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OBLING: A TESTER FOR TRANSFORMATIONAL GRAMMARS

1. INTRODUCTION

Transformational grammars have developed with recent research in linguistics. They appear to be a powerful and explicit device for characterizing the description of sentences; they also meet conditions of adequacy that can be applied to check that a sentence, or a set of rules, is well-formed.

A transformational grammar tester is part of a strategy for the selection of a well-formed grammar matching the data base. To put it more explicitly, a tester of this sort should provide the linguist a class of the possible grammars which concerns precisely the linguistic theory. These grammars have the form given by CHOMSKY in *Aspects* (see bibliography).

2. GENERAL DESCRIPTION OF THE SYSTEM

OBLING is a program for dealing with the structures of the French language: it performs the verification of phrase structure rules, the derivation of sentences according to the transformational component and the graphic illustration of the intermediate or final structures.

In the program, LING is the routine that controls all the subroutines and the matching of the input structures with those allowed by the phrase structure rules. If the matching is impossible, a comment is

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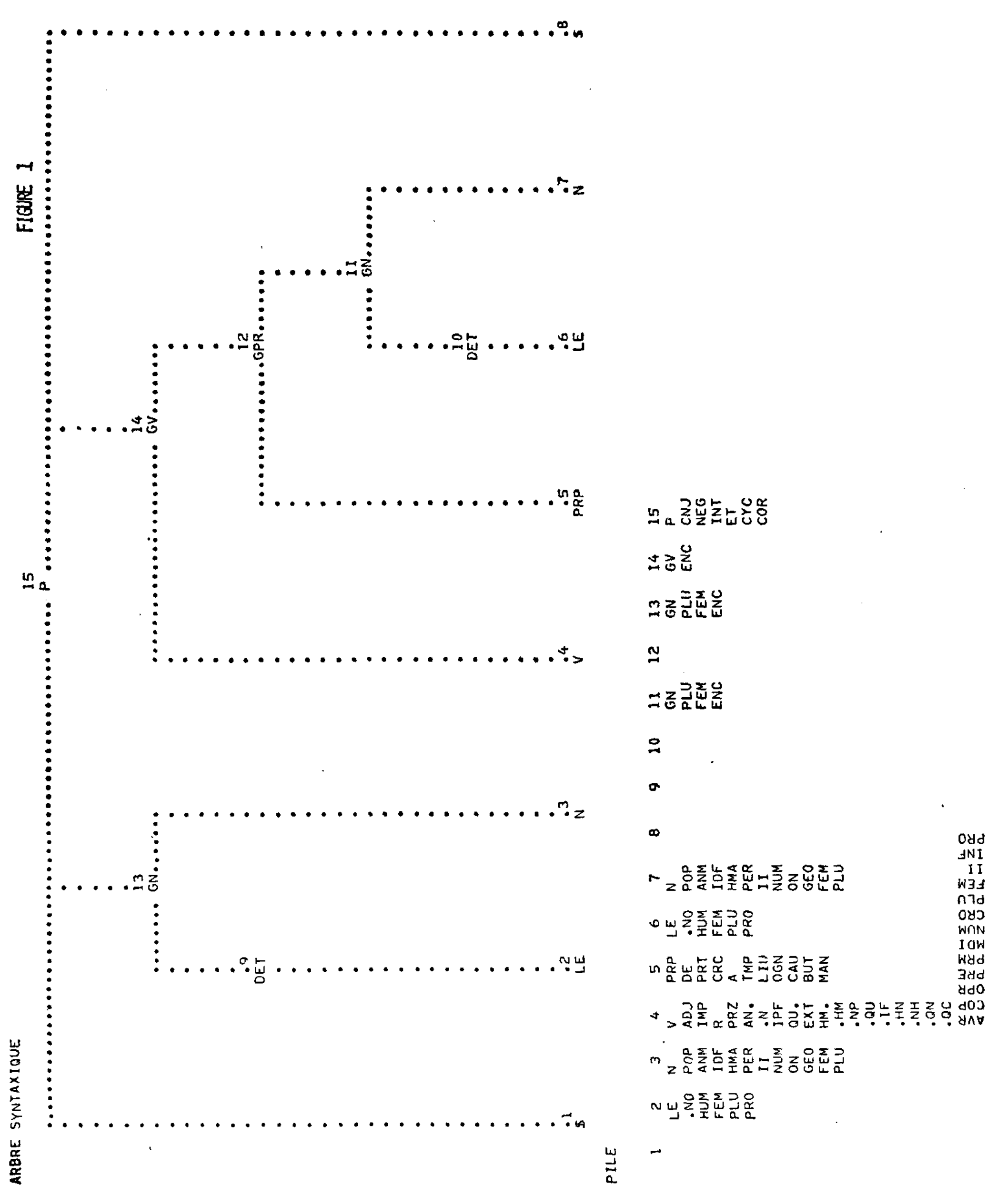
David Sankoff, of the Université de Montréal, is also responsible for the first version of the tree editing program. Finally, Josselyne Gérard helped debugging linguistic rules.



