dyadic ↑|dyadic :|
777 monadic +|monadic -|monadic ↑|
778 constant +|constant ×
779
780 For <empty>,<type>,<procedure identifier>,<value part> and <formal
781 parameter part> see the ALGOL 60 report [10] section 5.4.
782
783 First part of algorithm:;
784
785 procedure procedure declaration;
786 begin integer nr of param,a,b,su,nsu,i,proc ic,ptr to integer param,
787 ptr to formula param;
788 Boolean formula procedure;
789 Boolean procedure Identifier in paramlist(p); integer p;
790 if nr of param = 0 then Identifier in paramlist:= false else
791 begin integer a,i; i:= nr of param; a:= begin;
792 for a:= a + contents of [a] while
793 nr of ident ≠ contents of [a + 1] do
794 begin i:= i - 1; if i = 0 then
795 begin Identifier in paramlist:= false; goto OUT end
796 end; Identifier in paramlist:= true; p:= a;
797 if contents of [p + 3] : 32 ≠ 0 then ERR(
798 ‹equal identifiers in specification part›);

```
799     OUT:
800     end;
801     formula procedure:= false; su:= synt unit; nsu:= next synt unit;
802     if nsu = procedure symbol then
803     begin if su = formula symbol then
804       begin PR string(‡integer ‡); RE; formula procedure:= true end
805       else PR and RE
806     end; PR and RE;
807     if first scan then
808     begin nr of param:= 0; proc ic:=
809       STORE into information list(st(st(st(st(st(st(0,
810         nr of ident),
811         ptr to first letgit),
812         (if nsu = procedure symbol then su else 0) × t15 + 32 ×
813         procedure symbol +
814         (if formula procedure then with local else 0)),
815         0),
816         nr of param),0));
817         if formula procedure then ptr to integer param:= proc ic else
818         ptr to integer param:= 0;
819         ptr to formula param:= 0;
820         begin:= contents of [preceding begin]:=
821         STORE into information list(st(st(st(st(st(st(st(st(st(0,
822         - begin symbol),
823           begin),
824           0),0),0),0),0),0),0));
825       preceding begin:= begin + 3; RE
826     end first scan else
827     begin begin:= contents of [preceding begin];
828       preceding begin:= begin + 3;
829       proc ic:= begin - 7;
830       nr of param:= contents of [proc ic + 5];
831       if operator identifier then
832     begin if ¬ formula procedure
833       then ERR(‡operator identifier at wrong place‡);
834       if in formula procedure body > 0
835       then ERR(‡oper def in formula proc body‡);
836       if (-nr of ident) : 1024 = dyadic symbol then
```

```
837         begin if nr of param ≠ 2 v contents of [proc ic + 20] : 32 ≠
838               formula symbol × 1024 v
839               contents of [proc ic + 26] : 32 ≠ formula symbol × 1024
840               then ERR(¢operator identifier with wrong parameters¢)
841         end else if (-nr of ident) = monadic symbol × 1024 +
842               power symbol then
843         begin if nr of param ≠ 2 v contents of [proc ic + 20] : 32 ≠
844               formula symbol × 1024 v
845               contents of [proc ic + 26] : 32 = formula symbol × 1024
846               then ERR(¢operator identifier with wrong parameters¢)
847         end else if (-nr of ident) : 1024 = monadic symbol then
848         begin if nr of param ≠ 1 v contents of [proc ic + 20] : 32 ≠
849               formula symbol × 1024
850               then ERR(¢operator identifier with wrong parameters¢)
851         end else if (-nr of ident) : 1024 = constant symbol then
852         begin if nr of param ≠ 1 v contents of [proc ic + 20] : 32 =
853               formula symbol × 1024 then ERR(
854               ¢operator identifier with wrong parameters¢)
855           end; PR operator; RE
856         end else begin PR string(¢Z¢); PR and RE end
857       end;
858
859       if synt unit ≠ open symbol then
860       begin PR and RE semicolon; goto PROCEDURE BODY end;
861     FORMAL PARAMETER PART:
862       PR and RE; if first scan then
863       begin nr of param:= nr of param + 1;
864         STORE into information list(st(st(st(st(st(0,
865           nr of ident),
866           ptr to first letgit),
867           specified as name),
868           0),0));
869       end; PR string(¢Z¢); PR and RE;
870       if synt unit = comma symbol then goto FORMAL PARAMETER PART;
871       CHECK(close symbol); PR and RE; PR and RE semicolon;
872       if first scan then contents of [proc ic + 5]:= nr of param;
873       if synt unit = value symbol then
874       begin VALUE PART: RE; if first scan then
```

```
875     begin if Identifier in param list(a) then
876       contents of [a + 3]:= specified as value
877       else ERR(¢value part not O.K.¢)
878     end; RE; if synt unit = comma symbol then goto VALUE PART;
879     RE semicolon;
880     if second scan then
881     begin Boolean value symbol is printed;
882       value symbol is printed:= false;
883       a:= begin; SAVE reading ptrs;
884       for i:= 1 step 1 until nr of param do
885       begin a:= a + contents of [a]; b:= contents of [a + 3];
886         if b : t15 ≠ formula symbol ^ b - b : 32 × 32 =
887         specified as value then
888         begin if ¬ value symbol is printed then
889           PR string(¢ value ¢) else PR string(¢,¢);
890           value symbol is printed:= true;
891           SET reading ptrs on (contents of [a + 2]);
892           PR string(¢Z¢); PR synt unit
893       end end; RESET reading ptrs;
894       if value symbol is printed then PR string(¢;¢)
895   end end value part;
896
897 comment:
898 As can be seen above, all parameters are placed in the information
899 list and their possible occurrence in the value part has been taken
900 account of.
901 During the translation of the specification part, described below, the
902 types of these parameters are filled in. If it is necessary to inspect
903 the type of the i-th parameter of the procedure whose identifier
904 occupies the IC with entry "a", we have to look into:
905 "contents of [a + 17 + 6 × (i - 1) + 3]".
906
907 Syntactic definition 2:
908
909 <specification part>::= <empty>|<specification list>;
910 <specification list>::= <specification>|<specification list>;
911 <specification>
912 <specification>::= <ordinary specification>|
```

913 <formal procedure specification>
914 <ordinary specification>::= <specifier><identifier list>|
915 formula <identifier list>|
916 formula array <identifier list>
917 <formal procedure specification>::= <formal procedure specifier>
918 <formal procedure segment list>
919 <formal procedure specifier>::= procedure|<type> procedure|
920 formula procedure
921 <formal procedure segment list>::= <formal procedure segment>|
922 <formal procedure segment list>,
923 <formal procedure segment>
924 <formal procedure segment>::= <identifier>
925 <specification of parameters>
926 <specification of parameters>::= <empty>|(<type of parameters list>)
927 <type of parameters list>::= <type of parameter>|
928 <type of parameters list>,<type of parameter>
929 <type of parameter>::= <empty>|<specifier>|formula|formula value|
930 formula array|formula procedure
931 For specifier, type and identifier list see the ALGOL 60 report [10]
932 section 5.4, from which a procedure as specifier should be swept out.
933
934 Example of a procedure heading:
935 formula procedure P(a,b,c,d,e); value a; formula a,b;
936 real c; procedure d; formula procedure e(formula value,formula,,,);
937 with this procedure heading a call P(x,y,3.14,PRINT,P)" is possible.
938 The reason for introducing the specification of parameters for a
939 formal procedure parameter is that the compiler has to know of each
940 parameter of a procedure whether it is specified as formula and
941 whether, in this case, it is called by value. A parameter which is not
942 specified will be treated as to be not of type formula.
943 Note that a specification of parameters concerns the parameters of
944 the formal procedure with its identifier given in the formal procedure
945 segment only. Hence, "procedure a,b(formula);" means that the formal
946 procedure "a" does not have a parameter of type formula and that the
947 formal procedure "b" has one parameter of type formula which is called
948 by name.
949
950 Second part of algoritm:;

```
951
952  SPECIFICATION PART:
953  if synt unit = procedure symbol v
954  next synt unit = procedure symbol ^
955  (synt unit = real symbol v synt unit = integer symbol v
956   synt unit = Boolean symbol v synt unit = formula symbol)
957  then
958  begin integer su,nsu,nr of param; su:= synt unit;
959    nsu:= next synt unit;
960    if nsu = procedure symbol then
961    begin if su = formula symbol then
962      begin PR string(‡ integer ‡); RE end else PR and RE
963    end;
964  PROCEDURE SEGMENT: PR and RE;
965    if first scan then
966    begin nr of param:= 0;
967      if Identifier in paramlist(a) then contents of [a + 3]:=
968      (if nsu = procedure symbol then su else 0) × t15 +
969        32 × procedure symbol + specified as name
970    else ERR(‡formal procedure param not in formal param part‡)
971  end; PR string(‡Z‡); PR and RE;
972  if synt unit = open symbol then
973  begin if second scan then
974    begin RE; SKIP text until(synt unit = close symbol); RE end else
975    begin integer t; TYPE OF PARAM: RE;
976      if synt unit = comma symbol v synt unit = close symbol then
977        t:= 0 else
978      if next synt unit = value symbol then
979      begin t:= synt unit × t15 + specified as value; RE; RE end
980      else if next synt unit = array symbol v
981        next synt unit = procedure symbol then
982      begin t:= synt unit × t15 + 32 × next synt unit +
983            specified as name; RE; RE
984  end else
985  begin t:= synt unit × t15 + specified as name; RE end;
986  b:= STORE into information list(st(0, -t - 1));
987  nr of param:= nr of param + 1;
988  if nr of param = 1 then contents of[a + 4]:= b;
```

```
989         comment The type of the i - th parameter of a formal procedure
990           is equal to:
991             -1 - contents of[contents of[a + 4] - 1 + i × 2],
992             where "a" defines the IC of this procedure.;
993           if synt unit ≠ close symbol then goto TYPE OF PARAM;
994           contents of [a + 5]:= nr of param; RE
995       end end specification parameters of specified formal procedure;
996       if synt unit = comma symbol then goto PROCEDURE SEGMENT;
997       PR and RE semicolon
998     end procedure specification else
999
1000    if synt unit = array symbol ∨ next synt unit = array symbol then
1001    begin integer a,su,nsu;
1002      su:= synt unit; nsu:= next synt unit;
1003      if nsu = array symbol then
1004      begin if su = formula symbol then
1005        begin PR string(≠ integer ≠); RE end else PR and RE
1006      end;
1007    ARRAY IDENTIFIER: PR and RE;
1008      if first scan then
1009      begin if Identifier in paramlist(a) then
1010        contents of [a + 3]:= contents of [a + 3] +
1011        (if nsu = array symbol then su else real symbol) × t15 +
1012          32 × array symbol
1013        else ERR(≠array param not in formal param list≠)
1014      end; PR string(≠Z≠); PR and RE;
1015      if synt unit = comma symbol then goto ARRAY IDENTIFIER;
1016      PR and RE semicolon
1017    end array specification else
1018
1019    if is specifier(synt unit) then
1020    begin integer a,b,su; su:= synt unit;
1021      if su = formula symbol then
1022      begin PR string(≠ integer ≠); RE end else PR and RE;
1023    OTHER IDENTIFIER:
1024      if first scan then
1025      begin if Identifier in paramlist(a) then
1026        b:= contents of [a + 3]:= su × t15 + contents of [a + 3]
```

```
1027        else ERR(‡specified param not in form param list‡);
1028        if b = formula symbol × t15 + specified as value then
1029          begin contents of [a + 4]:= ptr to formula param;
1030            ptr to formula param:= a
1031          end
1032      end; PR string(‡Z‡); PR and RE;
1033      if synt unit = comma symbol then
1034      begin PR and RE; goto OTHER IDENTIFIER end;
1035      PR and RE semicolon
1036    end other specification;
1037
1038    if is specifier(synt unit) then goto SPECIFICATION PART;
1039
1040    if first scan then
1041    begin i:= nr of param; a:= begin; su:= 0;
1042      for a:= a + contents of [a] while i > 0 do
1043      begin i:= i - 1; b:= contents of [a + 3] : 32;
1044          if b = 0 v b = label symbol × 1024 v
1045          b = switch symbol × 1024 then su:= 1
1046    end end;
1047
1048  comment:
1049  Third part of algorithm:;
1050
1051  PROCEDURE BODY: in formula procedure body:=
1052                  in formula procedure body + 1;
1053    if first scan then
1054    begin contents of [begin + 4]:= ptr to integer param;
1055      contents of [begin + 5]:= ptr to formula param
1056    end;
1057    envelope of block(begin);
1058    if first scan ^ su = 1 then
1059    begin if EVEN(contents of [proc ic + 16] : 8) = -1
1060      then dangerous procedures:= true
1061    end; in formula procedure body:= in formula procedure body - 1;
1062    PR and RE semicolon
1063  end procedure declaration;
1064
```

```
1065  comment:
1066
1067  6.4. Translation of a statement
1068
1069  Syntactic definition:
1070
1071  <statement>::= <optional label sequence><unlabelled statement>
1072  <optional label sequence>::= <empty>|<label sequence>
1073  <label sequence>::= <label>:|<label sequence><label>:
1074  <label>::= <identifier>|<unsigned integer>
1075  <unlabelled statement>::= <conditional statement>|
1076                            <unconditional statement>|<for statement>
1077
1078  Algorithms:;
1079
1080  procedure optional label sequence(divisible,begin printed);
1081  value divisible; Boolean divisible,begin printed;
1082  begin Boolean label; label:= begin printed:= false;
1083  A: if (synt unit = identifier v synt unit = integral number) ^
1084        next synt unit  = colon symbol then
1085    begin if synt unit = identifier then PR string(¢Z¢);
1086      if operator identifier then
1087      begin ERR(¢operator identifier occurs as label¢);
1088        PR operator; RE
1089      end else PR and RE;
1090      PR and RE; block contains labels:= label:= true;
1091      goto A
1092    end;
1093    if second scan then
1094    begin if label ^ (dangerous inner block v dangerous procedures) then
1095      begin if ¬ divisible then
1096        begin PR string(¢begin ¢); begin printed:= true end;
1097        PR string(¢ ERASE(snn);¢)
1098  end end end optional label sequence;
1099
1100  procedure statement(divisible); value divisible; Boolean divisible;
1101  begin Boolean beg pr; optional label sequence(divisible,beg pr);
1102    if synt unit = if symbol then
```

```
1103    begin PR and RE; conditional statement end else
1104    if synt unit = for symbol then
1105    begin PR and RE; for statement end else
1106      unconditional statement(beg pr v divisible);
1107      if beg pr then PR string(¢end ¢)
1108  end statement;
1109
1110  comment:
1111
1112  6.4.1. Translation of a conditional statement
1113
1114  Syntactic definition:
1115
1116  <conditional statement>::= <if statement>|
1117          <if statement> else <statement>|
1118          <if clause><optional label sequence><for statement>
1119  <if statement>::= <if clause><optional label sequence>
1120                  <unconditional statement>
1121  <if clause>::= if <Boolean expression> then
1122
1123  Algoritm:;
1124
1125  procedure conditional statement;
1126  begin Boolean bp,pias; other expression; CHECK(then symbol);
1127    PR and RE;
1128    optional label sequence(false,bp);
1129    if synt unit = for symbol then
1130    begin PR and RE; for statement; if bp then PR string(¢end  ¢)
1131    end else
1132    begin unconditional statement(bp); if bp then PR string(¢end ¢);
1133      pias:= proc id ass stat; proc id ass stat:= false;
1134      if synt unit = else symbol then
1135      begin PR and RE; statement(false) end;
1136        proc id ass stat:= pias ^ proc id ass stat
1137  end end conditional statement;
1138
1139  comment:
1140
```

6.4.2. Translation of a for statement

Syntactic definition:

See the ALGOL 60 report [10] section 4.6. Note that as for-list-variable one may not have a formula variable, but one may have an arithmetic variable only.

Algorithm:;

```
procedure for statement;
begin integer a; if second scan then
  begin if Search for identifier(a) then
    begin a:= contents of[a + 3] : t15;
      if a = formula symbol then
      ERR(‹for list element of type formula›)
  end end; other expression; CHECK(becomes symbol); PR and RE;
for list element: other expression;
  if synt unit = step symbol then
  begin PR and RE; other expression; CHECK(until symbol);
    PR and RE; other expression
  end else
  if synt unit = while symbol then
  begin PR and RE; other expression end;
  if synt unit = comma symbol then
  begin PR and RE; goto for list element end;
  CHECK(do symbol); PR and RE; statement(false);
  proc id ass stat:= false
end for statement;
```

comment:

6.4.3. Translation of an unconditional statement

Syntactic definition:

```
<unconditional statement>::= <compound statement>|<block>|
  <goto statement>|<assignment statement>|<procedure statement>|
  <dummy statement>
```

```
<compound statement>::= begin <compound tail>
<compound tail>::= <statement> end |<statement>; <compound tail>
<goto statement>::= goto <designational expression>
<dummy statement>::= <empty>
For designational expression see the ALGOL 60 report [10] section 3.5.

Algorithm:;

procedure unconditional statement(divisible);
value divisible; Boolean divisible;
if synt unit = begin symbol then
begin if is declarator(next synt unit) then envelope of block(0) else
  begin PR and RE begin; S: statement(true);
    if synt unit ≠ semicolon symbol ^ synt unit ≠ end symbol then
    begin ERR(≮statement not appropriately closed≯);
      SEEK(synt unit = semicolon symbol v
           synt unit = end symbol)
    end;
  L: if synt unit = semicolon symbol then
    begin PR and RE semicolon; goto L end;
    if synt unit ≠ end symbol then
    begin proc id ass stat:= false; goto S end;
    PR and RE end
end end else
if synt unit = goto symbol then
begin block contains gotos:= true; PR and RE; other expression
end else
if synt unit = identifier ^ (next synt unit = becomes symbol v
                             next synt unit = sub symbol) then
assignment statement(divisible) else
if synt unit = identifier then procedure statement(false) else
begin comment dummy statement;; end unconditional statement;

comment:
```

6.4.4. Translation of an assignment statement

Syntactic definition:

```
1217
1218  <assignment statement>::= <ordinary assignment statement>|
1219                            <formula assignment statement>
1220  <ordinary assignment statement>::= <left part list>
1221                                     <Bool or arith expression>
1222  <formula assignment statement>::= <left part list><formula expression>
1223  <left part list>::= <left part>|<left part list><left part>
1224  <left part>::= <variable>:=|<procedure identifier>:=
1225  <Bool or arith expression>::= <Boolean expression>|
1226                                <arithmetic expression>
1227
```

The left part list in a formula assignment statement may, of course, contain variables or procedure identifiers of type formula only.

