LEXICAL FEATURES IN TRANSLATION AND PARAPHRASING: AN EXPERIMENT

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I Introduction

It is obvious to any user of a monolingual dictionary that the meaning of a lexical item is not only dependent on the external form of the item but also on its syntactic or semo-syntactic properties.[1] The terms homonymy and polysemy reflect this knowledge. It is equally obvious for the user of a better than average bilingual dictionary that the meaning of a lexical item is also a function of each selection restriction associated with it. This observation is evident from the fact that different translations are associated with a particular lexical item dependent on the syntactic and/or semantic properties of the constituents in its environment. The verb *erinnern* provides an example for German: In the environment "reflexive pronoun" its translation is *remember*; in the environment "non-reflexive object" its translation is *remind.*

The observations are, of course, true for lexical items in a language independent of their translatability into some other language. Only a few monolingual dictionaries, however, make this observation explicit. Among the few notable examples are the German Woerterbuch der deutschen Gegenwartssprache[2] and Hornby's An Advanced Learner's Dictionary[3]. Hornby lists for each verb the complement structures with which it may occur and the meanings it has in each environment. Thus, observe

may mean *to take notice of (to watch)* or *to say as comment* in the environment *"that* S", e.g. *He observed that his wife had arrived.* However, in the environment "NP", *observe* can only have the first interpretation, e.g. *He observed the arrival of his wife*[4].

In view of the possibility of specifying the meaning of a lexical item or selecting a proper translation equivalent for it by taking its environment into account, it may seem surprising to the uninitiated that earlier MT systems had attempted to make such selections based on different criteria: considerations of the type of text to be translated or of probability of occurrences of lexical items. The difficulties confronting attempts to access the selection restrictions of a lexical item during the surface analysis of a sentence by means of a context-free grammar have been described in various monographs. These difficulties are multiplied when attempting the translation of languages, such as German, where various agreement and government relations hold between constituents, where lexical items and phrasal expressions often occur as discontinuous elements, and where sentence constituents can occur in various orders. The attempt to incorporate selection restrictions of lexical items into non-terminal symbols of context-free grammars would have increased the number of such rules to unmanageable proportions. For this reason, the incorporation of such selection restrictions was consequently suppressed. The loss was two-fold:

a) The number of syntactic interpretations for a sentence often increased ("forced readings").

b) The selection of proper translation equivalents had to be based on different criteria.

II Background of the Experiment

In summer 1966 I began investigating the possibilities of improving various parts of the Linguistics Research System[5] in order to cope with the increasing difficulties encountered in the attempts to analyze and translate sentences in natural language: the prohibitively large number of syntactic and translation rules necessary for the description and translation of surface structures into surface structures and the inability to deal with discontinuous constituents.[6] The research was influenced by the following guidelines:

1) to improve translation by permitting access to selection restrictions;

2) to decrease the number of forced readings assigned to sentences without an unreasonable increase in the number of grammar and translation rules;

3) to preserve as many as possible of the various algorithms used for surface analysis, translation mapping and surface production.

The results were reported in December 1966 in an unpublished paper which stated:

a) that vastly improved translations were possible by performing translation not from surface structures into surface

structures but from standardized surface structures (standard strings) into standardized surface structures;

b) that these standard strings could be derived from the syntactic reading of a sentence by means of an additional straightforward algorithm;

c) that these translations could be obtained with an overall decrease of grammar rules;

d) that the core of the LRS algorithms could be retained;[7]

e) that non-trivial paraphrases could be performed over standard strings which were not possible over surface strings.

An experiment was subsequently performed to compare the proposed translation procedure with the established one. In order to facilitate this comparison, a text was selected for translation part of which had been translated in February 1966 using the Linguistics Research Center's first and second order translation system. Since the program which derived the standard strings from the corresponding sentence readings did not exist, the standard terminals were represented as surface terminals enclosed in asterisks. Only in cases where surface terminals occurred as homographs in the given text was a descriptor added in parentheses to reflect the disambiguating effect of the standardization procedure.