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PILE
1
2  LE .NO HUM FEM PLU PRO
3  N POP ANM IDF HMA PER II NUM ON GEO FEM PLU
4  V ADJ IMP R PRZ AN. .N IPF QU. EXT HM. .HM .NP .QU .IF .HN .NH .QN .OC AVR COP OPR PRE PRM MDI NUM CRO PLU FEM II INF PRO
5  PRP DE PRT CRC A TMP LIU OGN CAU BUT MAN
6  LE .NO HUM FEM PLU PRO
7  N POP ANM IDF HMA PER II NUM ON GEO FEM PLU
8
9
10
11 GN PLU FEM ENC
12
13 GN PLU FEM ENC
14 GV ENC
15 P CNJ NEG INT ET CYC COR
```

Fig. 1. *Tree for an input sentence*

made. Otherwise, the output gives the graphic illustration of the tree for this sentence, or the input structures are immediately processed using transformational rules. For example,

General transformational rules are operated by a number of subroutines of which the main are explained hereafter.

3. GENERAL CAPACITIES OF THE SYSTEM

The system OBLING is divided into four parts: a main program LING, the service subroutines, the phrase structure grammar tester and the transformational grammar testers. LING and the service subroutines are stored in the central memory while the two grammars testers operate on disks.

The main program invokes the various linguistic rules and controls the application of these rules to the data base structure(s) or the derived structure(s). The service subroutines are called by the routines concerning the application of the transformational rules and work in parallel with LING during the processing.

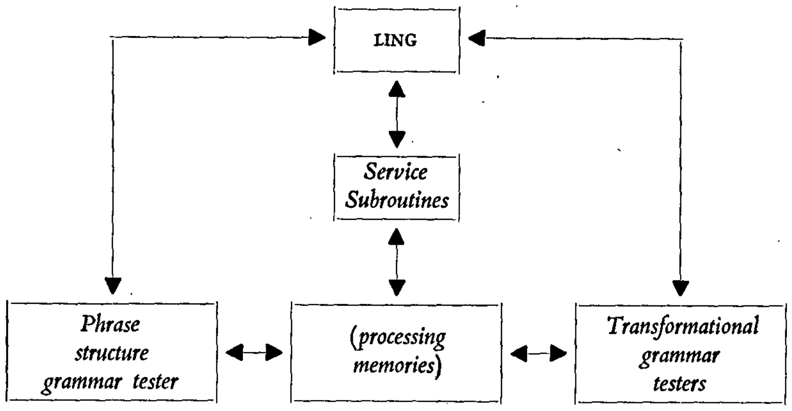
LING
Service Subroutines
Phrase structure grammar tester
(processing memories)
Transformational grammar testers

Fig. 2. *The* OBLING *system*

4. SPECIFIC CAPABILITIES OF THE PROGRAM LING

The program LING will first initialize the working areas. Then, it loads and operates the program VERIFICATEUR which, after the reading and the verification of the input data, returns control to LING.

LING will then load and execute, using an overlay technique, the small control programs CYCLI Q1, CYCLI Q2, ..., CYCLI Qi. Each of these handles, in conjunction with LING, the mapping on the input structure of a fixed number of transformation rules. In the current version of the program, CYCLI Q1 deals with the linguistic transformational rules T_1 to T_5 included, CYCLI Q2 the rules T_6 to T_{10} included, etc. The total number of these control programs CYCLI Q depends on the memory space allowed; processing is most efficient if the number of these control programs is as small as possible.

5. INFORMATION PATTERN BETWEEN LING AND VERIFICATEUR

When VERIFICATEUR (the phrase structure grammar tester) is in memory, the structure to be analysed is read from the standard input unit (punched cards) and is processed by the subroutine CKARBRE to

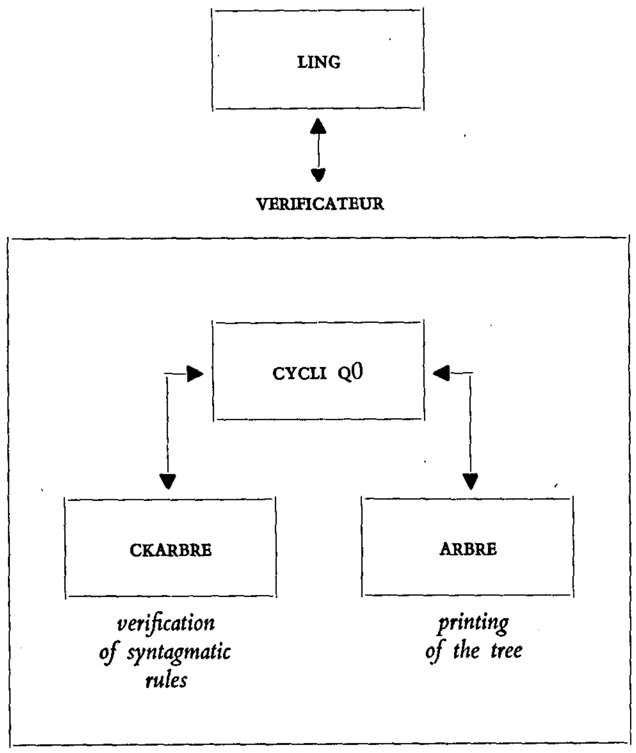

Fig. 3. *The* VERIFICATEUR *program (see figure* 1 *for updated tree and structure)*

be validated. This subroutine first checks if the phrase structure is consistent, then calls up CKC which tests the names of the constituents describing the structure; finally, it compares this structure with those allowed by the phrase structure rules.

When errors are discovered during the processing, various sorts of comments are printed and followed if possible by a partial or full tree of the sentence. When updating is done, the tree is printed and the program VERIFACATEUR passes control to LING. The following illustrations concern first, the program VERIFICATEUR and second, an example of an updated tree and structure.

6. INFORMATION PATTERN BETWEEN LING AND THE TRANSFORMATIONAL GRAMMAR TESTERS

Each time LING receives the control from VERIFICATEUR, that is, when no further errors have been detected, it loops in order to call successively the monitors CYCLI Q1, ..., CYCLI Q9 which contain up 45 different rules; we suppose that we are working now with a specific version of a grammar.

The first of these monitors has the following structure.

Transformational rule # 1
Transformational rule # 2
Transformational rule # 3
Transformational rule # 4
Transformational rule # 5

Fig. 4. *The* CYCLI Q1 *program*

When CYCLI Q1 gets control, it is bound to the application of T_1, ..., T_5 which correspond to the first five transformational rules; then control is switched to LING which calls CYCLI Q2. The programs CYCLI Qn process cyclic rules and the output structure is the input structure for the following rule. When all the cyclic rules have been applied to the input structure, LING starts over again at CYCLI Q1. If no modifications to the already processed structures occur, or if new errors are discovered, control returns to LING.

After all the cyclic rules have been applied, the post-cyclic rules are processed in a similar manner: CYCLI QA comprises the first five post-cyclic rules CYCLI QB, the five following, and so on.

This chart illustrates the general interaction between the programs for the processing of cyclic or post-cyclic rules.

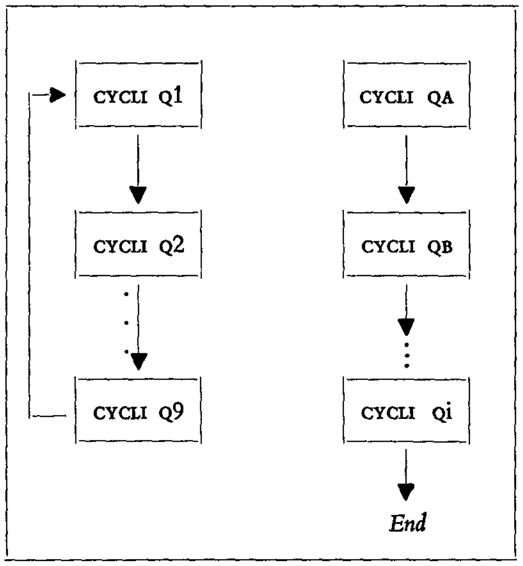

Fig. 5. *Flow of Control between control programs under the direction of* LING

7. SERVICE SUBROUTINES

They are implemented within the main monitor LING. All but a few of these subroutines are called during the execution of the routines corresponding to the 88 rules, that is during the phrase structure analysis or the mapping of *n* structures.

A short description of the main subroutines follows: ARBRE (tree). This subroutine is responsible for printing the tree. At the input, we find a vector *D* of *ND* elements which represents the tree. The horizontal distance for printing is calculated along with the total number and the relative position of these nodes; the vertical one is fixed.

For example,

FIGURE 6A

```
TACHE*     2 *

NOMBRE DE NOEUDS  21

NOMBRE DE NOEUDS TERMINAUX  12

CHAINE

 1 =   $  , D( 1) =  20
 2 =  LE  , D( 2) =  13
 3 =   N  , D( 3) =  15
 4 =   V  , D( 4) =  16
 5 =   $  , D( 5) =  20
 6 =   $  , D( 6) =  21
 7 = PRP  , D( 7) =  17
 8 = QUE  , D( 8) =  17
 9 =  LE  , D( 9) =  14
10 =   N  , D(10) =  18
11 =   V  , D(11) =  19
12 =   $  , D(12) =  21
13 = DET  , D(13) =  15
14 = DET  , D(14) =  18
15 =  GN  , D(15) =  20
16 =  GV  , D(16) =  20
17 =   C  , D(17) =  21
18 =  GN  , D(18) =  21
19 =  GV  , D(19) =  21
20 =   P  , D(20) =  -1
21 =   P  , D(21) =  -1