Let fp1,fp2 and fp3 be formula procedure identifiers and f1,f2,f3 and f4 formula variables, then the translations of:
f1:= f2:= fp1:= fp2:= f3:= fp3:= f4:= expr
is as follows:
FP1:= FP2:= FP3:= ASSIGN(F1,ASSIGN(F2,ASSIGN(F3,ASSIGN(F4,EXPR))))
possibly followed by "; protect:= true".
With the protect statement, the whole is, dependent on the value of "divisible", surrounded by begin and end.

Note that as identifiers we may now encounter the special operator identifiers: dyadic + etc.

```
1242
1243  Algorithm:;
1244
1245  procedure assignment statement(divisible);
1246  value divisible; Boolean divisible;
1247  if first scan then
1248  begin L: if interested in proc id ^ ¬ proc id ass stat then
1249    begin if next synt unit = becomes symbol then
1250      proc id ass stat:= nr of ident = contents of [procedure body-6]
1251    end; operator identifier:= false;
1252    RE; if synt unit = sub symbol then other expression;
1253    if synt unit = becomes symbol then
1254    begin RE; if synt unit = identifier ^
```

```
1255      (next synt unit = becomes symbol ∨ next synt unit = sub symbol)
1256      then goto L;
1257      other expression
1258  end end first scan else
1259  begin integer a,t,p,m,n,i,b,
1260    ptr to first formula procedure identifier,prec ptr;
1261    Boolean form ass stat,first,protection needed;
1262    protection needed:= false; first:= true;
1263    ptr to first formula procedure identifier:= 0; n:= 0;
1264  L1: n:= n + 1; block depth:= 0;
1265    if Search for identifier(a) then
1266    begin m:= contents of[a + 3]; t:= m : t15;
1267      m:= m - t × t15; p:= m : 32; m:= m - p × 32
1268    end else t:= p:= m:= 0;
1269
1270    if first then
1271    begin form ass stat:= t = formula symbol; first:= false;
1272      if form ass stat then
1273      begin SAVE reading ptrs; min block depth:= 0 end
1274  end else if ¬ (form ass stat = t = formula symbol) then
1275    ERR(‡left part list of assignment statement not O.K.‡);
1276  if form ass stat then
1277  begin if p = procedure symbol then
1278    begin protection needed:= protection needed ∨ m = with local;
1279      if m = specified as name then ERR(
1280        ‡assignment to parameter procedure‡);
1281      comment In behalf of the procedure "formula expression" we
1282      introduce the following two statements. The block depth is the
1283      block depth of the procedure declaration.;
1284      proc id ass stat:= true;
1285      if min block depth > block depth then
1286      min block depth:= block depth; if block depth = 0 then ERR(
1287        ‡assignment to proc ident outside body‡);
1288      p:= begin; if in formula procedure body > 1 then
1289      begin if m = with local ↑ block depth < -1 then
1290        begin l11: b:= p - 7; t:= contents of [b + 3];
1291          if contents of [b] = 7 ↑ t = formula symbol × t15
1292          + procedure symbol × 32 + with local then
```

```
1293            contents of [b + 6]:= contents of [b + 6] : 4 × 4 + 2;
1294            block depth:= block depth + 1;
1295              if block depth < -1 then
1296              begin p:= contents of [contents of[p + 2] + 2]; goto 111
1297          end end end;
1298          if ptr to first formula procedure identifier = 0 then
1299          ptr to first formula procedure identifier:= (a × 1024 + n) × 4
1300          else
1301          contents of [prec ptr]:=
1302          contents of [prec ptr] + (a × 1024 + n) × 4;
1303          prec ptr:= a + 6;
1304          if contents of [prec ptr] : 4 ≠ 0 then
1305          begin contents of [prec ptr]:=
1306            remainder(contents of [prec ptr],4);
1307            ERR(
1308            ‡two equal form proc idents in lhs of ass stat‡)
1309          end;
1310
1311          comment
1312          The fourth element of the information cell of the formula
1313    procedure identifier is used as link for a list of integers, and can
1314    not be used as a temporary link in the list of left parts now being
1315    formed. In a situation like:
1316          "formula procedure fp1 ;
1317          begin formula procedure fp2 ; fp1:= fp2:= f ;
1318            integer i ; i:= lhs of fp2
1319          end", we see clearly the danger.
1320          Therefore, the sixth element is chosen, with the obligation to
1321    save the two-bits information;
1322        end else if m = declared as value v
1323        m = specified as value then ERR(‡assignment to value variable‡);
1324
1325        RE; if synt unit = sub symbol then
1326        begin RE; SKIP text until(synt unit = bus symbol); RE end;
1327        CHECK(becomes symbol); RE;
1328        if synt unit = identifier then
1329        begin if next synt unit = becomes symbol then goto L1;
1330          if next synt unit = sub symbol then
```

```
1331        begin SAVE reading ptrs; RE; RE;
1332          SKIP text until(synt unit = bus symbol);
1333          if next synt unit = becomes symbol then
1334          begin RESET reading ptrs; goto L1 end
1335          else RESET reading ptrs
1336      end end;
1337      RESET reading ptrs;
1338      if ptr to first formula procedure identifier ≠ 0 then
1339      begin if protection needed ^ ¬ divisible then
1340        PR string(≮begin ≯); SAVE reading ptrs;
1341        a:= ptr to first formula procedure identifier : 4;
1342      L2: m:= a : 1024;
1343        SET reading ptrs on (contents of[m + 2]);
1344        a:= contents of [m + 3]; a:= a - a : 32 × 32;
1345        if a = with local then PR string(≮Y≯);
1346        if operator identifier then PR operator else
1347        begin if a = without local then PR string(≮Z≯);
1348          PR synt unit
1349        end;
1350        PR string(≮:= ≯); a:= contents of [m + 6] : 4;
1351        if a ≠ 0 then goto L2; RESET reading ptrs
1352      end;
1353      a:= ptr to first formula procedure identifier : 4; p:= 0; i:= 1;
1354    L3: if a ≠ 0 then
1355      begin m:= a : 1024; t:= a - m × 1024 -1;
1356        b:= contents of [m + 6]; a:= b : 4;
1357        contents of [m + 6]:= b - a × 4
1358      end else t:= n;
1359      for i:= i step 1 until t do
1360      begin PR string(≮ASSIGN(Z≯); p:= p + 1; PR and RE;
1361        if synt unit = sub symbol then other expression;
1362        CHECK(becomes symbol); RE; PR string(≮,≯)
1363      end;
1364      if t < n then
1365      begin comment Skip the procedure identifier assignment; RE; RE;
1366        i:= t + 2; goto L3
1367      end;
1368      formula expression;
```

```
1369        for i:= 1 step 1 until p do PR string(¢)¢);
1370        if protection needed then
1371        begin PR string(¢; protect:= true ¢);
1372          if ¬ divisible then PR string(¢end ¢)
1373        end
1374      end form ass stat else
1375      begin PR string(¢Z¢); PR and RE;
1376        if synt unit = sub symbol then other expression;
1377        CHECK(becomes symbol); PR and RE;
1378        if synt unit = identifier then
1379        begin if next synt unit = becomes symbol then goto L1;
1380          if next synt unit = sub symbol then
1381          begin SAVE reading ptrs; RE; RE;
1382            SKIP text until(synt unit = bus symbol);
1383            if next synt unit = becomes symbol then
1384            begin RESET reading ptrs; goto L1 end else
1385              RESET reading ptrs
1386        end end;
1387          other expression
1388  end end assignment statement;
1389
1390  comment:
1391
1392  6.4.5. Translation of a procedure statement
1393
1394  Syntactic definition:
1395
1396  <procedure statement>::= <procedure identifier>
1397                           <actual parameter part>
1398  <actual parameter part>::= <empty>|(<actual parameter list>)
1399  <actual parameter list>::= <actual parameter>|
1400                       <actual parameter list> <parameter delimiter>
1401                       <actual parameter>
1402  <actual parameter>::= <string>|<formula expression>|
1403                       <Bool or arith expression>|<switch identifier>|
1404                       <array identifier>|<procedure identifier>
1405  <Bool or arith expression>::= <Boolean expression>|
1406                                <arithmetic expression>
```

```
1407  <parameter delimiter>::=,|)<letter string>:(
1408
1409  Algorithm:;
1410
1411  procedure procedure statement(IRN necessary);
1412  value IRN necessary; Boolean IRN necessary;
1413  if first scan then
1414  begin if next synt unit ≠ open symbol then RE else
1415    begin RE; RE; SKIP text until(synt unit = close symbol); RE
1416  end end else
1417  begin integer a,i,type,p,m,first param,nr of param,mode of proc;
1418    Boolean piass; i:= 0; block depth:= 0;
1419    if Search for identifier(a) then
1420    begin i:= contents of [a + 3];
1421      if i - i : 32 × 32 = specified as name then
1422      begin mode of proc:= 1; first param:= contents of [a + 4] - 1;
1423        nr of param:= contents of [a + 5]
1424      end else
1425      begin mode of proc:= 2; first param:= a + 14;
1426        nr of param:= contents of [a + 5]
1427    end end else
1428    begin if Search for standard identifier(nr of param) then
1429      mode of proc:= 3 else
1430      begin ERR(≠proc not declared≠);
1431        nr of param:= mode of proc:= 0
1432    end end;
1433
1434    if IRN necessary then
1435    begin i:= i : t15; if i = real symbol v (mode of proc = 3 ^
1436      type of standard identifier = real symbol) then PR string(≠RN(≠)
1437      else if i = integer symbol v (mode of proc = 3 ^
1438      type of standard identifier = integer symbol) then
1439      PR string(≠IN(≠) else if i = formula symbol then
1440    begin if proc id ass stat then
1441      begin if block depth > min block depth v mode of proc = 1 then
1442        PR string(≠abs(≠) else IRN necessary:= false
1443      end else IRN necessary:= false
1444    end else IRN necessary:= false
```

```
1445    end; piass:= proc id ass stat; proc id ass stat:= false;
1446
1447    if mode of proc ≠ 3 then PR string(‹Z›); PR and RE;
1448    i:= 0; if synt unit ≠ open symbol then goto END;
1449  L: PR and RE; i:= i + 1; m:= 0;
1450    if mode of proc = 1 then
1451    begin if i ≤ nr of param then
1452      m:= -1 - contents of [first param + i × 2]
1453    end else
1454    if i > nr of param ^ mode of proc ≠ 0 then
1455    ERR(‹too much param in proc call›) else
1456    if mode of proc = 2 then m:= contents of [first param + i × 6];
1457    type:= m : t15; m:= m - type × t15; p:= m : 32;
1458    m:= m - p × 32;
1459    if p ≠ 0 then
1460    begin if synt unit = identifier then
1461      begin if next synt unit = comma symbol v next synt unit =
1462                                  close symbol then
1463      begin if type ≠ formula symbol then goto L1 else
1464        if Search for identifier(a) then
1465        begin if contents of [a + 3] : 32 = type × 1024 + p then
1466          goto L1
1467    end end end; ERR(‹actual param not O.K.›);
1468  L1: PR string(‹Z›); PR and RE
1469  end else if type = formula symbol then
1470  begin if m = specified as name then
1471    begin if synt unit = identifier ^
1472      (next synt unit = comma symbol
1473      v next synt unit = close symbol) then
1474      begin if Search for identifier(a) then
1475        begin m:= contents of [a + 3];
1476          if m : 32 = type × 1024 then
1477        begin if m - m : 32 × 32 = specified as value
1478          then PR string(‹Y›) else PR string(‹Z›);
1479          PR and RE; goto OUT
1480      end end
1481    end else if synt unit = identifier ^ next synt unit =
1482    sub symbol then
```

```
1483        begin SAVE reading ptrs; RE; RE;
1484          SKIP text until(synt unit = bus symbol);
1485          if next synt unit = comma symbol v
1486             next synt unit = close symbol then
1487          begin RESET reading ptrs;
1488            if Search for identifier(a) then
1489            begin m:= contents of [a + 3];
1490              if m : 32 = type × 1024 + array symbol then
1491              begin PR string(ǂZǂ); PR and RE;
1492                other expression; goto OUT
1493          end end end else RESET reading ptrs
1494      end end;
1495      formula expression
1496    end else other expression;
1497  OUT: if synt unit = comma symbol then goto L;
1498    CHECK(close symbol); PR and RE;
1499  END: if mode of proc ǂ 1 then
1500    begin if i ǂ nr of param ^ mode of proc ǂ 0 then
1501      ERR(ǂnr of param not O.K.ǂ)
1502    end; proc id ass stat:= piass; if IRN necessary then
1503    PR string(ǂ)ǂ)
1504  end procedure statement;
1505
1506  comment:
1507
1508  6.5. Translation of an expression
1509
1510  Syntactic definition:
1511
1512  <expression>::= <simple expression>|
1513                  if <Boolean expression> then <simple expression>
1514                                          else <expression>
1515  <simple expression>::= <simple formula expression>|
1516                         <simple other expression>
1517  <simple other expression>::= <simple Boolean expression>|
1518                               <simple arithmetic expression>|
1519                               <simple designational expression>
1520  Boolean- , arithmetic- , designational- and formula expressions are
```

1521 expressions in which the simple expressions are chosen of the
1522 appropriate type.
1523
1524 Algorithm:;
1525
1526 procedure other expression;
1527 if synt unit = if symbol then
1528 begin PR and RE; other expression; CHECK(then symbol); PR and RE;
1529 simple other expression; CHECK(else symbol); PR and RE;
1530 other expression
1531 end else simple other expression;
1532
1533 procedure formula expression;
1534 begin Boolean piass; piass:= proc id ass stat;
1535 if synt unit = if symbol then
1536 begin PR and RE; proc id ass stat:= false;
1537 other expression; CHECK(then symbol); PR and RE;
1538 proc id ass stat:= piass; simple formula expression(false);
1539 CHECK(else symbol); PR and RE; proc id ass stat:= piass;
1540 formula expression
1541 end else simple formula expression(false)
1542 end formula expression;
1543
1544 comment:
1545 A simple other expression is syntactically defined in the ALGOL 60
1546 report [10] chapter 3, with the following addition:
1547 as primary in a simple arithmetic expression a formula enquiry, a
1548 length enquiry and a type enquiry are allowed. These enquiries are
1549 syntactically defined as follows:
1550 <formula enquiry>::= <kind of enquiry> of <formula name>
1551 <type enquiry>::= type of <formula name>
1552 <length enquiry>::= length of <formula name>
1553 <kind of enquiry>::= lhs|rhs|el <arithmetic expression>
1554 <formula name>::= <formula primary>
1555 Moreover, as primaries in a boolean expression, the following
1556 constructions are allowed:
1557 constant <formula name>,
1558 monadic <formula name>,

```
1559  dyadic <formula name>,
1560  polyadic <formula name>,
1561  rowadic <formula name>.
1562  These are called type category enquiries.
1563
1564  Algorithm:;
1565
1566  procedure enquiry;
1567  begin integer s; s:= synt unit; RE;
1568    if s = el symbol then
1569    begin PR string(¢EL(¢); other expression; PR string(¢,¢) end else
1570    if s = lhs  symbol then PR string(¢LHS(¢) else
1571    if s = rhs  symbol then PR string(¢RHS(¢) else
1572    if s = type symbol then PR string(¢TYPE(¢) else
1573    if s = length symbol then PR string(¢LENGTH(¢) else
1574    ERR(¢error in enquiry¢); CHECK(of symbol); RE;
1575    if first scan then other expression else
1576    simple formula expression(true);
1577      PR string(¢)¢)
1578  end enquiry;
1579
1580  comment:
1581
1582  6.5.1. Translation of a simple other expression
1583
1584  Algorithm:;
1585
1586  procedure simple other expression;
1587  begin: if synt unit = identifier then
1588  begin if next synt unit = open symbol then procedure statement(false)
1589    else
1590    begin integer a,t,p,m,br; br:= 0;
1591      if second scan then
1592    begin if Search for identifier(a) then
1593      begin m:= contents of [a + 3]; t:= m : t15;
1594        m:= m - t × t15; p:= m : 32; m:= m - p × 32;
1595      end else if Search for standard identifier(a) then
1596      begin t:= 0; p:= procedure symbol; m:= standard identifier
```

```
1597        end else t:= p:= m:= 0;
1598        if t = formula symbol then
1599        begin if p = procedure symbol v (p = 0 ^ (m = declared as value
1600          v m = specified as value v m = specified as name)) then
1601          begin PR string(≠abs(≠); br:= 1 end;
1602          if p = array symbol v p ≠ procedure symbol ^
1603             m = declared as name then
1604          begin PR string(≠V(≠); br:= br + 1 end else
1605          if m = specified as name ^ p ≠ procedure symbol then
1606          begin PR string(≠VN(≠); br:= br + 1 end
1607        end; if t = formula symbol ^ p = 0 ^ m = specified as value
1608        then PR string(≠Y≠)
1609        else if m ≠ standard identifier then PR string(≠Z≠)
1610      end else a:= t:= p:= m:= 0; PR and RE;
1611
1612      if synt unit = sub symbol then
1613      begin if second scan then
1614        begin if t = formula symbol then
1615          begin if p ≠ array symbol then ERR(
1616            ≠formula array not declared≠)
1617          end end;
1618        L: PR and RE;
1619          other expression; if synt unit = comma symbol then goto L;
1620          CHECK(bus symbol); PR and RE
1621        end; for br:= br - 1 while br ≥ 0 do PR string(≠)≠)
1622      end variable; goto begin
1623  end else
1624  if is enquiry then
1625  begin if synt unit = lhs symbol v
1626    synt unit = rhs symbol v synt unit = el symbol
1627    then PR string(≠AR≠); enquiry; goto begin
1628  end else
1629  if is adic symbol(synt unit) then
1630  begin if second scan then
1631    begin PR int num(synt unit - constant symbol);
1632      PR string(≠= TYPE CAT(≠); RE; simple formula expression(true);
1633      PR string(≠)≠)
1634    end else RE; goto begin
```

```
1635  end else
1636  if synt unit = open symbol v synt unit = sub symbol then
1637  begin Boolean open; open:= synt unit = open symbol;
1638  L: PR and RE; other expression;
1639    if synt unit = comma symbol then goto L;
1640    if open then CHECK(close symbol) else CHECK(bus symbol);
1641    PR and RE; goto begin
1642  end else
1643  begin integer a; for a:= semicolon symbol,end symbol,else symbol,
1644    then symbol,comma symbol,close symbol,bus symbol,step symbol,
1645    until symbol,do symbol,while symbol,colon symbol,becomes symbol,
1646    of symbol do if synt unit = a then goto END;
1647    PR and RE; goto begin;
1648  END:
1649  end simple other expression;
1650
1651  procedure translate string;
1652  begin integer m,n,i,p,T; m:= n:= T:= 0;
1653    p:= ptr of text2 - 3; i:= ptr of text1 - 1; PR string(¢STRING(¢);
1654  L: i:= i + 1; if take from text array(i) ≠ smaller than symbol then
1655    goto L;
1656    for i:= i + 1 step 1 until p do
1657    begin n:= n + 1; T:= T × 256 + take from text array(i) + 1;
1658      if n = 3 v i = p then
1659      begin PR string(¢st(¢); PR int num(T);
1660        PR string(¢,¢); T:= n:= 0; m:= m + 1
1661    end end;
1662    PR string(¢0¢); for i:= 1 step 1 until m do PR string(¢)¢);
1663    PR string(¢,¢); PR int num(m); PR string(¢)¢)
1664  end translate string;
1665
1666  comment:
1667  The translation of "¢01234567¢" is:
1668    "STRING(st(66051,st(263430,st(1800,0))),3)",
1669  where
1670    66051 = ((0+1)×256+(1+1))×256+(2+1),
1671    263430= ((3+1)×256+(4+1))×256+(5+1),
1672    1800  = (6+1)×256+(7+1).
```

6.5.2. Translation of a simple formula expression

Syntactic definition:

A simple formula expression resembles highly a simple arithmetic expression. As formula primaries we may have all the arithmetic primaries, a string, and a formula base (see below). As in an arithmetic expression, the formula-, type- and length enquiries are also possible.
As the syntactic definition of a formula expression is, apart for the primary, identical to the definition of an arithmetic expression, we define a formula primary only:

```
<formula primary>::= <unsigned number>|
        <variable>|<function designator>|(<formula expression>)|
        <formula variable>|<formula enquiry>|<type enquiry>|
        <length enquiry>|<string>|<formula base>

<formula base>::= constant(<type>,<int arith expr>,<int arith expr>)|
        monadic(<type>,<formula expression>,<int arith expr>)|
        dyadic(<type>,<formula expression>,<formula expression>)|
        polyadic(<type>,<int id>,<length>,<formula expression>)|
        rowadic(<type>,<int id>,<length>,<int arith expr>)
<type>::= <int arith expr>
<int id>::= <identifier>
<length>::= <int arith expr>
```

int arith expr is an arithmetic expression delivering an integer.