ARBORESCENCE NON PRODUITE SUR DEMANDE : AUCUNE

REGLES IGNOREES SUR DEMANDE : AUCUNES
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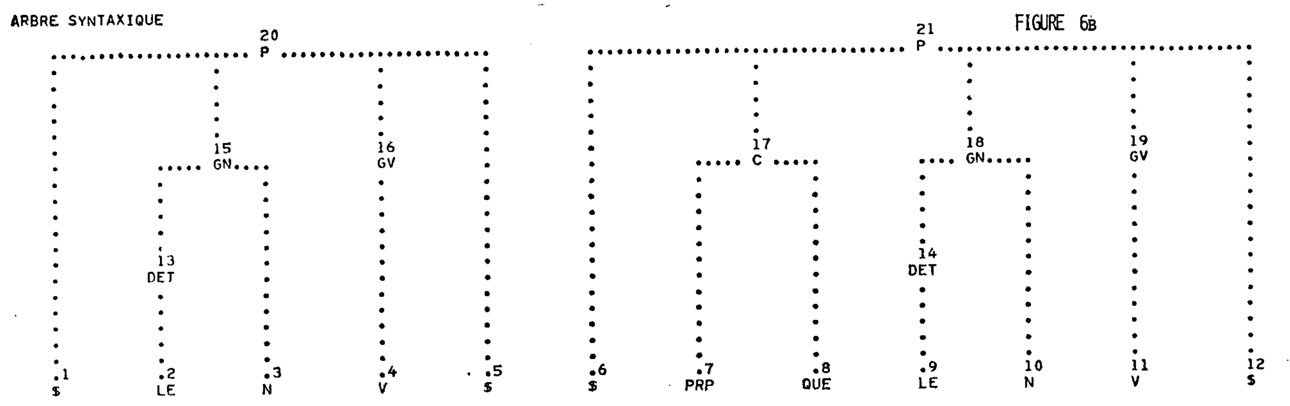
Fig. 6*a*. *Representation of the tree in memory*

7.1. OTE (*Remove*).

This subroutine is needed when nodes are erased; another subroutine, NEWTREE will erase the nodes. In the example below, OTE sets $D(6)$, $D(7)$, $D(13)$ to zero, and NEWTREE erases nodes numbered 6, 7 and 13. If node 12 was also erased, OTE and NEWTREE would have erased node 28 automatically. The same holds for the node 32, where all the nodes between 6 and 13 would have been erased.

7.2. DFER, DFERX, GFER, GFERX.

Except for a few details, these four subroutines do the same work. For example, DFERX $[I, J]$ is applied to a structure J that has to be moved to the right under a dominating node I. As illustrated below, DFERX [31, 30] moves the structure headed by 30 to the right under the node



```
PILE

1    2    3    4    5    6    7    8    9    10   11   12   13   14   15   16   17   18   19   20   21
     LE   N    V              PRP       LE   N    V                   GN   GV        GN   GV   P    P
     .NO  POP  ADJ            DE        .NO  POP  ADJ                 PLU  +ENC      PLU  ENC  CNJ  CNJ
     HUM  ANM  IMP            PRT       HUM  ANM  IMP                 FEM            FEM       NEG  NEG
     FEM  IDF  R              +CRC      FEM  IDF  R                   ENC            ENC       INT  INT
     PLU  HMA  PRZ            A         PLU  HMA  PRZ                                          ET   ET
     PRO  PER  AN.            TMP       PRO  PER  AN.                                          CYC  CYC
          II   .N             LIU            II   .N                                           COR  COR
          NUM  IPF            -OGN           NUM  IPF
          ON   QU.            CAU            ON   QU.
          GEO  EXT            BUT            GEO  EXT
          FEM  HM.            MAN            FEM  HM.
          PLU  .HM                           PLU  .HM
               .NP                                .NP
               .QU                                .QU
               .IF                                .IF
               .HN                                .HN
               .NH                                .NH
               .QN                                .QN
               .QC                                .QC
               AVR                                AVR
               COP                                COP
               OPR                                OPR
               PRE                                PRE
               PRM                                PRM
               MDI                                MDI
               NUM                                NUM
               CRD                                CRD
               PLU                                PLU
               FEM                                FEM
               II                                 II
               INF                                INF
               PRO                                PRO
```