It is necessary that

1. The value v of type satisfies: $0 \leq v \leq 30$.
2. The value v of the right-hand side of the int arith expr in a constant formula satisfies: $abs(v) < 2 \uparrow 17 - 1$.
3. The value v of length satisfies: $v \geq 0$.

Algorithm:;

```
1711  procedure simple formula expression(primary only);
1712  value primary only; Boolean primary only;
1713  begin integer iF,primary symbol,int num,f,nr of brackets;
1714    integer array Fl,Ft,Fr[1:100]; Boolean scan1;
1715
1716  comment:
1717  In a first  pass (scan1  = true),  the expression is scanned  by means
1718  of the procedures  "elevator" and "primary" during which a syntactical
1719  tree is formed and stored  into  the arrays "Fl",  "Ft" and "Fr",which
1720  have a pointer "iF".
1721  In a second pass (scan1 = false),  output s produced by a call of "PR
1722  form expr",  which,  by using the procedure "primary" forms the output
1723  climbing through the syntactical tree.
1724  If the expression  is  the right-hand  side  of  an  assignment  to  a
1725  procedure identifier,  in which  case "proc id ass stat" has the value
1726  true,  a special translation,  involving  the  abs function  in front
1727  of some formula variables  and some formula function designators,  is
1728  performed. As soon as this variable or function designator is shielded
1729  by another procedure,  the "abs"  is suppressed  as  a result  of the
1730  statement: "proc id ass stat:= false" in "PR form expr".
1731  Concerning  the  treatment  of  brackets  we  remark  that  "PR  form
1732  expr"  skips leading  opening brackets  and trailing closing brackets.
1733  Therefore,  "primary"  starts reading,  during  the second  pass,  a
1734  non-opening  bracket  symbol,  and "RE"  in "PR form expr",  reads  an
1735  operator symbol (except when it skips brackets).
1736  Special attention is given to the primary:  "(if  ...  then  ...  else
1737  ...)".  The translation is a translation from infix notation to prefix
1738  notation.;
1739
1740    integer procedure elevator(floor); value floor; integer floor;
1741    if floor = 0 then elevator:= primary else
1742    begin integer el,s;
1743    if floor = 3 then
1744    begin s:= synt unit; if s = plus symbol v s = minus symbol then
1745      begin RE; el:= elevator(2); iF:= iF + 1;
1746        if iF > 100 then FATAL ERR(‡formula expression too long†);
1747        Fl[iF]:= el; Ft[iF]:= s + 1024; el:= iF;
1748        goto again
```

```
1749      end end; el:= elevator(floor - 1);
1750    again: s:= synt unit;
1751      if floor = 3 ^ (s = plus symbol v s = minus symbol) v
1752         floor = 2 ^ (s = times symbol v s = over symbol v
1753                      s = int div symbol) v
1754         floor = 1 ^ (s = power symbol) then
1755      begin RE; iF:= iF + 1; if iF > 100 then FATAL ERR(
1756        ‡formula expression too long‡);
1757        Fl[iF]:= el; el:= iF; Ft[el]:= s;
1758        Fr[el]:= elevator(floor - 1); goto again
1759      end; elevator:= el
1760    end elevator;
1761
1762    procedure PR form expr(f); value f; integer f;
1763    begin procedure skip opens;
1764      for synt unit:= synt unit
1765      while synt unit = open symbol do
1766      begin nr of brackets:= nr of brackets + 1; RE end;
1767      skip opens;
1768      if f = primary symbol v f = int num then primary else
1769      begin integer l,t,r; l:= Fl[f]; t:= Ft[f]; r:= Fr[f];
1770        proc id ass stat:= false;
1771        if t > 1024 then
1772        begin t:= t - 1024;
1773          if t = plus symbol then PR string(‡PL(‡)
1774          else PR string(‡MI(‡);
1775          RE; PR form expr(l); PR string(‡)‡)
1776        end else
1777        if t = power symbol ^ r = int num then
1778        begin PR string(‡IE(‡); PR form expr(l);
1779          PR string(‡,‡); RE; skip opens; PR and RE; PR string(‡)‡)
1780        end else
1781        begin if t = plus symbol then PR string(‡S(‡) else
1782          if t = minus symbol then PR string(‡D(‡) else
1783          if t = times symbol then PR string(‡P(‡) else
1784          if t = over  symbol then PR string(‡Q(‡) else
1785          if t = int div symbol then PR string(‡IQ(‡) else
1786          if t = power symbol then PR string(‡E(‡);
```

```
1787          PR form expr(l); PR string(↓,↑); RE; PR form expr(r);
1788          PR string(↓)↑)
1789        end end; for synt unit:= synt unit
1790        while synt unit = close symbol ^ nr of brackets > 0 do
1791        begin nr of brackets:= nr of brackets - 1; RE end
1792      end PR form expr;
1793
1794      integer procedure primary;
1795      begin primary:= primary symbol;
1796        if is adic symbol(synt unit) then
1797        begin if scan1 then
1798          begin RE; RE; SKIP text until(synt unit = close symbol); RE
1799          end else
1800          begin integer s; s:= synt unit; RE;
1801            CHECK(open symbol); RE; proc id ass stat:= false;
1802            if s = polyadic symbol ∨ s = rowadic symbol then
1803            begin PR string(↓STORE ROW(↑);
1804              if s = polyadic symbol then PR string(↓96,↑)
1805              else PR string(↓128,↑); other expression;
1806              CHECK(comma symbol); PR and RE; CHECK(identifier);
1807              PR string(↓Z↑); PR and RE; CHECK(comma symbol);
1808              PR and RE; other expression; CHECK(comma symbol);
1809              PR and RE;
1810              if s = polyadic symbol then formula expression else
1811              other expression; CHECK(close symbol); PR and RE
1812          end else
1813          begin PR string(↓STORE ↑);
1814            if s = constant symbol then PR string(↓CONST(↑) else
1815            if s = monadic symbol then PR string(↓MONADIC(↑) else
1816            if s = dyadic symbol then PR string(↓DYADIC(↑);
1817            other expression;
1818            CHECK(comma symbol); PR and RE;
1819            if s = constant symbol ∨ s = monadic symbol then
1820            other expression else formula expression;
1821            CHECK(comma symbol); PR and RE;
1822            if s = constant symbol then other expression
1823            else formula expression; CHECK(close symbol); PR and RE
1824      end end end else
```

```
1825
1826      if synt unit = integral number v synt unit = real number then
1827      begin if ¬ scan1 then
1828        begin if synt unit = integral number
1829          then PR string(‹IN(›) else PR string(‹RN(›);
1830          PR and RE; PR string(‹)›)
1831        end else
1832        begin if synt unit = integral number
1833          then primary:= int num; RE
1834      end end else
1835
1836      if synt unit = identifier then
1837      begin if scan1 then
1838        begin if next synt unit = open symbol v next synt unit =
1839          sub symbol then
1840          begin RE; RE; SKIP text until(
1841            synt unit = close symbol v synt unit = bus symbol)
1842          end; RE
1843        end else
1844        if next synt unit = open symbol then procedure statement(true)
1845        else
1846        begin integer a,t,p,m,br; br:= 1; block depth:= 0;
1847          if Search for identifier(a) then
1848          begin m:= contents of [a + 3]; t:= m : t15; m:= m - t × t15;
1849            p:= m : 32; m:= m - p × 32;
1850          end else
1851          if Search for standard identifier(a) then
1852          begin t:= real symbol; p:= procedure symbol;
1853            m:= standard identifier
1854          end else
1855          begin ERR(‹id not declared in form expr›);
1856            t:= p:= m:= 0
1857        end; if t = formula symbol then
1858        begin if proc id ass stat then
1859          begin if block depth > min block depth ^ (p = procedure
1860            symbol v m = declared as value v m = specified as value v
1861            m = specified as name) v (p = procedure symbol ^
1862            m = specified as name) then
```

```
1863            begin PR string(‡abs(‡); br:= 2 end
1864          end;
1865            if m = declared as name ^ p ≠ procedure symbol v
1866               p = array symbol then PR string(‡V(‡)else
1867            if m = specified as name ^ p ≠ procedure symbol then
1868            PR string(‡VN(‡) else br:= br - 1
1869          end else if t = real symbol then PR string(‡RN(‡)
1870          else if t = integer symbol then PR string(‡IN(‡) else br:= 0;
1871          if t = formula symbol ^ p = 0 ^ m = specified as value
1872          then PR string(‡Y‡) else
1873          if m ≠ standard identifier then PR string(‡Z‡); PR and RE;
1874          if synt unit = sub symbol then
1875          begin if p ≠ array symbol then ERR(
1876            ‡form array not declared‡);
1877          L: PR and RE; other expression;
1878            if synt unit = comma symbol then goto L;
1879            CHECK(bus symbol); PR and RE
1880               end; for br:= br - 1 while br ≥ 0 do PR string(‡)‡)
1881        end end else
1882
1883        if synt unit = string then
1884        begin if ¬ scan1 then translate string; RE end else
1885
1886        if is enquiry then
1887        begin if scan1 then
1888          begin if synt unit = el symbol then
1889            begin RE; SKIP text until(synt unit = of symbol) end
1890            else RE; CHECK(of symbol); RE;
1891            if synt unit = open symbol then
1892            begin RE; SKIP text until(synt unit = close symbol); RE
1893            end else primary:= primary
1894          end else
1895            if synt unit = type symbol v synt unit = length symbol
1896            then begin PR string(‡IN(‡); enquiry; PR string(‡)‡) end
1897            else enquiry
1898        end else
1899
1900        if ¬ scan1 ^ synt unit = if symbol then
```

```
1901      begin PR string(¢(¢); formula expression; PR string(¢)¢) end else
1902
1903      if synt unit = open symbol then
1904        begin RE; if synt unit = if symbol then
1905          SKIP text until(synt unit = close symbol) else
1906          begin primary:= elevator(3); CHECK(close symbol) end; RE
1907        end else ERR(¢primary in formula expr not O.K.¢)
1908    end primary;
1909
1910    comment: Finally the procedure body of simple formula expression;
1911    scan1:= true; iF:= 0; primary symbol:= -1;
1912    int num:= -2; nr of brackets:= 0;
1913    SAVE reading ptrs;
1914    f:= elevator(if primary only then 0 else 3);
1915    scan1:= false; RESET reading ptrs;
1916    PR form expr(f)
1917  end simple formula expression;
1918
1919  comment:
1920  The body of envelope of block:; block or statement
1921  end envelope of block and all the syntax-translating procedures.;
1922
1923  comment:
1924
1925
1926  6.6. Auxiliary equipment
1927
1928  6.6.1. Declaration and initialization of symbols
1929
1930  Algorithm:;
1931
1932  integer symbol,underlining  symbol,space symbol,bar symbol,tab symbol,
1933  nlcr symbol,goto  symbol,if symbol,then symbol,else symbol,for symbol,
1934  do  symbol,step  symbol,until  symbol,while symbol,comment  symbol,
1935  begin symbol,end  symbol,Boolean symbol,integer  symbol,real  symbol,
1936  array  symbol,switch  symbol,procedure symbol,string  symbol,  label
1937  symbol,value  symbol,formula  symbol,type  symbol,lhs  symbol,  rhs
1938  symbol,el  symbol,of symbol,constant  symbol,monadic  symbol,  dyadic
```

```
1939  symbol,polyadic  symbol,rowadic  symbol,length symbol,  int  div
1940  symbol,unequal symbol,power symbol,becomes  symbol,  other symbol,plus
1941  symbol,minus  symbol,times  symbol,over  symbol,  smaller  than
1942  symbol,equal  symbol,greater  than symbol,and  symbol,  comma
1943  symbol,point  symbol,lower  ten symbol,colon  symbol,  semicolon
1944  symbol,open symbol,close symbol,sub  symbol,bus  symbol,  numb  of und
1945  symbols,string,identifier,integral number,real number, prec symbol;
1946  integer array und symbol[1:350],ref1 to und symbol[30:105],
1947    ref2 to und symbol[129:179],adic op[1:6,0:2];
1948
1949  procedure INITIALIZE symbols;
1950  begin integer j,k,p,hash,ptr;
1951    procedure rs(symbol); integer symbol; symbol:= text symbol;
1952    procedure ra(symbol); integer symbol;
1953    begin j:= j + 1; symbol:= j + 128 end;
1954
1955    procedure ru(symbol); integer symbol;
1956    comment
1957    This procedure  puts  the symbols of the underlined word delimiters,
1958  together with  the number  of those symbols  and the internal
1959  representation (the value of j),  in the array "und symbol".  For each
1960  underlined  word delimiter  a hash h is calculated  and  the index  of
1961  the delimiter where it  is placed in "und symbol",  is put in "ref1 to
1962  und symbol[h]".  Moreover, in "ref2 to und symbol[s]",  where s is the
1963  internal representation,  the same index is put.  In the higher syntax
1964  reading procedures  the internal representations  are used in the form
1965  of "goto symbol", "end symbol" etc. See also "Read synt unit".;
1966    begin integer i,s; i:= 0; j:= j + 1;
1967      for s:= text symbol while s ≠ semicolon symbol do
1968      if s = underlining symbol then
1969      begin s:= text symbol;
1970        if s ≠ underlining symbol then
1971        begin i:= i + 1; und symbol[ptr + i + 1]:= s end
1972      end;
1973      symbol:= und symbol[ptr]:= j + 128;
1974      und symbol[ptr + 1]:= i;
1975      hash:= if i = 1 then und symbol[ptr + 2] else
1976      und symbol[ptr + 2] + und symbol[ptr + i + 1] × 2;
```

```
1977      if hash < 30 v hash > 105 then
1978      FATAL ERR(‡und symbol in string incorrect‡);
1979      und symbol[ptr + i + 2]:= ref1 to und symbol[hash];
1980      ref1 to und symbol[hash]:= ref2 to und symbol[symbol]:= ptr;
1981        ptr:= ptr + i + 3
1982    end ru;
1983
1984    integer procedure text symbol;
1985    begin p:= p + 1; text symbol:= STRING SYMBOL(p,
1986      ‡_|   +-x/<=>^,.₁₀:;()[]
1987       goto;go to;if;then;else;for;do;step;until;while;comment;
1988       begin;end;Boolean;boolean;integer;real;array;switch;
1989       procedure;formula;string;label;value;
1990       :;<;>;=;¬;true;false;
1991       type;lhs;length;rhs;el;of;constant;monadic;dyadic;
1992       polyadic;rowadic;
1993      ‡)
1994    end text symbol;
1995
1996    for j:= 30 step 1 until 105 do ref1 to und symbol[j]:= 0;
1997    ptr:= 1; j:= 0; p:= -1;
1998    rs(underlining symbol); rs(space symbol); rs(bar symbol);
1999    rs(tab symbol); rs(plus symbol); rs(minus symbol);
2000    rs(times symbol); rs(over symbol); rs(smaller than symbol);
2001    rs(equal symbol); rs(greater than symbol); rs(and symbol);
2002    rs(comma symbol); rs(point symbol); rs(lower ten symbol);
2003    rs(colon symbol); rs(semi colon symbol); rs(open symbol);
2004    rs(close symbol); rs(sub symbol); rs(bus symbol);rs(nlcr symbol);
2005
2006    k:= ptr; ru(goto symbol); ru(goto symbol);
2007    und symbol[k]:= goto symbol; ru(if symbol);ru(then symbol);
2008    ru(else symbol); ru(for symbol); ru(do symbol); ru(step symbol);
2009    ru(until symbol); ru(while symbol); ru(comment symbol);
2010    ru(begin symbol); ru(end symbol); k:= ptr;
2011    ru(Boolean symbol); ru(Boolean symbol);
2012    und symbol[k]:= Boolean symbol; ru(integer symbol);
2013    ru(real symbol); ru(array symbol); ru(switch symbol);
2014    ru(procedure symbol); ru(formula symbol); ru(string symbol);
```

```
2015    ru(label symbol); ru(value symbol); ru(int div symbol);
2016
2017    comment the following symbols are read: ≤, ≥, ≡, ¬,
2018      true, false;
2019      for k:= 1,2,3,4,5,6 do ru(symbol);
2020      ru(type symbol); ru(lhs symbol); ru(length symbol); ru(rhs symbol);
2021      ru(el symbol); ru(of symbol); ru(constant symbol);
2022      ru(monadic symbol); ru(dyadic symbol); ru(polyadic symbol);
2023      ru(rowadic symbol); numb of und symbols:= j;
2024
2025      ra(power symbol); ra(becomes symbol); ra(other symbol); ra(string);
2026      ra(identifier); ra(integral number); ra(real number);
2027      fill alf
2028  end INITIALIZE symbols;
2029
2030  procedure fill alf;
2031  comment
2032  This procedure is executed  once,  in order  to define  the array alf.
2033  This array  is being  used  in the process  to search an identifier of
2034  a standard procedure.  All standard identifiers begin  with lower case
2035  letters with internal representation from 10 to 36. One should compare
2036  the procedures: "Search for standard identifier" and "standard symbol"
2037  of the next section.  The absolute  value  of alf[s] determines  for a
2038  certain  letter,  with internal representation  s,  the entry  in the
2039  string of standard identifiers  where the identifiers with this letter
2040  as first one are placed.;
2041  begin integer i,k,s; boolean lc; k:= -1;
2042    for i:= 10 step 1 until 36 do alf[i]:= 10↑4;
2043  cyc1: lc:= true;
2044    k:= k + 1; s:= standard symbol(k);
2045    if s = 255 then goto out;
2046    if s = plus symbol then
2047    begin lc:= false; i:= k; k:= k + 1;
2048      s:= standard symbol(k)
2049    end;
2050    if s < 10 v s > 36 then
2051    ERR(‡list of standard symbols not correct‡);
2052    alf[s]:= if lc then k else - i; i:= s;
```

```
2053  cyc2: k:= k + 1; s:= standard symbol(k);
2054    if s = over symbol then goto cyc1;
2055    if s = plus symbol ^ lc then
2056    begin lc:= false; alf[i]:= - alf[i] end;
2057    goto cyc2;
2058  out:
2059  end fill alf;
2060
2061  comment:
2062
2063  6.6.2. The text reading equipment
2064
2065  Algorithm:;
2066
2067  integer ptr of text,ptr of text1,ptr of text2,synt unit,
2068    next synt unit,line number,line number1,additional synt unit,
2069    line number2,nr of stringquotes,delimiter array ptr,
2070    ptr to first letgit,nr of ident,nr of begins,adic sym;
2071  Boolean from delimiter array;
2072  integer array text array[0:10000],alf[10:36],delimiter array[1:30];
2073
2074  procedure put in text array(s); value s; integer s;
2075  begin integer i,j; ptr of text:= ptr of text + 1;
2076    if ptr of text > 29999 then FATAL ERR(
2077    ↓program text too long↓);
2078    i:= (ptr of text - 1) : 3;
2079    j:= ptr of text - i × 3;
2080    text array[i]:=
2081    if j = 1 then s × 160000 else
2082    if j = 2 then text array[i] : 160000 × 160000 + s × 400 else
2083    text array[i] : 400 × 400 + s
2084  end;
2085
2086  integer procedure take from text array(p); value p; integer p;
2087  begin integer i,j,t; i:= (p - 1) : 3; j:= p - i × 3;
2088    t:= text array[i];
2089    if j = 1 thent:= t : 160000 else
2090    if j = 2 then begin t:= t - t : 160000 × 160000; t:= t : 400 end
```

```
2091    else t:= t - t : 400 × 400;
2092    take from text array:= t
2093  end;
2094
2095  procedure NS;
2096  if first scan ^ reading allowed then
2097  begin prec symbol:= symbol;
2098    comment
2099    The symbols are normally read with RESYM.  If, however, an erroneous
2100  parameter  delimiter has been  read  of the form ")abc:1(",  then  the
2101  symbols "abc:1"  have been  put in the array "delimiter array" and the
2102  boolean "from delimiter array" has been made equal  to true.  See also
2103  READ synt unit.;
2104    if from delimiter array then
2105    begin delimiter array ptr:= delimiter array ptr + 1;
2106      symbol:= delimiter array[delimiter array ptr];
2107      if symbol = -1 then