Fig. 6b. *Corresponding printed tree*

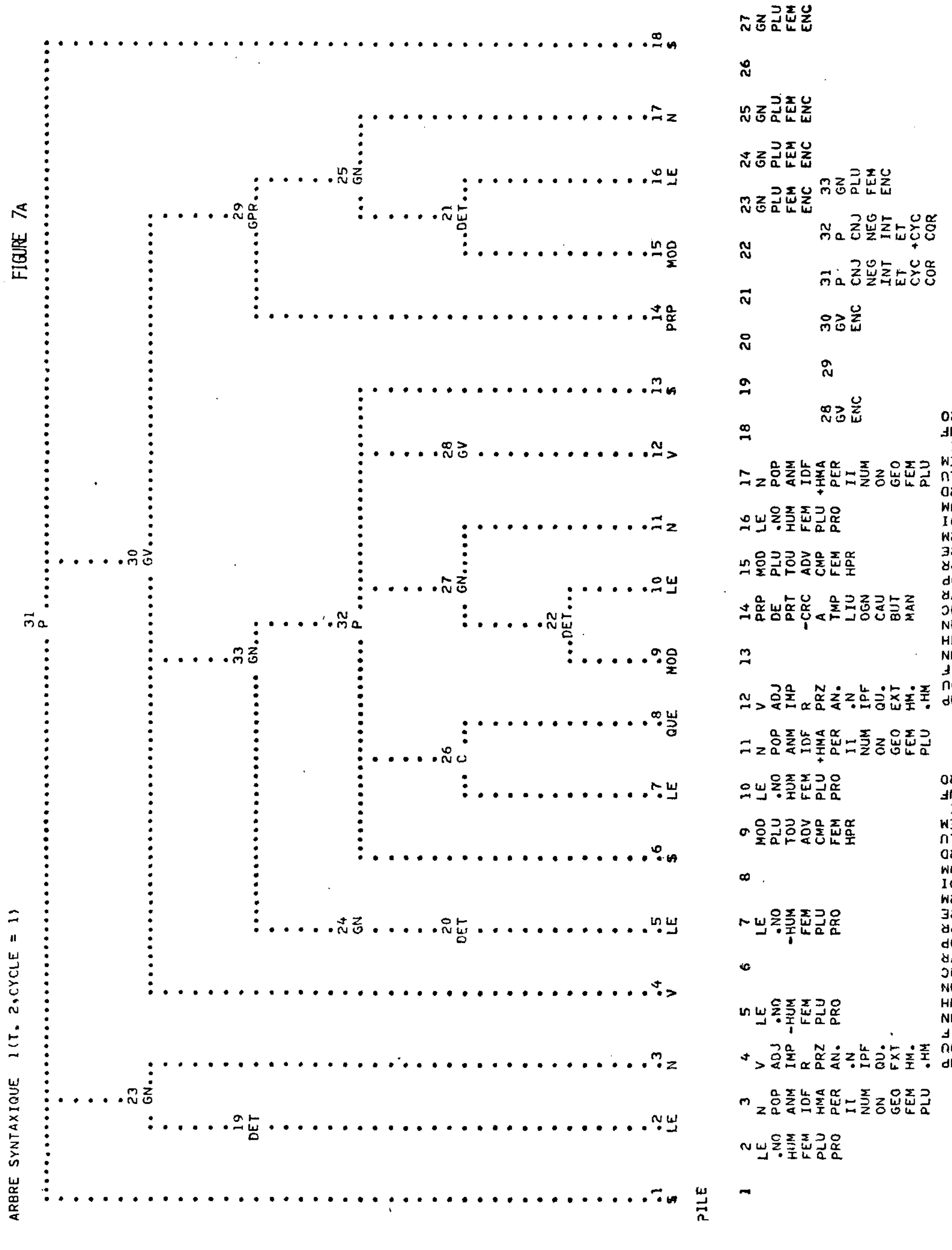


Fig. 7*a*. *Sample tree before* OTE *and* NEWTREE *apply*

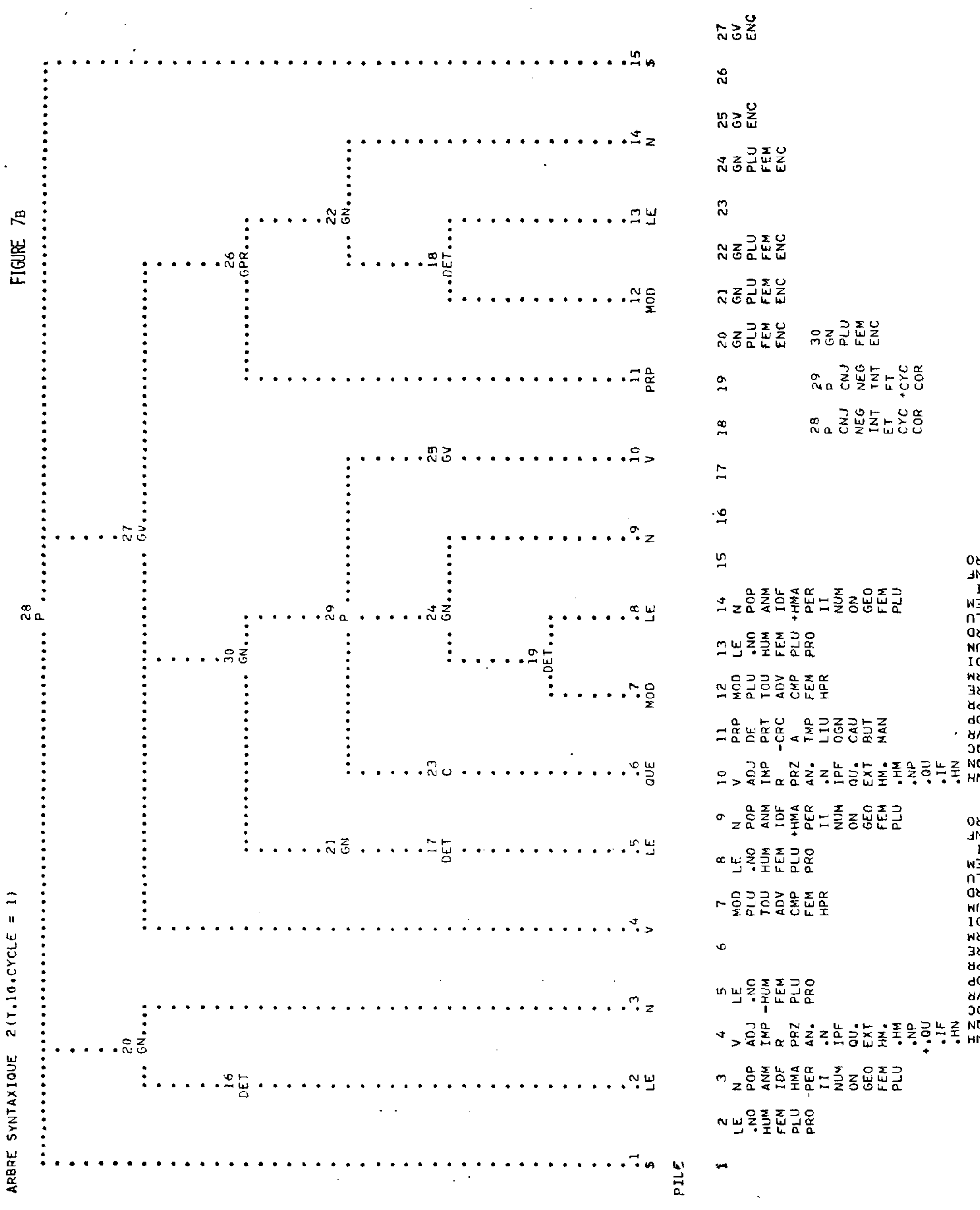


Fig. 7*b*. *Sample tree where* OTE *and* NEWTREE *have applied*

31. (Node 31 was created by rule *T*2 and DFER was applied on the resulting tree)

DFER	[*I*, *J*]	makes node *J* the next younger brother of node *I*
DFERX	[*I*, *J*]	makes node *J* the youngest son of node *I*
GFER	[*I*, *J*]	makes node *J* the next older brother of node *I*
GFERX	[*I*, *J*]	makes node *J* the oldest son in node *I*

The general technique for these four subroutines is the following. Before modification, the tree is copied in another area of memory. All the terminal nodes identified with the structure *J* take the place of the terminal nodes identified with the structure *I*. Then, the terminal nodes of *I* are requested in the copied structure and parsed with their dominating nonterminal nodes at the right place. GFER permits the new numbering of the sequence and, if necessary, prunes the tree.

In the example illustrated below (Fig. 9*a* and 9*b*), GFER [14, 13] is applied and node *CPL* (13) has been attached to node 16, the father of node 14. If GFERX [14, 13] had been specified, node *CPL* would have been attached directly to node 14, rather than the father of node 14.

7.3. INTERV.

This subroutine is used for the permutation of 2 structures. For example, INTERV [*I*, *J*] where $I = 24$ and $J = 28$ gives rise to the structural change illustrated below.

7.4. INSERT.

This subroutine is used for the insertion of a new terminal node; for example, INSERT [4, 1*HE*, 1*HT*, 1*HR*, 9] introduces node with name *ETR* which becomes a new son of node 9.

7.5. *Other subroutines.*

There is a number of other subroutines concerning conditions specified within a rule, such as the presence or absence of a node or of a feature in the whole structure, the logical restrictions of loose equality or strict equality.