2108      begin from delimiter array:= false; symbol:= RESYM end
2109    end else symbol:= RESYM;
2110    put in text array(symbol);
2111    if symbol = semicolon symbol ^
2112    prec symbol = underlining symbol then
2113    early end of program;
2114    comment
2115    If the symbol ";" is read,  the procedure "early end  of program"
2116  is called  to provide  for  as many string  quotes  and end's that are
2117  necessary  to appropriately close  the text  of the  ABC ALGOL program
2118  under consideration.;
2119    if symbol = nlcr symbol then
2120    begin line number2:= line number2 + 1;
2121      NLCR; ABSFIXT(4,0,line number2)
2122    end else PRSYM(symbol)
2123  end else
2124  begin ptr of text:= ptr of text + 1;
2125    symbol:= take from text array(ptr of text);
2126    if symbol = nlcr symbol then line number2:= line number2 + 1
2127  end NS;
2128
```

```
2129  procedure early end of program;
2130  begin integer i,p; p:= ptr of text:= ptr of text - 2;
2131    for i:= 1 step 1 until nr of stringquotes do
2132    begin put in text array(bar symbol);
2133      put in text array(greater than symbol)
2134    end;
2135    put in text array(semicolon symbol);
2136    put in text array(semicolon symbol);
2137    for i:= 1 step 1 until nr of begins do
2138    put in text array(end symbol);
2139    reading allowed:= false;
2140    ERR(‡program text contains ; ‡);
2141    ptr of text:= p
2142  end early end of program;
2143
2144  integer array und symbol read[1:9];
2145
2146  integer procedure READ synt unit;
2147  begin if is lay out(symbol) then
2148    begin L8: if symbol = space symbol then
2149      ptr of text:= ptr of text - 1;
2150      NS; if is lay out(symbol) then goto L8
2151    end;
2152    line number1:= line number2;
2153    if symbol = underlining symbol then
2154    begin integer i,j,k,hash,nr of letters,ptr; i:= 0;
2155    L: ptr of text:= ptr of text - 1; NS;
2156      if ¬ reading allowed then
2157      begin READ synt unit:= other symbol; goto endprog end;
2158      if symbol = underlining symbol then goto L;
2159      i:= i + 1; if i > 9 then
2160      begin ptr of text:= ptr of text - 1; NS;
2161        if symbol = underlining symbol then goto L;
2162        i:= other symbol; goto OUT
2163      end;
2164      und symbol read[i]:= symbol;
2165      ptr of text:= ptr of text - 1; NS;
2166      if symbol = underlining symbol then goto L;
```

```
2167        hash:= if i = 1 then und symbol read[1] else
2168        und symbol read[1] + 2 × und symbol read[i];
2169        if hash < 30 v hash > 105 then ptr:= 0 else
2170          ptr:= ref1 to und symbol[hash];
2171          comment
2172          From the hash of the underlined symbol read, the place of this
2173      symbol in "und symbol" is determined and it is checked whether the
2174      symbol has been written correctly.;
2175        cyc: if ptr = 0 then
2176          begin i:= other symbol; goto OUT end;
2177          nr of letters:= und symbol[ptr + 1];
2178          if nr of letters = i then
2179          begin j:= ptr + 1;
2180            for k:= 1 step 1 until i do
2181            if und symbol read[k] ≠ und symbol[j + k] then goto next;
2182            i:= und symbol[ptr]; goto OUT
2183          end;
2184        next: ptr:= und symbol[ptr + nr of letters + 2]; goto cyc;
2185          OUT: READ synt unit:= i; ptr of text:= ptr of text - 1;
2186          comment
2187          Note that the internal representation, determined by "und
2188      symbol[ptr]", is put in the text array. Not the symbols. This makes
2189      the reading of the text during the second scan much more rapid.;
2190          put in text array(i); put in text array(symbol);
2191        endprog:
2192        end else
2193
2194        if symbol = colon symbol then
2195        begin NS; if symbol = equal symbol then
2196          begin READ synt unit:= becomes symbol;
2197            ptr of text:= ptr of text - 2;
2198            put in text array(becomes symbol); NS
2199          end else
2200            READ synt unit:= colon symbol
2201        end else
2202        .
2203        if symbol = bar symbol then
2204        begin NS; if symbol = equal symbol then
```

```
2205        begin NS; READ synt unit:= unequal symbol end else
2206        if symbol = and symbol then
2207          begin NS; READ synt unit:= power symbol end else
2208          if symbol = smaller than symbol then
2209          begin integer s; s:= symbol; nr of stringquotes:= 1;
2210          L2: NS; if s = bar symbol then
2211            begin if symbol = smaller than symbol then
2212            nr of stringquotes:= nr of stringquotes + 1 else
2213              if symbol = greater than symbol then
2214              begin nr of stringquotes:= nr of stringquotes - 1;
2215              if nr of stringquotes = 0 then goto L3 end
2216            end; s:= symbol; goto L2;
2217          L3: NS; READ synt unit:= string
2218          end else READ synt unit:= other symbol
2219      end else
2220
2221      if is letter(symbol) then
2222        begin integer i,j,k,ptr,fill ptr,A,B,nls in ident;
2223          comment
2224          An identifier will be read now. It is compared with existing
2225      identifiers, which are stored as a binary tree in the upper part of
2226      the information list. The text array will contain the identification
2227      number of the identifier plus the new line symbols occurring in the
2228      identifier, but not the letters and digits.
2229          If the identification number is larger than 218, three "symbols"
2230      will be put in the text array: 399 and two derived from this number.;
2231          A:= symbol + 1; i:= 1; j:= ptr to name list;
2232          READ synt unit:= identifier;
2233          ptr of text2:= ptr of text; nls in ident:= 0;
2234          if line number 1 ≥ 2000 then FATAL ERR(‹too much lines›);
2235          ptr to first letgit:= ptr of text × 2000 +
2236          line number1;
2237      L1: NS; if is lay  out(symbol) then
2238        begin if symbol = nlcr symbol then
2239          nls in ident:= nls in ident + 1;
2240          goto L1
2241        end;
2242        if is letter(symbol) v is digit(symbol) then
```

```
2243      begin i:= i + 1; if i = 5 then
2244        begin contents of [j]:= A; A:= 0;
2245          j:= j - 1; if j - 7 ≤ ptr of inf list then
2246          FATAL ERR(↓inf list too small↓);
2247          i:= 1
2248        end;
2249        A:= A × 64 + symbol + 1; goto L1
2250      end;
2251      contents of [j]:= - A × 64 ↑ (4 - i);
2252      if j - 7 ≤ ptr of inf list then
2253      FATAL ERR(↓inf list too small↓);
2254      ptr:= ptr to first ident;
2255      for i:= ptr while ptr ≠ 0 do
2256      begin k:= ptr to name list;
2257      next: A:= contents of [i]; B:= contents of [k];
2258        if A = B then
2259        begin if A < 0 then goto FOUND else
2260          begin i:= i - 1; k:= k - 1; goto next end
2261        end;
2262        k:= if abs(A) > abs(B + .5) then 1 else 2;
2263      L2: if A > 0 then
2264        begin i:= i - 1; A:= contents of [i]; goto L2 end;
2265        fill ptr:= i - k;
2266        ptr:= contents of [i - k]
2267      end;
2268
2269      comment We treat a new identifier; i:= j;
2270      contents of [i - 1]:= contents of [i - 2]:= 0;
2271      contents of [i - 3]:= nr of identifiers:= nr of identifiers + 1;
2272      if nr of identifiers > max nr of identifiers then
2273      FATAL ERR(↓too much identifiers↓);
2274      code table [nr of identifiers]:= ptr to name list;
2275      if ptr to first ident = 0 then ptr to first ident:=
2276                                        ptr to name list else
2277        contents of [fill ptr]:= ptr to name list;
2278        ptr to name list:= i - 4;
2279    FOUND: nr of ident:= contents of [i - 3];
2280        ptr of text:= ptr of text2 - 1;
```

```
2281      if nr of ident ≤ 218 then
2282      put in text array (nr of ident + 180) else
2283      begin put in text array(399);
2284        put in text array(nr of ident : 400);
2285        put in text array(nr of ident - nr of ident : 400 × 400)
2286      end;
2287      for i:= 1 step 1 until nls in ident do
2288      put in text array(nlcr symbol);
2289      put in text array(symbol);
2290    end else
2291
2292    if symbol > 180 then
2293    begin READ synt unit:= identifier; ptr of text2:=
2294      ptr to first letgit:= ptr of text;
2295      if symbol = 399 then
2296      begin NS; nr of ident:= symbol × 400;
2297        NS; nr of ident:= nr of ident + symbol
2298      end else nr of ident:= symbol - 180;
2299      NS
2300    end else
2301
2302    if is digit(symbol) ∨ symbol = point symbol ∨
2303                  symbol = lower ten symbol then
2304    begin Boolean integer; integer:= true;
2305    L5: NS; if symbol = point symbol then integer:= false else
2306      if symbol = lower ten symbol then
2307      begin L51: NS; if is layout(symbol) then goto L51;
2308        integer:= false
2309      end else if ¬ (is layout(symbol) ∨ is digit(symbol))
2310      then goto L52;
2311      goto L5; L52:
2312      READ synt unit:= if integer then
2313      integral number else real number
2314    end else
2315
2316    if symbol = close symbol then
2317    begin integer p,l,nls in delimiter; if first scan then
2318      begin p:= ptr of text; l:= linenumber2;
```

```
2319          nls in delimiter:= 0
2320        end;
2321      L6: NS; if is letter(symbol) then
2322        begin comment
2323          Tentatively, a parameter delimiter will be read. If it turns out
2324    that  the delimiter  is not well formed  an error message is given and
2325    the reading  ptrs are set back to the beginning after the insertion of
2326    a semicolon symbol which most probably has been forgotten.;
2327          procedure store(s); value s; integer s;
2328          begin if delimiter array ptr < 29 then
2329            begin delimiter array ptr:= delimiter array ptr + 1;
2330              delimiter array[delimiter array ptr]:= s
2331            end;
2332            if s = nlcr symbol then
2333            nls in delimiter:= nls in delimiter + 1
2334          end;
2335          delimiter array ptr:= 0;
2336        L7: store(symbol); NS;
2337          if is letter(symbol) v is digit(symbol) v
2338          is lay out(symbol) then goto L7;
2339          if symbol = colon symbol then
2340          begin L8: store(symbol); NS;
2341            if is lay out(symbol) then goto L8;
2342            if symbol = open symbol then
2343            begin ptr of text:= p - 1;
2344              put in text array(comma symbol);
2345              for p:= 1 step 1 until nls in delimiter do
2346              put in text array(nlcr symbol);
2347              READ synt unit:= comma symbol; NS; goto out
2348            end else store(symbol)
2349          end;
2350        L9: ptr of text:= p; linenumber2:= 1;
2351          from delimiter array:= true;
2352          put in text array(semicolon symbol);
2353          symbol:= semicolon symbol;
2354          delimiter array[delimiter array ptr + 1]:= - 1;
2355          delimiter array ptr:= 0; READ synt unit:= close symbol;
2356          ERR(‹incorrect parameter delimiter›)
```

```
2357      end else if is lay out(symbol) then goto L6 else
2358      READ synt unit:= close symbol;
2359    out: end else
2360      begin READ synt unit:= symbol; NS end
2361  end READ synt unit;
2362
2363  Boolean procedure is adic symbol(s); value s; integer s;
2364  is adic symbol:= constant symbol ≤ s ^ s ≤ rowadic symbol;
2365
2366  Boolean procedure is declarator(s); value s; integer s;
2367  is declarator:= Boolean symbol ≤ s ^ s ≤ formula symbol;
2368
2369  Boolean procedure is specifier(s); value s; integer s;
2370  is specifier:= Boolean symbol ≤ s ^ s ≤ label symbol;
2371
2372  Boolean count nr of begins,delay one RE, no semicolon or
2373   begin end allowed, reading allowed;
2374
2375  Boolean procedure is letter(s); value s; integer s;
2376  is letter:= 10 ≤ s ^ s ≤ 62;
2377  Boolean procedure is layout(s); value s; integer s;
2378  is layout:= s = space symbol v s = tab symbol v s = nlcr symbol;
2379  Boolean procedure is digit(s); value s; integer s;
2380  is digit:= 0 ≤ s ^ s ≤ 9;
2381
2382  Boolean procedure is enquiry; is enquiry:=
2383    type symbol ≤ synt unit ^ synt unit ≤ el symbol;
2384
2385  Boolean procedure is operator(s,n); value s; integer s,n;
2386  begin procedure P(op); value op; integer op;
2387    begin n:= n + 1; if s = op then goto OUT end;
2388    n:= 0; P(plus symbol); P(minus symbol); P(times symbol);
2389    P(over symbol); P(int div symbol); P(power symbol);
2390    is operator:= false; goto END;
2391  OUT: is operator:= true;
2392  END: end is operator;
2393
2394  procedure RE;
```

```
2395  if delay one RE then delay one RE:= false else
2396  if no semicolon or begin end allowed ^
2397    (synt unit = semicolon symbol v
2398     synt unit = begin symbol v
2399     synt unit = end symbol) then else
2400  begin integer n; synt unit:= next synt unit;
2401    operator identifier:= false;
2402    ptr of text1:= ptr of text2; ptr of text2:= ptr of text;
2403    line number:= line number1;
2404    next synt unit:= if nr of begins > 0 then READ synt unit else
2405                     synt unit;
2406  L0: if count nr of begins then
2407    begin if next synt unit = begin symbol then
2408      nr of begins:= nr of begins + 1 else
2409      if next synt unit = end symbol then nr of begins:=
2410                                          nr of begins - 1
2411    end;
2412    if synt unit = end symbol then
2413    begin L: if next synt unit ≠ end symbol ^ next synt unit ≠
2414      else symbol ^ next synt unit ≠ semicolon symbol then
2415
2416      begin ptr of text2:= ptr of text; next synt unit:= READ synt unit;
2417        if count nr of begins ^ next synt unit = end symbol then
2418        nr of begins:= nr of begins - 1; goto L
2419      end
2420    end;
2421    if next synt unit = comment symbol then
2422    begin if ¬ (synt unit = semicolon symbol v synt unit = begin symbol)
2423      then ERR(↓comment not appropriate↓);
2424      ptr of text:= ptr of text -2;
2425    L1: if symbol ≠ semicolon symbol then
2426      begin NS; if symbol ≠ nlcr symbol then ptr of text:=
2427        ptr of text - 1; goto L1
2428      end;
2429      NS; next synt unit:= READ synt unit; goto L0
2430    end else
2431    if is adic symbol(synt unit) ^ is operator(next synt unit,n) then
2432    begin adic sym:= adic op[n,synt unit - constant symbol];
```

```
2433      if adic sym = 0 then ERR(‡wrong combination for operator ident‡);
2434      ptr to first letgit:= ptr of text1 × 2000 + line number1;
2435      nr of ident:= - (synt unit × 1024 + next synt unit);
2436        RE; operator identifier:= true; if next synt unit = identifier
2437        then ERR(‡identifier after operator identifier‡);
2438        synt unit:= identifier
2439      end
2440  end RE;
2441
2442  procedure RE semicolon;
2443  begin if synt unit ≠ semicolon symbol then
2444      begin ERR(‡no semicolon where required‡);
2445        SEEK(synt unit = semicolon symbol v
2446       synt unit = end symbol)
2447      end; no semicolon or begin end allowed:= false;
2448      if synt unit ≠ end symbol then RE;
2449      no semicolon or begin end allowed:= true
2450  end;
2451
2452  procedure RE end;
2453  begin no semicolon or begin end allowed:= false; RE;
2454          no semicolon or begin end allowed:= true
2455  end;
2456
2457  procedure RE begin; RE end;
2458
2459  procedure SAVE reading ptrs;
2460  begin integer i,j; j:= 0; count nr of begins:= false;
2461    nr of begins:= nr of begins + 2;
2462    comment The reason to augment "nr of begins" is that under
2463  extraordinary circumstances this variable could otherwise obtain the
2464  value -1. E.g. when "synt unit" denotes the last end, as in "... f:= 5
2465  end";
2466    ptr of old reading ptrs:= ptr of old reading ptrs + 1;
2467    for i:= synt unit,next synt unit,ptr to first letgit,
2468      nr of ident,ptr of text1,ptr of text2,ptr of text,symbol,
2469      line number,line number1,line number2 do
2470    begin j:= j + 1; old reading ptrs[ptr of old reading ptrs,j]:=i end;
```

```
2471    old reading ptrs[ptr of old reading ptrs,j+1]:=
2472    if operator identifier then 1 else 0
2473  end SAVE reading ptrs;
2474
2475  integer array old reading ptrs[1:10,1:12];
2476  integer ptr of old reading ptrs;
2477
2478  procedure RESET reading ptrs;
2479  begin integer i; procedure A(x); integer x;
2480    begin i:= i + 1; x:= old reading ptrs[ptr of old reading ptrs,i]
2481    end; i:= 0; A(synt unit); A(next synt unit);
2482    A(ptr to first letgit); A(nr of ident); A(ptr of text1);
2483    A(ptr of text2); A(ptr of text); A(symbol); A(line number);
2484    A(line number1); A(line number2);
2485    operator identifier:=
2486    old reading ptrs[ptr of old reading ptrs,i + 1] = 1;
2487    if ptr of old reading ptrs = 1 then count nr of begins:= true;
2488    nr of begins:= nr of begins - 2; delay one RE:= false;
2489    ptr of old reading ptrs:= ptr of old reading ptrs - 1
2490  end RESET reading ptrs;
2491
2492  procedure SET reading ptrs on(t); value t; integer t;
2493  begin ptr of text:= t : 2000; operator identifier:= false;
2494    line number2:= t - ptr of text × 2000;
2495    ptr of text:= ptr of text - 1; NS; synt unit:= next synt unit:=
2496    comma symbol; delay one RE:= false; RE; RE
2497  end SET reading ptrs on;
2498  comment
2499  The following procedure skips text until a certain condition "b" is
2500  satisfied. The condition can be: "synt unit = close symbol" or "synt
2501  unit = bus symbol" or "synt unit = comma symbol v synt unit = close
2502  symbol".
2503  The symbols ), ] and , are read on the appropriate level, i.e. if
2504  they occur in a bracket structure [...] or (...), then the complete
2505  text enclosed by the brackets including the brackets is skipped
2506  automatically. The effect is that "a + b[x × (y + z) + 5] + c)"
2507  is treated as "a + b + c)", so that "skips until)" has the desired
2508  effect.
```

```
2509  In order  to restore erroneous situations,  in which  left brackets do
2510  not have corresponding right brackets, singly occurring right brackets
2511  stop the skipping process,  and,  if "b"  is not true,  "delay one RE"
2512  gets the value true  so that  a next  call  of  RE will  not result in
2513  reading a syntactic unit.  Due  to this construction,  skipping of the
2514  subscript of a in: "a[(b + c[d × (e + f]]", will be successful.;
2515
2516  procedure SKIP text until(b); Boolean b;
2517  begin delay one RE:= false;
2518  L: if synt unit = end symbol v synt unit = begin symbol then
2519    begin ERR(≠nr of brackets incorrect≠); goto end end
2520    else if synt unit = semicolon symbol then goto end
2521    else if synt unit = open symbol then
2522    begin RE; SKIP text until (synt unit = close symbol);
2523      RE; goto L
2524    end else
2525    if synt unit = sub symbol then
2526    begin RE; SKIP text until (synt unit = bus symbol);
2527      RE; goto L
2528  end else
2529  if is enquiry then
2530  begin if synt unit = el symbol then
2531    begin RE; SKIP text until(synt unit = of symbol);