*

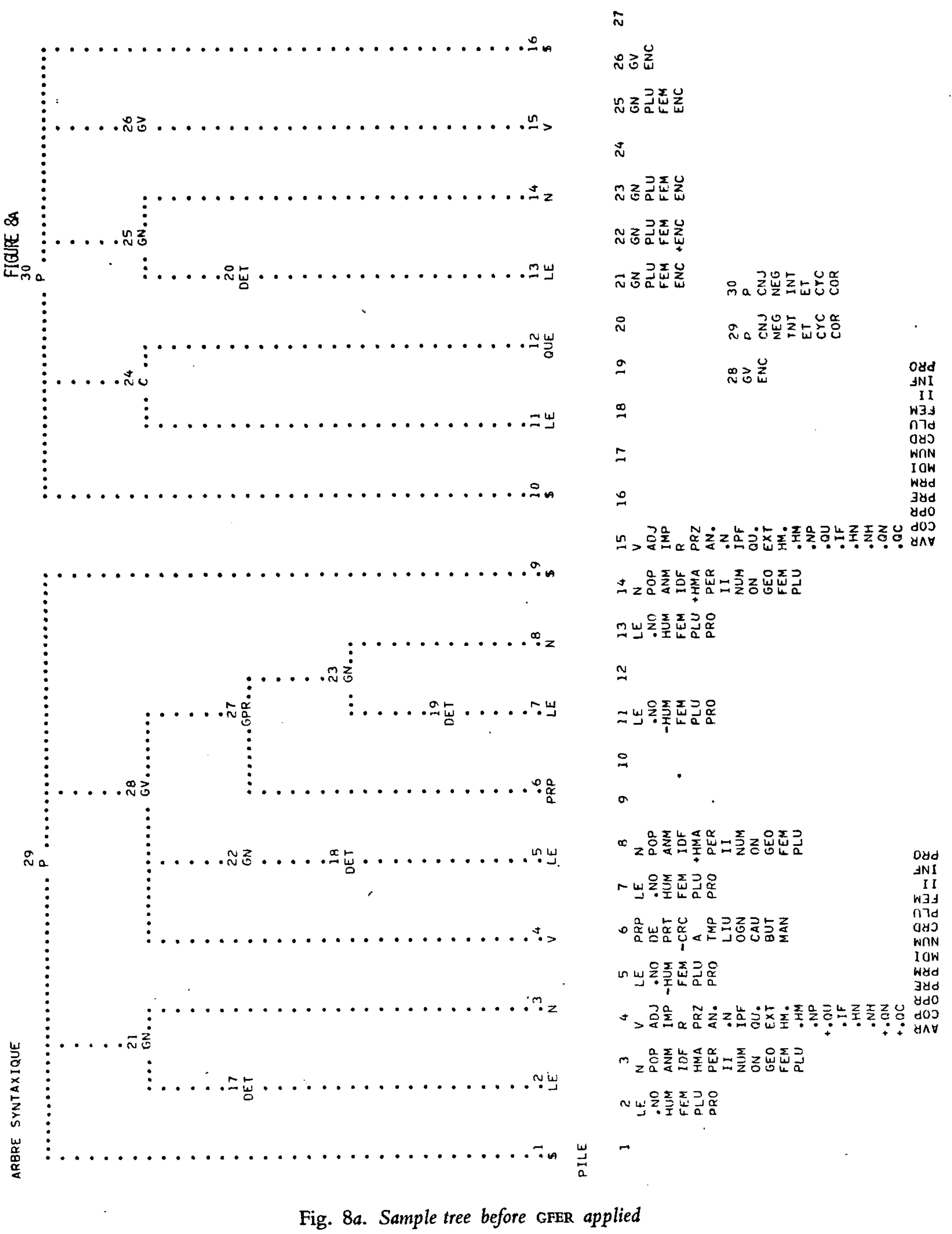


Fig. 8*a*. *Sample tree before* GFER *applied*

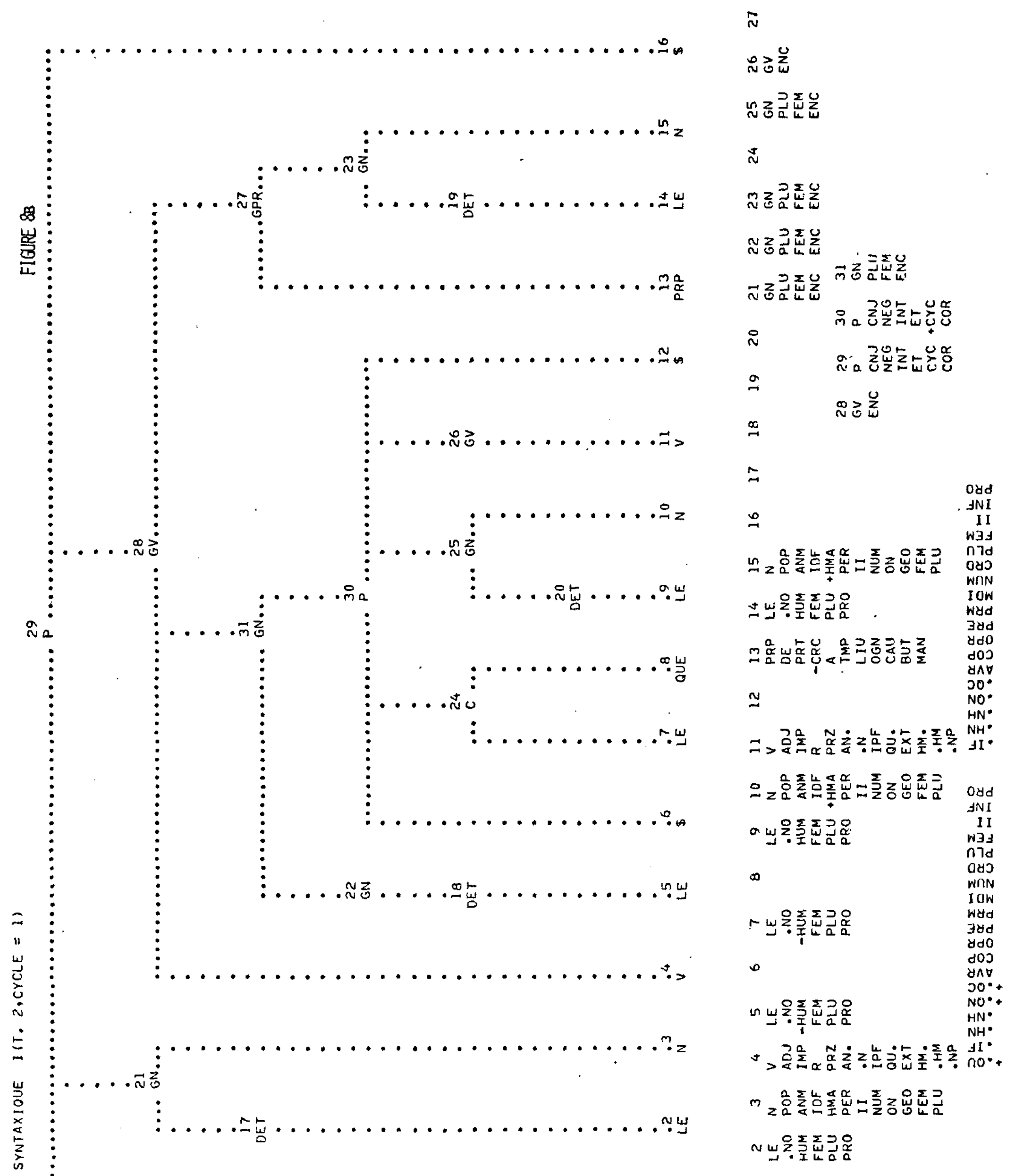


FIGURE 8B
ARBRE SYNTAXIQUE I(T, 2,CYCLE = 1)
29 P
21 GN
28 GV
31 GN
27 GPR
23 GN
30 P
22 GN
24 C
25 GN
26 GV
17 DET
18 DET
19 DET
20 DET
1 $
2 LE
3 N
4 V
5 LE
6 $
7 LE
8 QUE
9 LE
10 N
11 V
12 $
13 PRP
14 LE
15 N
16 $
PILE
1
2 LE .NO -HUM FEM PLU PRO
3 N POP ANM IDF HMA PER II NUM ON GEO FEM PLU
4 V ADJ IMP R PRZ AN. .N IPF QU. EXT HM. .HM .NP
5 LE .NO -HUM FEM PLU PRO
6
7 LE .NO -HUM FEM PLU PRO
8
9 LE .NO -HUM FEM PLU PRO
10 N POP ANM IDF +HMA PER II NUM ON GEO FEM PLU
11 V ADJ IMP R PRZ AN. .N IPF QU. EXT HM. .HM .NP
12
13 PRP DE PRT -CRC A .TMP LIU OGN CAU BUT MAN
14 LE .NO -HUM FEM PLU PRO
15 N POP ANM IDF +HMA PER II NUM ON GEO FEM PLU
16
17
18
19
20
21 GN PLU FEM ENC
22 GN PLU FEM ENC
23 GN PLU FEM ENC
24
25 GN PLU FEM ENC
26 GV ENC
27
28 GV ENC
29 P CNJ NEG INT ET CYC COR
30 P CNJ NEG INT ET +CYC COR
31 GN PLU FEM ENC
+.OU .IF .NH .NH +.ON +.OC AVR COP OPR PRE PRM MDI NUM CRD PLU FEM II INF PRO
.IF .NH .NH .ON .OC AVR COP OPR PRE PRM MDI NUM CRD PLU FEM II INF PRO