2532      RE; goto L
2533    end else
2534    begin RE; CHECK(of symbol); RE; goto L end
2535  end else
2536  if synt unit = close symbol v synt unit = bus symbol v
2537  synt unit = of symbol then
2538  begin if ¬ b then
2539    begin delay one RE:= true;
2540      comment For "additional synt unit" see the
2541        procedure "PR and RE" and CHECK;
2542      additional synt unit:= 0
2543    end;
2544    goto end
2545  end;
2546  if ¬ b then begin RE; goto L end;
```

```
2547  end:
2548  end SKIP text until;
2549
2550  procedure SEEK(b); Boolean b;
2551  begin delay one RE:= false;
2552  L: if ¬ b ^ synt unit ≠ begin symbol then begin RE; goto L end
2553  end;
2554
2555  integer type of standard identifier;
2556
2557  Boolean procedure Search for standard identifier(nr); integer nr;
2558  comment
2559  A given identifier  is compared  with  the identifiers of the standard
2560  procedures,  as given  in the string  of the next procedure  "standard
2561  symbol".
2562  The "+" means: identifier is allowed in lower and upper case.
2563  The integer means the number of parameters.
2564  The symbols ),  > and ] mean:  the procedure  is  a real procedure,  a
2565  non-type procedure and an integer procedure, respectively.
2566  The symbol  / denotes  the end  of a set of identifiers beginning with
2567  the same letter (it is used in the procedure "fill alf").;
2568  begin integer in,i,s,first letter,k,s1,s2,t,constant;
2569    boolean uc; if nr of ident < 0 then
2570    begin ERR(≠operator identifier in wrong place≠);
2571      goto notfound
2572    end; in:= i:= code table[nr of ident];
2573    s:= contents of [i]; first letter:= abs(s) : t18 - 1;
2574    uc:= first letter > 36; if uc then first letter:=
2575    first letter - 27; k:= alf[first letter];
2576    if k = ₁₀4 ∨ k > 0 ^ uc then goto notfound; k:= abs(k);
2577  newid: s1:= standard symbol(k); k:= k+1;
2578    if s1 = over symbol then goto notfound else
2579    if s1 = plus symbol then
2580    begin constant:= if uc then 28 else 1; s1:= standard symbol(k);
2581      k:= k + 1
2582    end else begin if uc then goto skipid else constant:= 1 end;
2583  newt: t:= 0; for s:= 1,2,3,4 do
2584    begin s2:= standard symbol(k); t:= t×64+constant+s1;
```

```
2585        if s2 = open symbol then
2586        begin t:= -tx64↑(4-s); goto compare end;
2587          s1:=s2; k:= k+1
2588        end;
2589    compare: s:= contents of [i];
2590        if s = t ^ s < 0 then goto found else if s = t then
2591        begin i:= i-1; s1:= s2; goto newt end else
2592        if abs(t) > abs(s + .5) then goto notfound else
2593    skipid:
2594        begin for k:= k+1 while standard symbol(k) ≠ semicolon symbol,
2595          k+1 do; i:= in; goto new id
2596        end;
2597    notfound: Search for standard identifier:= false; nr:= 0; goto out;
2598    found: Search for standard identifier:= true;
2599        k:= k+1; nr:= standard symbol(k);
2600        k:= k+1; i:= standard symbol(k);
2601        type of standard identifier:=
2602          if i = close symbol then real symbol else
2603          if i = bus symbol then integer symbol else 0;
2604    out:
2605    end Search for standard identifier;
2606
2607    integer procedure standard symbol(k); integer k;
2608    begin integer s;
2609    cyc:  s:= STRING SYMBOL(k,↓
2610        abs(1);absfixc(3>;+absfixp(3>;+absfixt(3>;and(2];
2611        arctan(1);available(0]; /
2612        bit(2];bitstring(3]; /
2613        +carriage(1>;circ shift(2];clear shift(2];col(1>;
2614        compose(2);cos(1);cpos(0];cpunch(1>;csym(1>; /
2615        date(0]; /
2616        entier(1];+even(1];+exit(0>;exp(1); /
2617        fix(4>;fixc(3>;+fixp(3>;+fixt(3>;flo(4>;floc(3>;
2618        +flop(3>;+flot(3>;+from drum(2>; /
2619        head of(1]; /
2620        +inprod(5); /
2621        +line number(0];ln(1); /
2622        matmat(6);mattam(6);matvec(5); /
```

```
2623    +new page(0>;+nlcr(0>;norm shift(2]; /
2624    or(2];outflexo(0>;outiso(0>; /
2625      +print(1>;print pos(0];+printtext(1>;+prsym(1>;+puhep(1>;
2626      +punch(1>;+punlcr(0>;+puspace(1>;+pusym(1>;+putext(1>; /
2627      +random(0);+read(0);read1(2);+rehep(0];+remainder(2];
2628      +resym(0];resymbol(0];+runout(0>; /
2629      set(4];+setrandom(1>;sign(1];sin(1);+space(1>;sqrt(1);
2630      +stopcode(0>;+stringsymbol(2];+sum(4); /
2631      +tab(0>;tail of(1];tammat(6);tamvec(5);time(0);+to drum(2>; /
2632      vecvec(5); /
2633      xor(2]; / +); if is lay out(s) then begin k:= k+1; goto cyc end
2634      else standard symbol:= s
2635  end standard symbol;
2636
2637  procedure INITIALIZE reading ptrs;
2638  begin ptr of text:= ptr of text1:= ptr of text2:= 0;
2639    synt unit:= next synt unit:= semicolon symbol; symbol:= 0;
2640    line number:= line number1:= line number2:= 0;
2641    ptr to first letgit:= nr of ident:= 0; nr of begins:= 2;
2642    delay one RE:= false; from delimiter array:= false;
2643    count nr of begins:= true; ptr of old reading ptrs:= 0;
2644    nr of stringquotes:= 0; NS; RE semicolon; RE semicolon;
2645    nr of begins:= nr of begins - 2
2646  end;
2647
2648  comment:
2649
2650  6.6.3. The printing equipment
2651
2652  Algorithm:;
2653
2654  procedure PR synt unit; if second scan then
2655  begin integer i,s,j,k,t,ptr,bound; Boolean nlcr pr;
2656    if operator identifier then
2657    begin operator identifier:= false;
2658      ERR(+operator ident in illegal place+)
2659    end; nlcr pr:= false;
2660    for i:= ptr of text1 step 1 until ptr of text2 - 1 do
```

```
2661    begin s:= take from text array(i);
2662      if s < 128 then
2663    begin if s = nlcr symbol then
2664      begin if nlcr pr ^ synt unit ≠ string then else
2665        begin PR sym(s); nlcr pr:= true end
2666      end else PR sym(s)
2667    end else
2668    begin if s = becomes symbol then PR string(≠:=≠) else
2669      if s = other symbol then PR string(≠other ≠) else
2670      if s < 180 then
2671      begin ptr:= ref2 to und symbol[s];
2672        bound:=ptr + und symbol[ptr + 1] + 1;
2673        for k:= ptr + 2 step 1 until bound do
2674        begin PUSYM(underlining symbol);PRSYM(underlining symbol);
2675          t:= und symbol[k]; PRSYM(t); PUSYM(t)
2676        end; PR string(≠ ≠)
2677      end else
2678        begin j:= if s < 399 then code table[s - 180]
2679          else code table[take from text array(i + 1) × 400
2680                          + take from text array(i + 2)];
2681          if s = 399 then i:= i + 2; j:= j + 1; k:= 1;
2682          for j:= j - 1 while k > 0 do
2683          begin k:= contents of [j]; t:= abs(k);
2684            for t:= t while t > 0 do
2685            begin s:= t : t18; t:= (t - s × t18) × 64;
2686              PUSYM(s - 1); PRSYM(s - 1)
2687          end end; PR string(≠ ≠)
2688  end end end end PR synt unit;
2689
2690  procedure PR and RE;
2691  begin if second scan ^ delay one RE then
2692  SHOW(additional synt unit,true) else PR synt unit; RE
2693  end;
2694
2695  procedure PR and RE semicolon;
2696  begin if synt unit = semicolon symbol then
2697  PR synt unit else SHOW(semicolon symbol,true);
2698    RE semicolon
```

```
2699  end;
2700
2701  procedure PR and RE end;
2702  begin if synt unit = end symbol then
2703    PR synt unit else SHOW(end symbol,true);
2704    RE end
2705  end;
2706
2707  procedure PR and RE begin;
2708  begin if synt unit = begin symbol then
2709    PR synt unit else SHOW(begin symbol,true);
2710    RE begin
2711  end;
2712
2713  integer procedure PR string(s); string s;
2714  begin PR string:= 1; if second scan then
2715    begin PRINTTEXT(s); PUTEXT(s) end
2716  end;
2717
2718  integer procedure PR nlcr; PR nlcr:= PR string(¢
2719  ¢);
2720
2721  procedure PR sym(i);
2722  if second scan then begin PRSYM(i); PUSYM(i) end;
2723
2724  procedure SHOW(su,punch); value su; integer su; Boolean punch;
2725  begin procedure p(s); string s;
2726    begin PRINTTEXT(s);if punch then PUTEXT(s) end;
2727    procedure PR(s); value s; integer s;
2728    begin PRSYM(s); if punch then PUSYM(s) end;
2729      if su = unequal symbol then p(¢≠¢) else
2730      if su = power  symbol then p(¢↑¢) else
2731      if su = becomes symbol then p(¢:=¢) else
2732      if su = string         then p(¢"string"¢) else
2733      if su = identifier     then p(¢"identifier"¢) else
2734      if su = integral numberthen p(¢"int num"¢) else
2735      if su = real number    then p(¢"real num"¢) else
2736      if su = other symbol   then p(¢"unknown"¢) else
```

```
2737      if su < 128 then PR(su) else
2738      begin integer j,k,ptr,bound; ptr:=ref2 to und symbol[su];
2739        bound:=ptr + und symbol[ptr + 1] + 1;
2740        for k:= ptr + 2 step 1 until bound do
2741        begin PR(underlining symbol); PR(und symbol[k]) end;
2742        PR(space symbol)
2743  end end SHOW;
2744
2745  integer procedure PR int num(a); value a; integer a;
2746  begin integer b; PR int num:= 1;
2747    if a < 0 then begin PR string(‡-‡); a:= -a end;
2748    if a ≤ 9 then PR sym(a) else
2749    begin b:= a : 10; a:= a - b × 10; PR int num(b); PR sym(a) end
2750  end PR int num;
2751
2752  procedure PR operator;
2753  begin operator identifier:= false;
2754    if adic sym ≥ 256 then PR sym(adic sym : 256);
2755    PR sym(adic sym - adic sym : 256 × 256)
2756  end;
2757
2758  procedure ERR(s); string s;
2759  begin integer i; i:= print pos; NLCR;PRINTTEXT(
2760    ‡xxxxxxxxxerrorxxxxxxxxx‡); ABSFIXT(4,0,line number);
2761    PRINTTEXT(s); SPACE(80 - print pos);
2762    SHOW(synt unit,false); SPACE(95 - print pos);
2763    SHOW(next synt unit,false); SPACE(110 - print pos);
2764    NLCR; SPACE(i)
2765  end ERR;
2766
2767  procedure FATAL ERR(s); string s;
2768  begin ERR(s); EXIT end;
2769
2770  procedure CHECK(s); value s; integer s;
2771  if synt unit ≠ s then
2772  begin integer i; i:= print pos; NLCR;
2773    ERR(‡synt unit not OK‡);
2774    NLCR; PRINTTEXT(‡synt unit should be:‡);
```

```
2775    SHOW(s,false); NLCR; SPACE(i); delay one RE:= true;
2776    additional synt unit:= s
2777  end;
2778
2779  integer procedure PR sn(s,n,tail); string s; integer n,tail;
2780  begin PR string(s); PR int num(n); PR sn:= tail end;
2781
2782  comment:
2783
2784  6.6.4. The information-cells equipment
2785
2786  Algorithm:;
2787
2788  integer procedure STORE into information list(list); integer list;
2789  begin integer x,p; p:= ptr of inf list;
2790    ptr of inf list:= ptr of inf list + 1;
2791    x:= list; contents of [p]:= ptr of inf list - p;
2792    if contents of [p + 1] > 0 then CHECK(identifier);
2793    STORE into information list:= p
2794  end STORE into information list;
2795
2796  integer procedure st(head,inf); integer head,inf;
2797  begin st:= head;
2798    if ptr of inf list > ptr to name list - 3 then FATAL ERR(
2799          ‡inf list too small‡);
2800    contents of [ptr of inf list]:= inf;
2801    ptr of inf list:= ptr of inf list + 1
2802  end st;
2803  integer ptr of inf list,max of inf list,ptr to first ident,
2804          ptr to name list,nr of identifiers,max nr of identifiers,
2805          t10,t15,t18,declared as value,declared as name, specified as
2806          value,specified as name,standard identifier,with local,
2807          reinitptr,without local,block depth,min block depth,in formula
2808          procedure body;
2809  Boolean normal compilation,print information list;
2810  integer array contents of [0:5000],code table[1:400];
2811  comment
2812  If "normal compilation"  has the value true "INITIALIZE inf list ptrs"
```

```
2813  begins with filling the information list and the contents of some "inf
2814  list ptrs" with the information of the catalogue. This is done via the
2815  procedure "reinit", which uses the procedure "catalogue symbol", in
2816  which, in the form of a string, this information is stored.
2817  The information of the catalogue is itself produced by the same
2818  compiler with "normal compilation" having the value false, while "inf
2819  list ptrs" are given their purely initial values. As a result, a
2820  string is produced being the procedure "catalogue symbol", by means of
2821  the procedure "print catalogue".
2822  The procedure "PR inf cells" does not come into action normally, as
2823  the boolean "print information list" has the value false. If one needs
2824  the contents of the information list, however, this value can easily
2825  be made true in the main program.;
2826
2827  procedure INITIALIZE inf list ptrs;
2828  begin integer procedure val(v); value v; integer v;
2829    val:= if normal compilation then reinit else v;
2830    max of inf list:= 5000; max nr of identifiers:= 400;
2831    t10:= 2 ↑ 10; t15:= t10 × 32; t18:=t15 × 8; reinitptr:= -1;
2832    declared as value:= 1; declared as name:= 2; specified as value:= 3;
2833    specified as name:= 4; standard identifier:= 5; with local:= 6;
2834    without local:= 7; block depth:= min block depth:= 0;
2835    in formula procedure body:= 0;
2836    ptr to first ident:= val(0); ptr of inf list:= val(1);
2837    ptr to name list:= val(max of inf list);
2838    nr of identifiers:= val(0); if normal compilation then
2839    begin integer i;
2840      for i:= ptr of inf list - 1 step - 1 until 1,
2841      ptr to name list + 1 step 1 until max of inf list do
2842      contents of[i]:= reinit;
2843      for i:= 1 step 1 until nr of identifiers do
2844      codetable[i]:= reinit
2845    end
2846  end;
2847
2848  procedure PR inf cells; if print information list then
2849  begin integer i,p,s,t; p:= 1;
2850    NLCR; NLCR; PRINTTEXT(‡contents of inf list‡);
```

```
2851  L: NLCR; if p ≥ ptr of inf list then
2852    begin p:=ptr to first ident; goto L2 end;
2853    for i:= p step 1 until p + contents of [p] - 1 do
2854    begin ABSFIXT(4,0,i); FIXT(8,0,contents of [i]) end;
2855    p:= p + contents of [p]; goto L;
2856  L2: if p = ptr to name list then goto out;
2857    NLCR; ABSFIXT(4,0,p); i:=1;
2858    for s:= contents of[p] while i > 0 do
2859    begin i:= s; s:= abs(s);
2860      for s:= s while s > 0 do
2861      begin t:= s : t18; s:= (s - t × t18) × 64;
2862        PRSYM(t - 1)
2863      end;
2864      p:= p - 1
2865    end;
2866    NLCR; PR string(¢    ¢);
2867    for i:= p,p - 1,p - 2 do ABSFIXT(4,0,contents of[i]);
2868    p:= p - 3; goto L2;
2869  out: NLCR; NLCR; for i:= 1 step 1 until nr of identifiers do
2870    begin ABSFIXT(4,0,i); ABSFIXT(4,0,codetable[i]) end
2871  end PR inf cells;
2872
2873  procedure print catalogue;
2874  begin integer i,j;
2875    procedure PR cat(x); value x; integer x;
2876    begin j:= j + 1; PR int num(x);
2877      if j = j : 5 × 5 then PR nlcr else PR string(¢ ¢)
2878    end PR cat;
2879    PR string(¢
2880  integer procedure catalogue symbol;
2881  begin reinitptr:= reinitptr + 1;
2882    catalogue symbol:= STRING SYMBOL(reinitptr,¢);
2883    PR nlcr; PR sym(bar symbol); PR sym(smaller than symbol);
2884    j:= 0; PR cat(ptr to first ident); PR cat(ptr of inf list);
2885    PR cat(ptr to name list); PR cat(nr of identifiers);
2886    for i:= ptr of inf list - 1 step - 1 until 1,
2887    ptr to name list + 1 step 1 until max of inf list do
2888    PR cat(contents of[i]);
```

```
2889    for i:= 1 step 1 until nr of identifiers do
2890    PR cat(codetable[i]); PR nlcr;
2891    PR sym(bar symbol); PR sym(greater than symbol);
2892      PR string(¢)
2893  end;¢)
2894  end print catalogue;
2895
2896  integer procedure reinit;
2897  begin integer s,k,t;
2898    for s:= catalogue symbol while is lay out(s) do;
2899    k:= if s = minus symbol then 0 else s;
2900    t:= if s = minus symbol then - 1 else 1;
2901    for s:= catalogue symbol while ¬ is lay out(s) do
2902    k:= k × 10 + s;
2903    reinit:= k × t
2904  end reinit;
2905
2906  integer procedure catalogue symbol;
2907  begin reinitptr:= reinitptr + 1;
2908    catalogue symbol:= STRING SYMBOL(reinitptr,
2909  ¢5000 49 4983 4 1
2910  -141 3 0 28 4882435
2911  24001 4 6 0 0
2912  4685827 20001 3 6 0
2913  0 4882435 16001 2 6
2914  32 0 0 0 40
2915  0 0 46 -140 10
2916  0 3 0 4736 12001
2917  1 7 0 0 0
2918  0 0 0 18 49
2919  -140 10 4 0 0
2920  -4456448 3 0 4987 -5829662
2921  2 4991 0 -4194304 1
2922  0 4995 -2937792 7403158 5000
2923  4995 4991 4987
2924  ¢)
2925  end;
2926
```

```
2927  procedure store bits(int,b); integer int; Boolean array b;
2928  begin integer i,k; i:= 0;
2929    for k:= 0,1,2,3,4,5 do
2930    i:= 2 × i + (if b[k] then 1 else 0); int:= i
2931  end;
2932
2933  procedure get bits(int,b); value int; integer int;
2934  Boolean array b;
2935  begin integer k;
2936    for k:= 0,1,2,3,4,5 do
2937    if int/32 > .99 then
2938    begin b[k]:= true; int:= (int - 32) × 2 end else
2939    begin b[k]:= false; int:= int × 2 end
2940  end;
2941
2942  comment:
2943
2944  6.6.5. The main program
2945
2946  Algorithm:;
2947
2948  Boolean first scan, second scan,dangerous procedures,
2949    operator identifier;
2950  real t1,t2;
2951  procedure EXIT;
2952  begin integer s; if reading allowed then
2953    begin L: s:= symbol; symbol:= RESYM;
2954      if ¬ (s = underlining symbol ^ symbol = semicolon symbol)
2955      then goto L
2956    end;
2957    t2:= time; PRINTTEXT(‹time is: ›); ABSFIXT(4,2,(t2 - t1)/3.6);
2958    PRINTTEXT(‹ mh›); PR sym(nlcr symbol); t1:= t2; goto BEGIN
2959  end EXIT;
2960
2961  begin integer i,j;
2962    for i:= 0,1,2 do for j:= 1,2,3,4,5,6 do adic op[j,i]:= 0;
2963    adic op[1,2]:= 55; comment S;
2964    adic op[2,2]:= 40; comment D;
```

```
2965     adic op[3,2]:= 52; comment P;
2966     adic op[4,2]:= 53; comment Q;
2967     adic op[5,2]:= 45 × 256 + 53; comment IQ;
2968      adic op[6,2]:= 41; comment E;
2969      adic op[1,1]:= 52 × 256 + 48; comment PL;
2970      adic op[2,1]:= 49 × 256 + 45; comment MI;
2971      adic op[6,1]:= 45 × 256 + 41; comment IE;
2972      adic op[1,0]:= 45 × 256 + 50; comment IN;
2973      adic op[3,0]:= 54 × 256 + 50; comment RN;
2974  end;
2975
2976  INITIALIZE symbols; t1:= time;
2977  normal compilation:= true; print information list:= true;
2978       BEGIN: dangerous procedures:= false; operator identifier:= false;
2979  first scan:= true; second scan:= false; INITIALIZE inf list ptrs;
2980   NEW PAGE; reading  allowed:= true;
2981  L: INITIALIZE reading ptrs; if synt unit ≠ begin symbol then
2982    begin ERR(‡program does not begin with begin ‡);
2983      synt unit:= begin symbol; nr of begins:= nr of begins + 1
2984    end;
2985    if nr of begins < 1 then nr of begins:= 1;
2986    begin:= 1; preceding begin:= 4;
2987    envelope of block(0);
2988    if first scan then
2989    begin first scan:= false; second scan:= true;
2990      operator identifier:= false;
2991      if normal compilation then
2992      begin contents of[begin + 2]:=
2993        STORE into information list(st(st(0,
2994        -end symbol),
2995        0))
2996      end else
2997      begin ptr of inf list:= ptr of inf list - 3;
2998        print catalogue; EXIT
2999      end;
3000      comment One extra symbol is placed after the program.;
3001      if symbol = space symbol then ptr of text:= ptr of text - 1;
3002      put in text array(semicolon symbol);
```

```
3003        RUNOUT;
3004        PR inf cells; CARRIAGE(3); goto L
3005    end; EXIT
3006  end
3007
```