Fig. 8*b*. *Sample tree where* GFER *has applied*

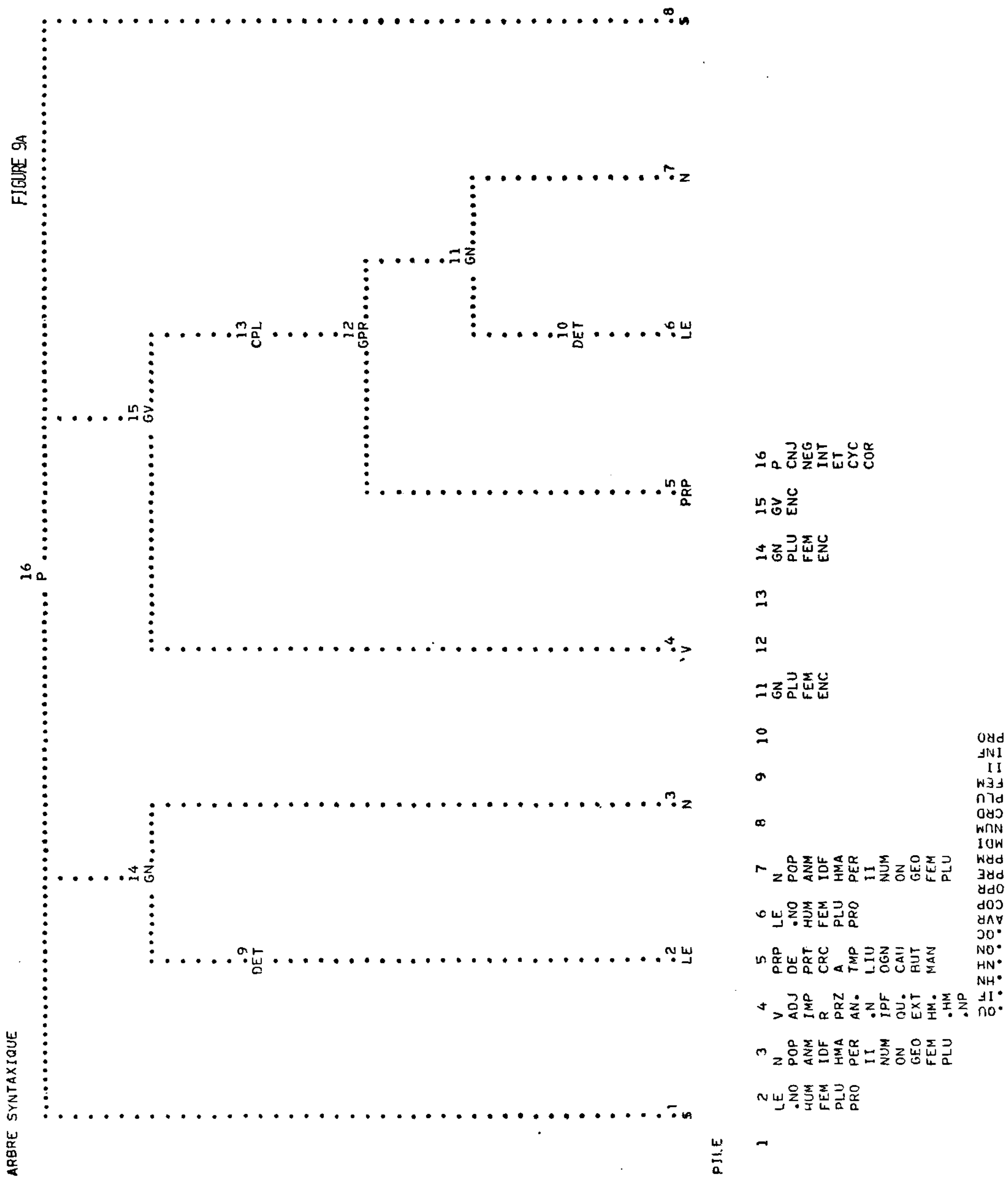
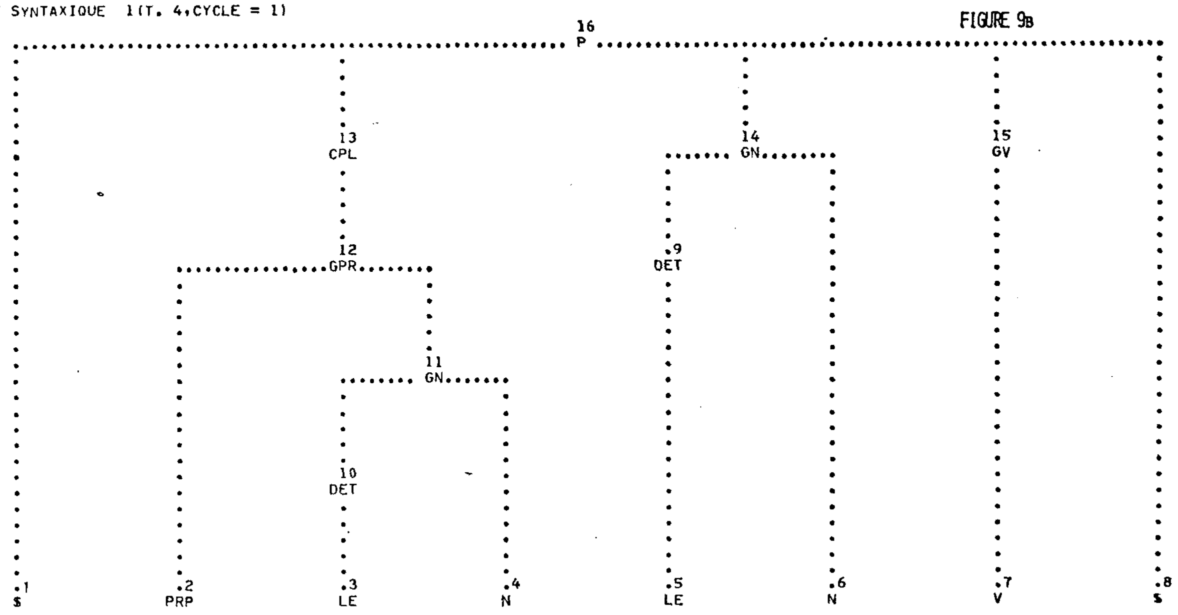

ARBRE SYNTAXIQUE
FIGURE 9A
16 P
14 GN
15 GV
13 CPL
12 GPR
11 GN
10 DET
9 DET
1 S
2 LE
3 N
4 V
5 PRP
6 LE
7 N
8 S
PILE
1
2 LE .NO HUM FEM PLU PRO
3 N POP ANM IDF HMA PER II NUM ON GEO FEM PLU
4 V ADJ IMP R PRZ AN. .N IPF OU. EXT HM. .HM .NP
5 PRP DE PRT CRC A TMP LIU OGN CAI BUT MAN
6 LE .NO HUM FEM PLU PRO
7 N POP ANM IDF HMA PER II NUM ON GEO FEM PLU
8
9
10 PRO INF II FEM PLU CRD NUM MDI PRM PRE OPR COP AVR .OC .ON .NH .HN .IF .OU
11 GN PLU FEM ENC
12
13
14 GN PLU FEM ENC
15 GV ENC
16 P CNJ NEG INT ET CYC COR