7. Examples of compiled programs

From all the test programs a selection has been chosen and is reproduced in this chapter. This selection does not pretend to give exhaustive tests; it serves illustrative reasons only.
The results of the ABC ALGOL compiler have been edited by an ALGOL editor.

7.1. General structure and information list

Example 1.1 is a simple example illustrating the block structure and the information list. Note that "f" occurs three times: as real, as formula and as formal parameter. Note also the three different translations of "f + 2 × f".
The print-out of the information list consists of three parts:
the part for the information cells,
the part containing the identifiers,
the part containing the code table for the identifiers.
Note the appearance of the catalogue in the information list. The first part of the information list is printed showing the information cells; i.e. the contents of each information cell is printed on a new line. Only the information cells for begin are printed on three lines.
The index and the contents of the array elements are printed. The first element of an information cell contains the number of array elements this particular information cell consists of. The information cells can easily be recognized:
with first element containing +10 : begin information cell
with first element containing +3 : end information cell
with first element containing +7 : procedure identifier cell
The second element contains for an identifier its identification number (note that the three "f"s have the same identification number equal to the identification number of the "f" in the library procedure "replace" (see sections 2.6 and 5.2.8)), for a begin the number -140 and for end the number -141.

The third element contains for an identifier its place of occurrence in the text (the last three digits determining the line number), for a begin the address of the corresponding end information cell and for an end the address (if it exists, otherwise it is 0) of the begin information cell of the enveloping block.
For other elements of the information cells we refer to an exhaustive description in section 5.1.2.
The part of the information list really pertaining to the program shown begins with the information cell with address 49 and ends with the information cell with address 112.
The second part of the information list shows the symbols constituting the identifiers preceded by the address of the identifier and followed by the address of the identifier alphabetically preceding, the address of the identifier alphabetically following and the identification number of the identifier.
The third part shows the code table containing for each identification number the address in the information list where the corresponding identifier is stored.

Example 1.2 demonstrates a scala of syntactic structures together with, for the last time, the contents of the information list.

Example 1.1.

```
1  begin real f;
2    begin formula f,g;
3      procedure P(f); value f; formula f; g:= f + 2 × f;
4      P(f); f:= 2 × f + f
5    end; f:= 2 × f + f
6  end
```

contents of inf list

1	+10	2	-140	3	+115	4	+49
		5	+0	6	+0	7	+0
		8	+0	9	+0	10	+0
11	+7	12	+1	13	+12001	14	+4736
		15	+0	16	+3	17	+0
18	+10	19	-140	20	+46	21	+0

```
                22      +0      23      +40     24      +0
                25      +0      26      +0      27      +32
28      +6      29      +2      30      +16001  31      +4882435
                32      +0      33      +0
34      +6      35      +3      36      +20001  37      +4685827
                38      +0      39      +0
40      +6      41      +4      42      +24001  43      +4882435
                44      +28     45      +0
46      +3      47      -141    48      +1
49      +10     50      -140    51      +112    52      +63
                53      +0      54      +0      55      +0
                56      +0      57      +0      58      +0
59      +4      60      +2      61      +12001  62      +4751360
63      +10     64      -140    65      +109    66      +90
                67      +0      68      +78     69      +0
                70      +0      71      +0      72      +32
73      +5      74      +2      75      +26002  76      +4882434
                77      +0
78      +5      79      +4      80      +30002  81      +4882434
                82      +73
83      +7      84      +5      85      +42003  86      +4736
                87      +0      88      +1      89      +0
90      +10     91      -140    92      +106    93      +0
                94      +0      95      +100    96      +0
                97      +0      98      +0      99      +32
100     +6      101     +2      102     +46003  103     +4882435
                104     +0      105     +0
106     +3      107     -141    108     +63
109     +3      110     -141    111     +49
112     +3      113     -141    114     +1
115     +3      116     -141    117     +0
```

```
5000 replace    4995    4983    1
4995 f             0    4991    2
4991 left       4987       0    3
4987 g             0       0    4
4983 P             0       0    5
```

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1 5000 2 4995 3 4991 4 987 5 4983

Translation 1.1.

```
begin real Zf ;lnr(1);begin
procedure ZP (Zf ); integer Zf ;begin integer Yf ,fnn; fnn:= gnn;lnr(3);

DEVAL(Yf ,Zf );ASSIGN(Zg ,S(Yf ,P(IN(2 ),Yf )))
; ERASE(fnn)
end ;
integer Zg ,Zf ,fnn; fnn:= gnn;lnr(2);
Zf := Zg := NULL;
DE(Zf ,NULL);DE(Zg ,NULL);ZP (V(Zf ));ASSIGN(Zf ,S(P(IN(2 ),V(Zf )),V(Zf )))
; ERASE(fnn)
end ;Zf :=2 ×Zf +Zf

end
```

Example 1.2.

```
1
2  begin integer k; formula f:= 3.13,g = 3.14; formula array h[1:10];
3    formula procedure dyadic + (a,b); formula a,b;
4    dyadic + := 5;
5    formula procedure dyadic - (a,b); value a,b; formula a,b;
6    dyadic - := 5;
7    integer i; real r;
8    if dyadic f ^ monadic h[7] then
9    for i:= 1,1 step 1 until 1, while i < 10,11 do i:= i + 5;
10   f:= lhs of el 5 of rhs of f;
11   r:= lhs of el 5 of rhs of(f + g × h[3]);
12   f:= el 7 of ¢01234567¢;
13   i:= length of ¢01234567¢;
14   r:= date + f + g;
15   f:= rowadic(10,i,5,i + 5);
16   f:= polyadic(10,i,5,i + 5);
17   f:= +f + g × 3.14 - f × (-r + 314₁₀-2/f - f) ↑
18       (h[5] + f : (((f ↑ 1024 ↑ 2048/10))));
```

```
19  end

 contents of inf list
```

1	+10	2	-140	3	+156	4	+49
		5	+0	6	+0	7	+0
		8	+0	9	+0	10	+0
11	+7	12	+1	13	+12001	14	+4736
		15	+0	16	+3	17	+0
18	+10	19	-140	20	+46	21	+0
		22	+0	23	+40	24	+0
		25	+0	26	+0	27	+32
28	+6	29	+2	30	+16001	31	+4882435
		32	+0	33	+0		
34	+6	35	+3	36	+20001	37	+4685827
		38	+0	39	+0		
40	+6	41	+4	42	+24001	43	+4882435
		44	+28	45	+0		
46	+3	47	-141	48	+1		
49	+10	50	-140	51	+153	52	+87
		53	+144	54	+69	55	+74
		56	+1	57	+1	58	+32
59	+5	60	+5	61	+14002	62	+4718593
		63	+0				
64	+5	65	+2	66	+20002	67	+4882434
		68	+0				
69	+5	70	+4	71	+34002	72	+4882433
		73	+64				
74	+6	75	+6	76	+52002	77	+4887104
		78	+0	79	+1		
80	+7	81	-172096	82	+78003	83	+4887175
		84	+0	85	+2	86	+0
87	+10	88	-140	89	+109	90	+119
		91	+80	92	+0	93	+0
		94	+0	95	+0	96	+0
97	+6	98	+7	99	+84003	100	+4882436
		101	+0	102	+0		
103	+6	104	+8	105	+88003	106	+4882436
		107	+0	108	+0		

```
109      +3   110     -141   111      +49
112      +7   113  -172097   114  +130005   115  +4887175
              116      +0   117       +2   118       +0
119     +10   120     -140   121     +141   122       +0
              123     +112   124     +135   125       +0
              126      +0    127       +0   128      +32
129      +6   130      +7    131  +136005   132  +4882435
              133      +0    134       +0
135      +6   136      +8    137  +140005   138  +4882435
              139     +129   140       +0
141      +3   142     -141   143      +49
144      +5   145      +9    146  +190007   147  +4718593
              148     +59
149      +4   150     +10    151  +196007   152  +4751360
153      +3   154     -141   155       +1
156      +3   157     -141   158       +0

5000 replace    4995    0     1
4995 f          4975  4991    2
4991 left       4987  4963    3
4987 g             0  4983    4
4983 k          4979     0    5
4979 h             0  4967    6
4975 a             0  4971    7
4971 b             0  4959    8
4967 i             0     0    9
4963 r             0     0   10
4959 date          0     0   11

1  5000    2  4995    3  4991    4  4987    5  4983    6  4979
7  4975    8  4971    9  4967   10  4963   11  4959
```

Translation 1.2.

```
begin
integer low1c1,up1c1,i1;
integer fnn; fnn:= gnn;lnr(2);
low1c1:= 1;up1c1:= 10;
```

```
begin integer procedure S(Za ,Zb ); integer Za ,Zb ;begin lnr(4);S:= IN(5)
end ;integer procedure D(Za ,Zb ); integer Za ,Zb ;
begin integer Yb ,Ya ,fnn; fnn:= gnn;lnr(6);

DEVAL(Ya ,Za );DEVAL(Yb ,Zb );D:= IN(5)
; ERASE(fnn)
end ;real Zr ;
 integer array Zh [low1c1: up1c1];
integer Zi ,Zk ,Zg ,Zf ,fnn; fnn:= gnn;
Zf := Zg := NULL;
DE(Zf ,RN(3.13));DEVAL(Zg ,RN(3.14));
for i1:= low1c1 step 1 until up1c1 do
begin DE(Zh [i1],NULL) end;
if 2= TYPE CAT(V(Zf ))^1= TYPE CAT(V(Zh [7]))then
 for Zi :=1,1 step 1 until 1,while Zi <10,11 do Zi :=Zi +5;
 ASSIGN(Zf ,LHS(EL(5 ,RHS(V(Zf )))));
Zr :=ARLHS(EL(5 ,RHS(S(V(Zf ),P(Zg ,V(Zh [3])))))));
ASSIGN(Zf ,EL(7 ,STRING(st(66051,st(263430,st(1800,0))),3)));
Zi :=LENGTH(STRING(st(66051,st(263430,st(1800,0))),3));
Zr :=date +V(Zf )+abs(Zg );
ASSIGN(Zf ,STORE ROW(128,10,Zi ,5,Zi +5));
ASSIGN(Zf ,STORE ROW(96,10,Zi ,5,S(IN(Zi ),IN(5))));
ASSIGN(Zf ,D(S(PL(V(Zf )),P(Zg ,RN(3.14 ))),P(V(Zf ),E(D(S(MI(RN(Zr )),
Q(RN(314₁₀-2),V(Zf ))),V(Zf )),S(V(Zh [5]),IQ(V(Zf ),Q(IE(IE(V(Zf ),
1024 ),2048),IN(10)))))))));
; ERASE(fnn)
end
; ERASE(fnn) end
```

7.2. Block-entry, block-exit

Examples 2.1 - 2.8 demonstrate the effect of goto statements, innerblocks with formula declarations and procedures with unspecified parameter on the appearance of the integer snn in the block heading and the introduction of "ERASE(snn)" in the translation of a label.