Fig. 9*a*. *Input structure*

```
ARBRE SYNTAXIQUE  1(T. 4,CYCLE = 1)
```

FIGURE 9B



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PILE

 1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16
     PRP  LE   N    LE   N    V                   GN             GN   GV   P
     DE   .NO  POP  .NO  POP  ADJ                 PLU            PLU  ENC  CNJ
     PRT  HUM  ANM  HUM  ANM  IMP                 FEM            FEM       NEG
     CRC  FEM  IOF  FEM  IDF  R                   ENC            ENC       INT
     A    PLU  HMA  PLU  HMA  PRZ                                          ET
     TMP  PRO  PER  PRO  PER  AN.                                          +CYC
     LIU       II        II   .N                                           COR
     OGN       NUM       NUM  IPF
     CAU       ON        ON   QU.
     BUT       GEO       GEO  EXT
     MAN       FEM       FEM  HM.
               PLU       PLU  .HM
                              .NP
                              .QU
                              .1F
                              .HN .NH .ON .QC AVR +COP OPR PRE PRM MDI NUM CRD PLU FEM II INF PRO
```

Fig. 9*b*. *Output structure after* GFER *has applied*

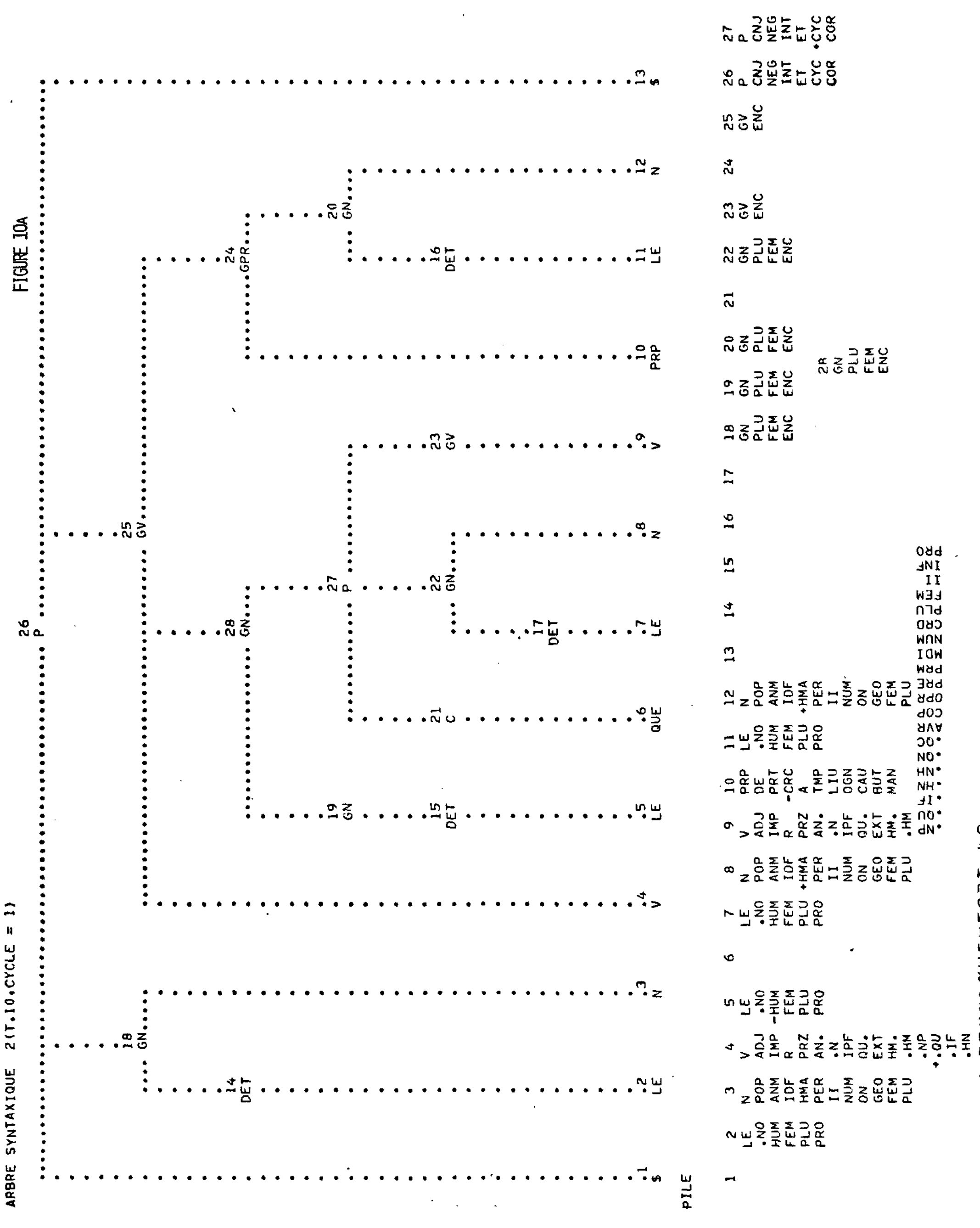

Fig. 10*a*. *Input structure*

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                                          UT21--     11   13
                                          2--T36--        2
ARBRE SYNTAXIQUE  3(T.15.CYCLE = 2)                                            FIGURE 10B
```
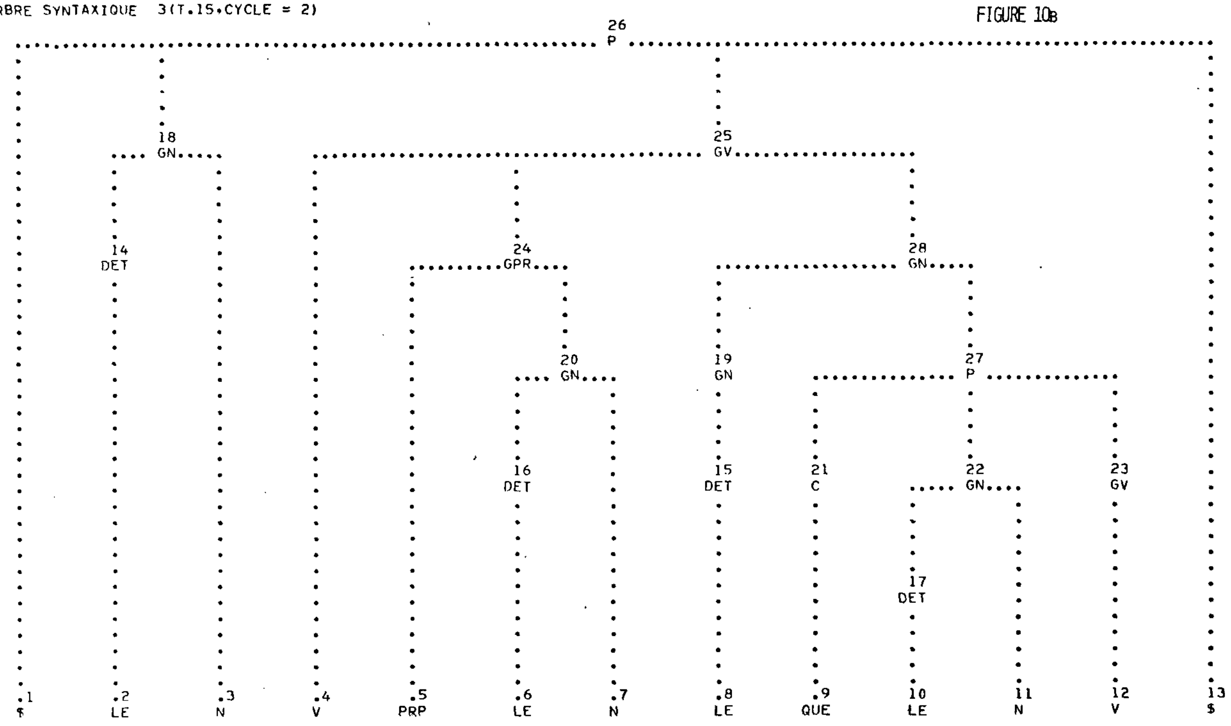
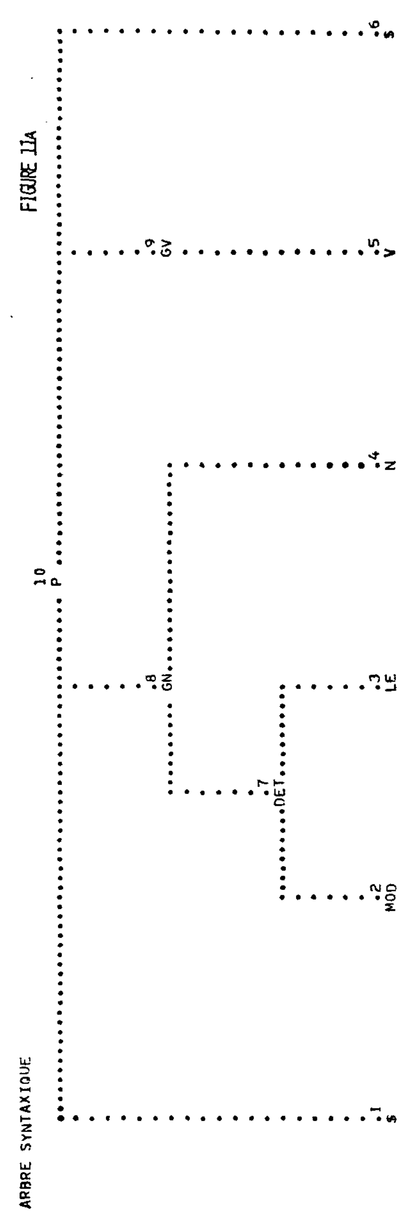



```
PILE

1     2     3     4     5     6     7     8     9     10    11    12    13    14    15    16    17    18    19    20    21    22    23    24    25    26    27
      LE    N     V     PRP   LE    N     LE          LE    N     V                                   GN    GN    GN          GN    GV          GV    P     P
      .NO   POP   ADJ   DE    .NO   POP   .NO         .NO   POP   ADJ                                 PLU   PLU   PLU         PLU   ENC         ENC   CNJ   CNJ
      HUM   ANM   IMP   PRT   HUM   ANM   -HUM        HUM   ANM   IMP                                 FEM   FEM   FEM         FEM                     NEG   NEG
      FEM   IDF   R     -CRC  FEM   IDF   FEM         FEM   IDF   R                                   ENC   ENC   ENC         ENC                     INT   INT
      PLU   HMA   PRZ   A     PLU   +HMA  PLU         PLU   +HMA  PRZ                                                                                 ET    ET
      PRO   PER   AN.   TMP   PRO   PER   PRO         PRO   PER   AN.                                             28                                    +CYC  -CYC
            II    .N    LIU         II                      II    .N                                              GN                                    COR   COR
            NUM   IPF   OGN         NUM                     NUM   IPF                                             PLU
            ON    QU.   CAU         ON                      ON    QU.                                             FEM
            GEO   EXT   BUT         GEO                     GEO   EXT                                             ENC
            FEM   HM.   MAN         FEM                     FEM   HM.
            PLU   .HM               PLU                     PLU   .HM
                  .NP +.QU .IF .HN .NH +.QN +.QC AVP COP OPR PRE PRM MDI NUM CRD PLU FEM II INF PRO
                                                                  .NP .QU .IF .HN .NH .QN .QC .AVR COP OPR PRE PRM MDI NUM CRD PLU FEM II INF PRO
```

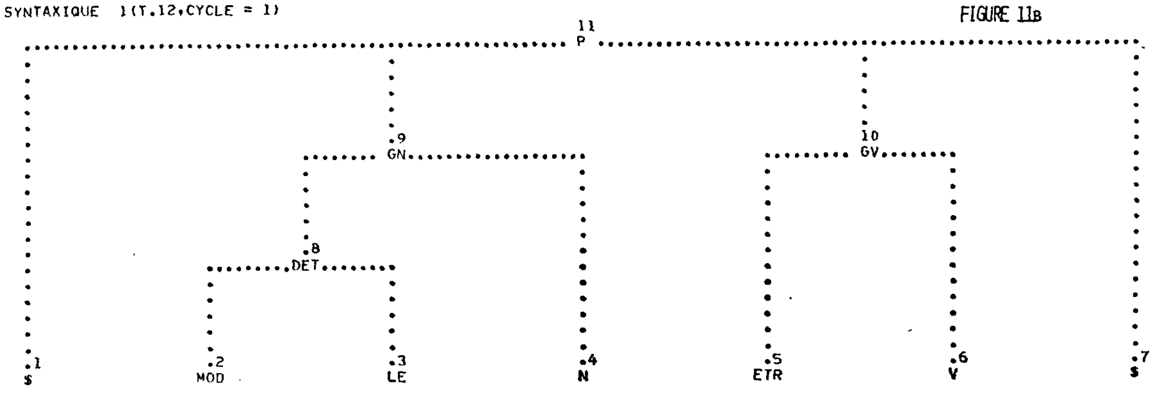
Fig. 10*b*. *Output structure after* INTERV *has applied*



```
PILE

 1    2    3    4    5    6    7    8    9    10
     MOD  LE   N    V              GN   GV   P
     PLU  .NO  POP  +ADJ           PLU  ENC  CNJ
     TOU  HUM  ANM  -IMP           FEM       NEG
     ADV  FEM  IDF  +R             ENC       INT
     CMP  PLU  HMA  +PRZ                     ET
     FEM  PRO  PER  AN.                      CYC
     HPR       II   .N                       COR
               NUM  IPF
               ON   QU.
               GEO  EXT
              +FEM  HM.
               PLU  .HM
                    .NP
                    .QU
                    .IF
                    .HN
                    .NH
                    .QN
                    .QC
                    AVR
                    COP
                    OPR
                    PRE
                    PRM
                    MOI
                    NUM
                    CRD
                   +PLU
                    FEM
                    II
                    INF
                    PRO
```

Fig. 11*a*. *Insertion of a node (before)*

ARBRE SYNTAXIQUE 1(T.12,CYCLE = 1) FIGURE 11B



```
PILE

 1    2    3    4    5    6    7    8    9    10   11
     MOD  LE   N    ETR  V              GN   GV   P
     PLU  .NO  POP  ADJ  +ADJ           PLU  ENC  CNJ
     TOU  HUM  ANM  IMP  -IMP           FEM       NEG
     ADV  FEM  IDF  R    +R             ENC       INT
     CMP  PLU  HMA  PRZ  +PRZ                     ET
     FEM  PRO  PER  AN.   AN.                     +CYC
     HPR       II   .N   .N                        COR
               NUM  IPF  IPF
               ON   QU.  QU.
               GEO  EXT  EXT
              +FEM  HM.  HM.
               PLU  .HM  .HM
                    .NP  .NP
                    .QU  .QU
                    .IF  .IF
                    .HN  .HN
                    .NH  .NH
                    .QN  .QN
                    .QC  .QC
                    AVR  AVR
                    COP  COP
                    OPR  OPR
                    PRE  PRE
                    PRM  PRM
                    MDI  MDI
                    NUM  NUM
                    CRD  CRD
                    PLU  +PLU
                    FEM  FEM
                    II   II
                    INF  INF
                    PRO  PRO
```

Fig. 11b. *Insertion of a node (after)*

8. CONCLUSIONS

OBLING is a system which has been implemented in low-level FORTRAN IV for the CDC 6400. It occupies $55{,}000_8$ 60-bit words of memory. It has about 7000 lines of comments and instructions.

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