Example 2.1.

```
begin formula f:= 1,g= 2; f:= f + g end ;
```

Translation 2.1.

```
begin integer Zg, Zf, fnn;
  fnn:= gnn; lnr(2); Zf:= Zg:= NULL; DE(Zf, IN(1)); DEVAL(Zg, IN(2));
  ASSIGN(Zf, S(V(Zf), Zg)); ERASE(fnn)
end
```

Example 2.2.

```
begin formula f; 1: f:= 5; begin formula g; goto 1 end end ;
```

Translation 2.2.

```
begin integer Zf, fnn, snn;
  fnn:= gnn; lnr(2); Zf:= NULL; DE(Zf, NULL); snn:= gnn;
Z1: ERASE(snn); ASSIGN(Zf, IN(5));
  begin integer Zg, fnn;
    fnn:= gnn; lnr(2); Zg:= NULL; DE(Zg, NULL); go to Z1; ERASE(fnn)
  end;
  ERASE(fnn)
end
```

Example 2.3.

```
begin formula f; 1: f:= 5; begin formula g; g:= f end end ;
```

Translation 2.3.

```
begin integer Zf, fnn;
  fnn:= gnn; lnr(2); Zf:= NULL; DE(Zf, NULL);
Z1: ASSIGN(Zf, IN(5));
  begin integer Zg, fnn;
```

```
fnn:= gnn; lnr(2); Zg:= NULL; DE(Zg, NULL); ASSIGN(Zg, V(Zf));
ERASE(fnn)
  end;
  ERASE(fnn)
end
```

Example 2.4.

```
begin formula f; 1: f:= 5; begin formula g; goto h; h: end end ;
```

Translation 2.4.

```
begin integer Zf, fnn, snn;
  fnn:= gnn; lnr(2); Zf:= NULL; DE(Zf, NULL); snn:= gnn;
Z1: ERASE(snn); ASSIGN(Zf, IN(5));
  begin integer Zg, fnn;
    fnn:= gnn; lnr(2); Zg:= NULL; DE(Zg, NULL); go to Zh;
  Zh: ; ERASE(fnn)
  end;
  ERASE(fnn)
end
```

Example 2.5.

```
begin formula f; 1: f:= 5; begin real r; goto 1 end end ;
```

Translation 2.5.

```
begin integer Zf, fnn;
  fnn:= gnn; lnr(2); Zf:= NULL; DE(Zf, NULL);
Z1: ASSIGN(Zf, IN(5));
  begin real Zr;
    lnr(2); go to Z1
  end;
  ERASE(fnn)
end
```

Example 2.6.

```
begin formula f; 1: f:= 5;
  begin real r1;
    begin formula g;
      begin real r2; begin integer i; i:= 5 end;
        begin real r3; goto 1 end
end end end end ;
```

Translation 2.6.

```
begin integer Zf, fnn, snn;
  fnn:= gnn; lnr(2); Zf:= NULL; DE(Zf, NULL); snn:= gnn;
Z1: ERASE(snn); ASSIGN(Zf, IN(5));
  begin real Zr1;
    lnr(3);
    begin integer Zg, fnn;
      fnn:= gnn; lnr(4); Zg:= NULL; DE(Zg, NULL);
      begin real Zr2;
        lnr(5);
        begin integer Zi;
          lnr(5); Zi:= 5
        end;
        begin real Zr3;
          lnr(6); go to Z1
        end
      end;
      ERASE(fnn)
    end
  end;
  ERASE(fnn)
end
```

Example 2.7.

```
begin formula f; procedure p(label); goto label;
  1: f:= 5; p(1)
end ;
```

Translation 2.7.

```
begin

  procedure Zp(Zlabel);
  begin lnr(2); go to Zlabel end;

  integer Zf, fnn, snn;
  fnn:= gnn; lnr(2); Zf:= NULL; DE(Zf, NULL); snn:= gnn;
Z1: ERASE(snn); ASSIGN(Zf, IN(5)); Zp(Z1); ERASE(fnn)
end
```

Example 2.8.

```
begin formula f; procedure p(label); f:= 5;
  1: f:= 5; p(1)
end ;
```

Translation 2.8.

```
begin

  procedure Zp(Zlabel);
  begin lnr(2); ASSIGN(Zf, IN(5)) end;

  integer Zf, fnn;
  fnn:= gnn; lnr(2); Zf:= NULL; DE(Zf, NULL);
Z1: ASSIGN(Zf, IN(5)); Zp(Z1); ERASE(fnn)
end
```

7.3. Formula array in a procedure body

Examples 3.1 - 3.2 demonstrate the complications which arise from a formula array declaration in a procedure body. Note that the "f" parameter is not combined with the variables "x" and "y" into one integer declaration and one initialization, such as it is done in example 3.2.

Example 3.1.

```
begin formula procedure p1(f,g);
  value f; formula f,g;
  begin formula x,y; formula array fa[1:10];;
  end ;
end ;
```

Translation 3.1.

```
begin

  integer procedure Zp1(Zf, Zg); integer Zf, Zg;
  begin integer low1c1, up1c1, i1;
    integer Yf, fnn;
    fnn:= gnn; lnr(4); DEVAL(Yf, Zf); low1c1:= 1; up1c1:= 10;
    begin integer array Zfa[low1c1:up1c1];
      integer Yp1, Zy, Zx, fnn;
      fnn:= gnn; if protect then ERR(¢protection error in form proc¢);
      Yp1:= NULL; Zx:= Zy:= NULL; DE(Zx, NULL); DE(Zy, NULL);
      for i1:= low1c1 step 1 until up1c1 do
      begin DE(Zfa[i1], NULL) end;
      ; ; ERASE(fnn); if Yp1 = NULL then ERR(
      ¢no assignment to proc ident¢); Zp1:= Yp1; protect:= false
    end;
    ERASE(fnn)
  end;

  lnr(2);
end
```

Example 3.2.

```
begin procedure p1(f,g); value f; formula f,g;
  begin formula x,y;; end ;
end ;
```

Translation 3.2.

```
begin

  procedure Zp1(Zf, Zg); integer Zf, Zg;
  begin integer Zy, Zx, Yf, fnn;
    fnn:= gnn; lnr(3); Zx:= Zy:= NULL; DEVAL(Yf, Zf); DE(Zx, NULL);
    DE(Zy, NULL); ; ; ERASE(fnn)
  end;

  lnr(2);
end
```

7.4. Translation of procedure parameters

Example 4.1 demonstrates the way formal and actual procedure parameters are compiled. Note the effect of "call-by-value" and "call-by-name" on the translation of actual parameters.

Example 4.1.

```
begin procedure P(a,b,c,d); value a; formula a,b; formula array c;
        procedure d(formula value,formula,formula array,procedure);
      begin d(a,b,c,d); d(a+b,b,c,d); d(b,b,c,d);
            d(h[1],h[2],h,P); d(h[1],h[1]+h[2],h,P);
            d(h[1]+h[2],h[2],h,P); d(h[1]+h[2],h[1]+h[2],h,P)
      end;
    formula f:= 3.14,g = 3.14; formula array h[1:2];
    P(f,f,h,P); P(g,f,h,P); P(f+g,f,h,P); P(f,f+g,h,P); P(f,g,h,P);
    P(h[1],h[2],h,P); P(f,h[1]+h[2],h,P);
end ;
```

Translation 4.1.

```
begin integer low1c1, up1c1, i1;
  integer fnn;
  fnn:= gnn; lnr(2); low1c1:= 1; up1c1:= 2;
```

```
begin
procedure ZP(Za, Zb, Zc, Zd); integer Za, Zb; integer array Zc;
procedure Zd;
begin integer Ya, fnn;
  fnn:= gnn; lnr(4); DEVAL(Ya, Za); Zd(Ya, Zb, Zc, Zd);
  Zd(S(Ya, VN(Zb)), Zb, Zc, Zd); Zd(VN(Zb), Zb, Zc, Zd);
  Zd(V(Zh[1]), Zh[2], Zh, ZP);
  Zd(V(Zh[1]), S(V(Zh[1]), V(Zh[2])), Zh, ZP);
  Zd(S(V(Zh[1]), V(Zh[2])), Zh[2], Zh, ZP);
  Zd(S(V(Zh[1]), V(Zh[2])), S(V(Zh[1]), V(Zh[2])), Zh, ZP); ERASE(fnn)
end;

integer array Zh[low1c1:up1c1];
integer Zg, Zf, fnn;
fnn:= gnn; Zf:= Zg:= NULL; DE(Zf, RN(3.14)); DEVAL(Zg, RN(3.14));
  for i1:= low1c1 step 1 until up1c1 do
  begin DE(Zh[i1], NULL) end;
  ZP(V(Zf), Zf, Zh, ZP); ZP(Zg, Zf, Zh, ZP); ZP(S(V(Zf), Zg), Zf, Zh, ZP);
  ZP(V(Zf), S(V(Zf), Zg), Zh, ZP); ZP(V(Zf), Zg, Zh, ZP);
  ZP(V(Zh[1]), Zh[2], Zh, ZP); ZP(V(Zf), S(V(Zh[1]), V(Zh[2])), Zh, ZP);
  ; ERASE(fnn)
end;
ERASE(fnn)
end
```

7.5. Protection mechanism for formula procedures

Example 5.1 - 5.3 demonstrate the introduction of the protect- mechanism when it is not sure that the last executed statement in a procedure body of a formula procedure is the assignment to the procedure identifier such as, e.g., is the case in example 1.2.

Example 5.4 demonstrates what happens with formula procedures declared within each other. For "p7" the protect-mechanism is necessary, for "p8" it is not and for "p9"it is. This is reflected in the appearance of "if protect then ERR ..." and the declaration of a local "yp ..." in the block begin and in the appearance of "if yp ... = NULL then ERR ...; zp ...:= yp ...; protect:= false" at the block end for p7 and p9. Note, however, that the "protect:= false" part in the block end of p9 is not given as it should, due to the assignment to p7 in the body of p9.

Example 5.1.

```
begin formula procedure p10;
  begin formula f; f:= 5; p10:= f; f:= 5 end;
end ;
```

Translation 5.1.

```
begin
  integer procedure Zp10;
  begin integer Yp10, Zf, fnn;
    fnn:= gnn; lnr(3); if protect then ERR(
    ǂprotection error in form procǂ); Yp10:= NULL; Zf:= NULL; DE(Zf, NULL);
    ASSIGN(Zf, IN(5)); Yp10:= V(Zf); protect:= true; ASSIGN(Zf, IN(5));
    ERASE(fnn); if Yp10 = NULL then ERR(ǂno assignment to proc identǂ);
    Zp10:= Yp10; protect:= false
  end;

  lnr(2);
end
```

Example 5.2.

```
begin formula procedure dyadic + (a,b); value a,b; formula a,b;
  begin dyadic + := a; 1: end;
end ;
```

Translation 5.2.

```
begin

  integer procedure S(Za, Zb); integer Za, Zb;
  begin integer YS, Yb, Ya, fnn;
    fnn:= gnn; lnr(3); if protect then ERR(
    ⟨protection error in form proc⟩); YS:= NULL; DEVAL(Ya, Za);
    DEVAL(Yb, Zb); YS:= abs(Ya); protect:= true;
  Z1: ; ERASE(fnn); if YS = NULL then ERR(
    ⟨no assignment to proc ident⟩); S:= YS; protect:= false
  end;

  lnr(2);
end
```

Example 5.3.

```
begin formula f; integer i;
  formula procedure p14;
  if i = 1 then 1: f:= 5 else 2: p14:= 5;
  for i:= 1 do 3: f:= 5;
  begin formula g; goto 4 end
end ;
```

Translation 5.3.

```
begin

  integer procedure Zp14;
  begin integer Yp14;
    lnr(4); if protect then ERR(⟨protection error in form proc⟩);
    Yp14:= NULL; if Zi = 1 then
  1: ASSIGN(Zf, IN(5)) else
  2:
    begin Yp14:= IN(5); protect:= true end;
    if Yp14 = NULL then ERR(⟨no assignment to proc ident⟩); Zp14:= Yp14;
    protect:= false
  end;
```

```
integer Zi, Zf, fnn, snn;
fnn:= gnn; lnr(2); Zf:= NULL; DE(Zf, NULL); snn:= gnn;
 for Zi:= 1 do
3:
 begin ERASE(snn); ASSIGN(Zf, IN(5)) end;
 begin integer Zg, fnn;
   fnn:= gnn; lnr(6); Zg:= NULL; DE(Zg, NULL); go to 4; ERASE(fnn)
 end;
 ERASE(fnn)
end
```

Example 5.4.

```
begin formula procedure p7;
  begin formula procedure p8;
    begin formula procedure p9;
      begin f:= 5; p9:= f:= p8:= h[1 + lhs of h[3]]:=
        p7:= h[3 + el 1 of h[4] + length of h[5]] + h[4];
        f:= 5
    end;
    f:= 5;
    if 1 = 1 then begin f:= 5; f:= p8:= h[1]:= p7:= 5 end
    else begin p8:= 5; f:= 5; p8:= 5;;; end
  end;
  for i:= 1 do p7:= 5
end;
switch S:= S[1],S[2],if 0 < 1 then S[3] else S[4],1,2,3;
array a[1:10]; real array b[1:10,2:12];
Boolean array N[1 + 1 + 2:3 + 4 + 5];
integer array ia,ib,ic[0:0],id[1:1,1:1];
formula f:= 3.14,g = 3.14;
  formula array h[1:10];
; end ;
```

Translation 5.4.

```
begin integer low1c1, up1c1, i1;
```

```
  integer fnn;
  fnn:= gnn; lnr(2); low1c1:= 1; up1c1:= 10;
  begin

integer procedure Zp7;
begin

  integer procedure Zp8;
  begin

    integer procedure Zp9;
    begin integer Yp9;
      lnr(5); if protect then ERR(¢protection error in form proc¢);
      Yp9:= NULL; ASSIGN(Zf, IN(5));
      Yp9:= Zp8:= Yp7:= ASSIGN(Zf, ASSIGN(Zh[1 + ARLHS(V(Zh[3]))],
      S(V(Zh[3 + AREL(1,V(Zh[4])) + LENGTH(V(Zh[5]))]), V(Zh[4]))));
      protect:= true; ASSIGN(Zf, IN(5)); if Yp9 = NULL then ERR(
      ¢no assignment to proc ident¢); Zp9:= Yp9
    end;

    lnr(4); ASSIGN(Zf, IN(5)); if 1 = 1 then
    begin ASSIGN(Zf, IN(5));
      Zp8:= Yp7:= ASSIGN(Zf, ASSIGN(Zh[1], IN(5))); protect:= true
    end
    else
    begin Zp8:= IN(5); ASSIGN(Zf, IN(5)); Zp8:= IN(5); ; ;  end
end;

integer Yp7;
lnr(3); if protect then ERR(¢protection error in form proc¢);
Yp7:= NULL;
for Zi:= 1 do
begin Yp7:= IN(5); protect:= true end;
  if Yp7 = NULL then ERR(¢no assignment to proc ident¢); Zp7:= Yp7;
  protect:= false
end;

switch ZS:= ZS[1], ZS[2], if 0 < 1 then ZS[3] else ZS[4], 1, 2, 3;
```

```
array Za[1:10];
real array Zb[1:10,2:12];
boolean array ZN[1 + 1 + 2:3 + 4 + 5];
  integer array Zia, Zib, Zic[0:0], Zid[1:1,1:1];
  integer array Zh[low1c1:up1c1];
  integer Zg, Zf, fnn;
  fnn:= gnn; Zf:= Zg:= NULL; DE(Zf, RN(3.14)); DEVAL(Zg, RN(3.14));
  for i1:= low1c1 step 1 until up1c1 do
  begin DE(Zh[i1], NULL) end;
  ; ; ERASE(fnn)
 end;
 ERASE(fnn)
end
```

7.6. Assignment to formula procedure identifier

Example 6.1 demonstrates the complicated way variables are translated in an assignment statement to a formula procedure identifier. Due regard is given to the fact that a variable is local or global with respect to the procedure body, whether it is a formal parameter or not.

Example 6.1.

```
begin formula x,y;
  formula procedure p1;
  begin formula f:= x × y + x/y;
    begin formula procedure p2; p2:= lhs of f;
      p1:= p2;
      p1:= p3(p2)
    end
  end;

  formula procedure p3(p4); formula procedure p4;
begin p3:= p4;
      p3:= if p4 = x then p4 else
           if p4 = y then p4 else p4;

  begin procedure p5(p6,g);
```

```
        formula procedure p6; formula g;
        begin p3:= if p6 = x then g else
                   if p6 = y then p6 else g + p6;
                g:= if p6 = x then g else
                    if p6 = y then p6 else g + p6
            end;
            p5(p4,x)
    end end ; end ;
```

Translation 6.1.

```
    begin

      integer procedure Zp1;
      begin integer Yp1, Zf, fnn;
        fnn:= gnn; lnr(4); if protect then ERR(
        ǂprotection error in form procǂ); Yp1:= NULL; Zf:= NULL;
        DE(Zf, S(P(V(Zx), V(Zy)), Q(V(Zx), V(Zy))));
        begin

          integer procedure Zp2;
          begin lnr(5); Zp2:= LHS(V(Zf)) end;

          lnr(5); Yp1:= abs(Zp2); protect:= true; Yp1:= Zp3(Zp2);
          protect:= true
        end;
        ERASE(fnn); if Yp1 = NULL then ERR(ǂno assignment to proc identǂ);
        Zp1:= Yp1; protect:= false
    end;

    integer procedure Zp3(Zp4);
    integer procedure Zp4;
    begin integer Yp3;
    lnr(12); if protect then ERR(ǂprotection error in form procǂ);
    Yp3:= NULL; Yp3:= abs(Zp4); protect:= true;
    Yp3:= if abs(Zp4) = V(Zx) then abs(Zp4) else if abs(Zp4) = V(Zy) then
    abs(Zp4) else abs(Zp4); protect:= true;
    begin
```

```
    procedure Zp5(Zp6, Zg);
      integer procedure Zp6; integer Zg;
      begin lnr(18);
        Yp3:= if abs(Zp6) = V(Zx) then abs(VN(Zg)) else if abs(Zp6) =
        V(Zy) then abs(Zp6) else S(VN(Zg), Zp6); protect:= true;
        ASSIGN(Zg, if abs(Zp6) = V(Zx) then VN(Zg) else if abs(Zp6) =
        V(Zy) then Zp6 else S(VN(Zg), Zp6))
      end;

      lnr(16); Zp5(Zp4, Zx)
    end;
    if Yp3 = NULL then ERR(‡no assignment to proc ident‡); Zp3:= Yp3;
    protect:= false
  end;

  integer Zy, Zx, fnn;
    fnn:= gnn; lnr(2); Zx:= Zy:= NULL; DE(Zx, NULL); DE(Zy, NULL); ;
    ERASE(fnn)
  end
```

7.7. Error detection and error recovery

Example 7.1 demonstrates a very bad ABC ALGOL program and the resulting translation, which, with some luck, is indeed what the programmer wanted. The output from the printer is reproduced on the next pages so that one can see the actual error messages.
Examples 7.2 - 7.4 demonstrate the reaction of the compiler on some other erroneous programs. Examples which blow up the compiler are, obviously, until yet not known.

Example 7.1.

```
begin formula f,g;
  formula array fa,fg[1:2;
  f:= (f×(f+fa[(g+fg[f×(g+f]]+fg[1);
  g:= f; replace(f,1,g);
  g:= f+g)×f; printtext(↓abc↓de;↑)
end ;
```

Translation 7.1.

```
begin integer low1c1, up1c1, i1;
  integer fnn;
  fnn:= gnn; lnr(1); low1c1:= 1; up1c1:= 2;
  begin integer array Zfa, Zfg[low1c1:up1c1];
    integer Zg,Zf,fnn;
    fnn: = gnn; Zf: = Zg: = NULL; DE(Zf,NULL); DE(Zg,NULL);
    for i1: = low1c1 step 1 until up1c1 do
    begin DE(Zfa[i1],NULL); DE(Zfg[i1],NULL) end;
    ASSIGN(Zf,P(V(Zf),S(S(V(Zf),V(Zfa[(V(Zg) + V(Zfg[V(Zf) × (V(Zg) +
    V(Zf))]))]),V(Zfg[1])))); ASSIGN(Zg,V(Zf)); Zreplace(V(Zf),1,V(Zg));
    ASSIGN(Zg,S(V(Zf),V(Zg))); printtext(↓abc↓de↑↑); ; ; ERASE(fnn)
  end;
  ERASE(fnn)
end

begin lnr(0);  end
```

```
    1 BEGIN FORMULA F,G;
    2   FORMULA ARRAY FA,FG[1:2];
    3   F:= (F@(F+FA[(G+FG[F@(G+F)]+

**********ERROR**********    3 SYNT UNIT NOT OK                                  )              )

SYNT UNIT SHOULD BE:)
                              F

**********ERROR**********    3 SYNT UNIT NOT OK                                  )              +

SYNT UNIT SHOULD BE:)
                                    G[1])
    4

**********ERROR**********    3 SYNT UNIT NOT OK                                  )              )

SYNT UNIT SHOULD BE:]
          G!

**********ERROR**********    3 SYNT UNIT NOT OK                                  )              "IDENTIFIER"

SYNT UNIT SHOULD BE:)
            =F; REPLACE(F,1,G);
    5   G:= F+G)@F
**********ERROR**********    5 STATEMENT NOT PROPERLY CLOSED                     )              +
                  ;PRINTTEXT('ABC'DE_
**********ERROR**********    5 PROGRAM TEXT CONTAINS 1                           (              (
                              !

CONTENTS OF INF LIST
    1       +10     2     -140    3      +82    4      +49    5      +0    6      +0    7      +0    8      +0    9      +0
   10       +0
   11       +7     12       +1   13   +12001   14     +4736   15      +0   16      +3   17      +0
   18       +10    19     -140   20      +46   21       +0    22      +0   23     +49   24      +0   25      +0   26      +0
   27       +32
   28       +6     29       +2   30   +16001   31  +4882435   32      +0   33      +0
   34       +6     35       +3   36   +20001   37  +4885827   38      +0   39      +0
   40       +6     41       +4   42   +24001   43  +4882435   44     +28   45      +0
   46       +3     47     -141   48       +1
   49       +10    50     -140   51      +79   52       +0    53      +0   54     +64   55     +69   56      +1   57      +1
   58       +32
   59       +5     60       +2   61    +8001   62  +4882434   63      +0
   64       +5     65       +4   66   +12001   67  +4882434   68     +59
   69       +6     70       +5   71   +22002   72  +4887104   73      +0   74      +1
   75       +4     76       +6   77   +26002   78  +4887104
   79       +3     80     -141   81       +1
   82       +3     83     -141   84       +0

5000 REPLACE
     4995      0      1
4995 F
        0   4991      2
4991 LEFT
     4987   4975      3
4987 G
     4983      0      4
4983 FA
        0   4979      5
```

```
4979 FG
        0      0      6
4975 PRINTTEXT
        0      0      7

    1  5000      2  4995      3  4991      4  4987      5  4983      6  4979      7  4975

BEGIN
                INTEGER LOW1C1,UP1C1,I1;
                INTEGER FNNI; FNNI:= GNN(LNR(1));
                LOW1C1:= 1;UP1C1:= 2;

**********ERROR**********     2 SYNT UNIT NOT OK                                  !              "IDENTIFIER"
SYNT UNIT SHOULD BE:)

                BEGIN
                 INTEGER ARRAY ZFA ,ZFG (LOW1C1( UP1C1

**********ERROR**********     2 SYNT UNIT NOT OK                                  !              "IDENTIFIER"
SYNT UNIT SHOULD BE:)
                                                                                 ))
                INTEGER ZG ,ZF ,FNNI; FNNI:= GNN;
                ZF := ZG := NWWW;
                PE(ZF ,NWWW);PE(ZG ,NWWW);
                FOR I1:= LOW1C1 STEP 1 UNTIL UP1C1 DO
                BEGIN PE(ZFA (I1),NWWW);PE(ZFG (I1);NWWW) END;A99+GN(ZF ,

**********ERROR**********     3 SYNT UNIT NOT OK                                  !              "IDENTIFIER"
SYNT UNIT SHOULD BE:)

**********ERROR**********     3 SYNT UNIT NOT OK                                  !              "IDENTIFIER"
SYNT UNIT SHOULD BE:)
                                                                                 P(V(ZF ),P(P(V(ZF ),V(ZFA ((V(ZG )+V(ZFG (V(ZF )*(V(ZG )+V(ZF )

**********ERROR**********     3 SYNT UNIT NOT OK                                  !              !
SYNT UNIT SHOULD BE:)
                                                                                                                                  ))))

**********ERROR**********     3 SYNT UNIT NOT OK                                  !              +
SYNT UNIT SHOULD BE:)
V(ZFG (1                                                                                                                          ))))2

**********ERROR**********     3 SYNT UNIT NOT OK                                  !              !
SYNT UNIT SHOULD BE:)
        ))))));
A99+GN(ZG ,V(ZF ));ZREPLACE (V(ZF ),1,V(ZG ))
A99+GN(ZG ,6(V(ZF ),V(ZG )))
**********ERROR**********     5 STATEMENT NOT PROPERLY CLOSED                     !              *
                            ;PRINTTEXT ({ABC{DE}}
```

```
**********ERROR**********   5 SYNT UNIT NOT ON
SYNT UNIT SHOULD BE:)
                                        )))
                ) ERASE(FNN)
                END
                ) ERASE(FNN) ENDTIME IS:    1.35  MH
```

```
))
**********ERROR**********    0 PROGRAM DOES NOT BEGIN WITH BEGIN                    "UNKNOWN"      >

    1 -
**********ERROR**********    0 STATEMENT NOT PROPERLY CLOSED                    >           )
      END

CONTENTS OF INF LIST
    1       +10     2      -140     3       +62     4       +49     5       +0      6       +0      7       +0      8       +0      9       +0
   10        +0
   11        +7    12        +1    13    +12001    14     +4736    15       +0     16       +3     17       +0
   18       +10    19      -140    20       +46    21        +0    22       +0     23      +40     24       +0     25       +0     26       +0
   27       +32
   28        +6    29        +2    30    +16001    31  +4882435    32       +0     33       +0
   34        +6    35        +3    36    +20001    37  +4685827    38       +0     39       +0
   40        +6    41        +4    42    +24001    43  +4882435    44      +28     45       +0
   46        +3    47      -141    48        +1
   49       +10    50      -140    51       +59    52        +0    53       +0     54       +0     55       +0     56       +0     57       +0
   58        +0
   59        +3    60      -141    61        +1
   62        +3    63      -141    64        +0

5000 REPLACE
    4995      0     1
4995 F
       0   4991     2
4991 LEFT
    4987      0     3
4987 G
       0      0     4

   1  5000     2  4995     3  4991     4  4987

**********ERROR**********    0 PROGRAM DOES NOT BEGIN WITH BEGIN                    "UNKNOWN"      >
BEGIN LNR(0);
**********ERROR**********    0 STATEMENT NOT PROPERLY CLOSED                    >           )

          END TIME IS:     .33  MH
```

Example 7.2.

```
begin formula a,b,c;
  a:= lhs b;
  if true then c:= rhs a
end ;
```

Translation 7.2.

```
begin integer Zc, Zb, Za, fnn;
  fnn:= gnn; lnr(2); Za:= Zb:= Zc:= NULL; DE(Za, NULL); DE(Zb,NULL);
  DE(Zc, NULL); ASSIGN(Za, LHS(V(Zb)));
  if true then ASSIGN(Zc, RHS(V(Za))); ERASE(fnn)
end
```

Example 7.3.

```
begin integer procedure p(a); p:= 1;
  integer procedure p1(a)p1:=p(b);p1(1)
end ;
```

Translation 7.3.

```
begin

  integer procedure Zp(Za);
  begin lnr(2); Zp:= 1 end;

  integer procedure Zp1(Za);
  begin lnr(3); Zp1:= Zp(Zb) end;

  lnr(2); Zp1(1)
end
```

Example 7.4.

```
begin procedure p(a);;
  procedure p1(a)l:p(a);p1(1)
end ;
```

Translation 7.4.

```
begin

  procedure Zp(Za);
  begin lnr(1);  end;

  procedure Zp1(Za);
  begin lnr(2);
  Zl: Zp(Za)
  end;

    lnr(1); Zp1(1)
end
```

8. Machine dependencies

The machine-dependent characteristics of the ABC ALGOL system are described in this chapter.
Firstly, the restrictions are described with respect to size of tables as imposed by the memory size and word length of the particular EL - X8 computer used.
Secondly, short descriptions are given of the standard procedures (in particular for input - output) of the MC-ALGOL 60 system.
Thirdly, the dependencies of the ABC ALGOL system are described with respect to the internal representation of characters and to the way basic symbols, in particular word delimiters, are built up.

8.1. Size of tables

The information list, in the form of the integer array "contents of" has 5000 array elements. The number 5000 appears two times in the program at line 2810 and line 2830. The first time as the actual bound of the array, the second time as the value of the variable "max of inf list".
The integer array "code table" has 400 elements. To each different identifier corresponds one array element. The number 400 appears at lines 2810 and 2830 as array bound and as value of "max nr of identifiers".
For formula expressions three integer arrays: "Fl", "Ft" and "Fr", each with 100 elements, are declared on line 1714. They are used for storing the tree structure of formula expressions. For each of the arrays one array element is used per operator. No space is used for operands. The arrays are declared in a recursive procedure with the effect that more than one version of the arrays may simultaneously exist if the formula expression contains as primary a function designator with formula expressions as actual parameters or a subscripted variable with a formula expression somewhere appearing in the arithmetic expression.
The size of the above tables can be enlarged without any repercussions (the maximum bound must fit into an integer, however).
The size of the text array is 10000, a number appearing on line 2072, and implicitly, i.e. multiplied by 3 and then decreased by one, on line 2076.

The text array is capable of containing 30000 symbols. Lay-out (except new lines) and comment is deleted, symbols composed of several characters, as word delimiters and identifiers, are represented by one symbol, in the text array.
There are 400 different codes available for the symbols. If the code is greater than 180 it is the code for an identifier. The code 399 has a special function in that it indicates that the following two codes are used to identify an identifier. This means that there are maximally 399×400 + 399 = 159999 different identifiers possible if the size of code (400) were the only restriction.
The integer capacity of the EL - X8 is 2 ↑ 26; the code size 400 is therefore, optimal. If the ALGOL system had byte operations, a code size 256 would have been more economic. In that case the special function of 399 should be taken over by 255.
Normally, letters do not occur in the text array as they are used in word delimiters and in identifiers. One may not use this feature, however, to fill the text array more economically since letters may occur in strings.
A typical case shows how many symbols are needed: The program of chapter 3 section 3.1-5 consists (without comment) of 800 lines and needs 12 500 symbols in the text array.
The size 10000 is bounded not only by the memory size of the computer but also by the word size of an integer. The reason is that a pointer into the text array, pointing to a symbol, having the value 0 - 29999, is combined with the line number of that symbol to be stored in an element of an information cell. The integer value is built up as follows (see line 2235):

ptr to first letgit:= ptr to text × 2000 + line number.

The value of "ptr to first letgit" is used while treating a declaration. This representation automatically restricts the value of "line number" to 1999.

8.2. The MC-ALGOL 60 standard procedures

We now give an alphabetic list of the headings of the standard procedures used in the ABC ALGOL system together with a short description.
Almost all procedures may be used in capital letters as well as in small letters. We use capital letters where both versions may be used and small letters if the small-letter version may be used only.

procedure ABSFIXT(n,m,x); value n,m,x; integer n,m; real x;
Prints in fixed-point notation, n digits before and m digits after the decimal point, the absolute value of x without a sign.

procedure CARRIAGE(n); value n; integer n;
Has as effect, if n $\geq$ 0, n times NLCR.

real procedure compose(a,b); value a,b; integer a,b;
Delivers the real number as a result of composing from two X8 machine words, with values a and b, one real number.

integer procedure EVEN(n); value n; integer n;
EVEN:= (-1) ↑ n.

procedure EXIT; Discontinues the execution of the ALGOL program.

procedure FIXT(n,m,x); value n,m,x; integer n,m; real x;
Prints in fixed-point notation, n digits before and m digits after the decimal point, the value of x, always preceded by the sign of x.

integer procedure head of(x); value x; real x;
Delivers the integral number being the value of the first machine word of the two machine words in which the value of x is represented.

procedure NEW PAGE;
Produces a new page on the line printer. The first character to be printed will be printed at the first position of the first line.

procedure NLCR;
Produces a new line on the line printer. The first character to be printed will be printed at the first position of the line. (60 lines on a page invokes a NEW PAGE).

integer procedure print pos;
Determines at any moment the position on the line of the first character to be printed.

procedure PRINTTEXT(s); string s;
Prints the string s without the string quotes ⊀ and ⊁.

procedure PRSYM(n); value n; integer n;
Prints a character, according to the value of n. The internal representation table for MC ALGOL is used which is given here in a super condensed form:

character	code	other characters
digit 0 - 9	0 - 9	+ - × / ↑ = < > ¬ ↓ ∨ ^
letters a - z	10 - 35	, . ₁₀ : ; ( ) [ ] ' " ? _ |
letters A - Z	37 - 62	Space New Line
		with codes: 64 - 127

Note that, during the initialization, the ABC ALGOL compiler assigns values to variables like "plus symbol" or "space symbol" by means of characters read (RESYM) and not by assignment of the form: "plus symbol:= 64; space symbol:= 93;".

procedure PUSYM(n); value n; integer n;
Punches the bit pattern in paper tape, according to MC - Flexowriter code, of the character with internal representation given by the value of n.

procedure PUTEXT(s); string s;
Punches bit patterns in paper tape, according to MC - Flexowriter code, of the characters of the string without the string quotes ⊀ and ⊁.

integer procedure REMAINDER(a,b); value a,b; real a,b;
REMAINDER:= if b = 0 then a else a - a : b × b.

integer procedure RESYM;
Delivers the internal representation of the next character from input paper tape. The paper tape is advanced one character.

procedure RUNOUT;
Punches a piece of blank paper tape.

procedure SPACE(n); value n; integer n;

"Prints" n spaces on the line printer.

integer procedure STRING SYMBOL(k,s);
    value k; integer k; string s;
Delivers the internal representation of the (k+1) st character of the string s.
This procedure is used to have permanent tables, which do not need to be initialized. (See the procedures text symbol (line 1928), standard symbol (line 2414) and catalogue symbol (line 2873)).
To circumvent the use of this procedure one can introduce an integer array which is filled with information from input paper tape or from a file during the initialization.

integer procedure tail of(x); value x; real x;
Delivers the integral number being the value of the second machine word of the two machine words in which the value of x is represented.

real procedure time;
Delivers the time, measured in seconds, elapsed after the moment the ALGOL 60 program has been subjected to the ALGOL 60 compiler. The accuracy is .01 sec.

8.3. Other machine-dependent features

The treatment of characters is based on the table of internal representations as in use for the MC-ALGOL system. In particular, paper tape is used as input - and as output medium. A card version of the compiler exists also.
To publish the compiler in a most readable form lead us to use paper tape and underlined word delimiters, instead of key words or words between apostrophes.
If one wants to use the apostrophe representation, changes have to made in the following procedures:
.READ synt unit (line 2146), where the reaction to the "underlining symbol" has to be changed.

.INITIALIZE symbols (line 1949), where the word delimiters are read from input tape in order to give initial values to the variables "goto symbol" - "rowadic symbol".
.PR synt unit (line 2654), which prints the word delimiters.
.SHOW (line 2724), which also prints the word delimiters.

The special symbol ";" which must close every ABC ALGOL program is underlined. If one wants to change this into ? or ';', one has to change NS only.
If one wants the string quotes ↓ and ↑ to be changed, one has to change "READ synt unit" (line 2203), "early end of program" (line 2132), which inserts right string quotes, "translate string" (line 1651) and some places where run-time error messages are produced (e.g. lines 721 or 749). The procedure "print catalogue" (line 2873) should also be changed.

The word length of the EL - X8 computer imposes restrictions on lhs and rhs quantities in constant and monadic formula values, and in the choice of the radix of the rational number system of chapter 3.
With respect to the information list cells we, finally, remark that a type value may have the form:

synt unit1 × 2 ↑ 15 + synt unit2 × 2 ↑ 5 + mode.

This implies that an integer word should be large enough to contain the number 180 × 2 ↑ 15, 180 being the maximum number of "synt unit1" and "synt unit2".

The definition of the output for the operators +, ×, /, etc. in lines 2963 - 2973 is rather machine-dependent as the internal representation of the characters S, P, Q, etc. is used explicitly.

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