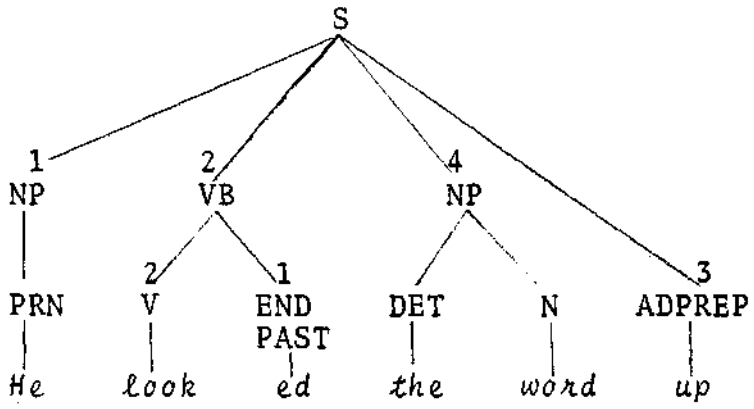
In order to reduce the time spent on this experiment, only one standard string of those sentences which had more than one surface reading was selected. (The number of readings for

sentence 486 was 24, sentences 488, 489, and 492 had two readings each, all others had one.)

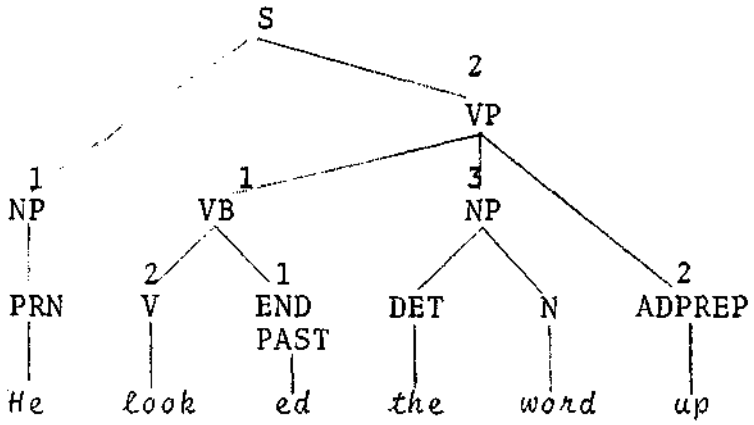
III Standard Strings

The standard representation of a sentence is a reordering of its terminal elements (with their part-of-speech interpretation) based on the surface interpretation of that sentence. The reordering could be performed by means of ordering instructions assigned to each constituent in the consequent of a rule which is part of the sentence reading.[8]

Assume the sentence *He looked the word up* is analyzed by the rules represented in the following tree diagram:



or, if you prefer, by



(The digits at the end of branches determine the mapping order of the sister nodes).

The standard string corresponding to this reading would then be:

he	*ed*	*look*	*up*	*the*	*word*
<PRN>	<END> <PAST>	<V>	<ADPREP>	<DET>	<N>

where the part-of-speech interpretation of each terminal is represented in angled brackets. (One can obtain a standard string by tracing down from each node, beginning with S, all branches in their indicated order and not tracing up a branch before all terminals below that branch have been reached).

The following standard order was defined for German surface constituents:

For clause level elements:

Subject (of an active sentence), agent adverbial (of a passive sentence), predicate, prefix, direct object, subject (of a passive sentence), predicative complement, indirect object, adverbials.

For phrase level elements:

Verbals: Finite verb, non-finite verb, prefix.

Noun phrases: Head, post-modifier, pre-modifier, determiner.

Prepositional phrases: Preposition, object.

For word level: Affixes, stem.

Conjoined elements "A, B and C": and , A B C .

The standard order defined for English differed from that for German only in that the elements of noun phrases occurred in the sequence: Determiner, pre-modifier, post-modifier, head of noun phrase. No significance is to be attributed to this difference; the distinction was made primarily to facilitate the reading of the output, the English standard strings. The distinction, however, shows the independence of the standard orders of the two languages.

The greater ease with which strings given in standard order could be analyzed may be evident when comparing the syntactic description of the following five sentences with the corresponding standard descriptions.

1) *Das Buch hat er seiner Frau gegeben.*

2) Seiner Frau hat er das Buch gegeben.

3) Der Frau ist er gefolgt.

4) Seiner Frau hat er gehorcht.

5) Das Buch hat er gelesen.

(Clause level constituents consisting of more than one word are underlined). These sentences were analyzed by the following rules:

```
l')  S → OBJ  AUX  SUBJ  OBJ  PASTPART[9]
          ACC  H    3     DAT  H
               3    SG         ACC
               SG   DAT

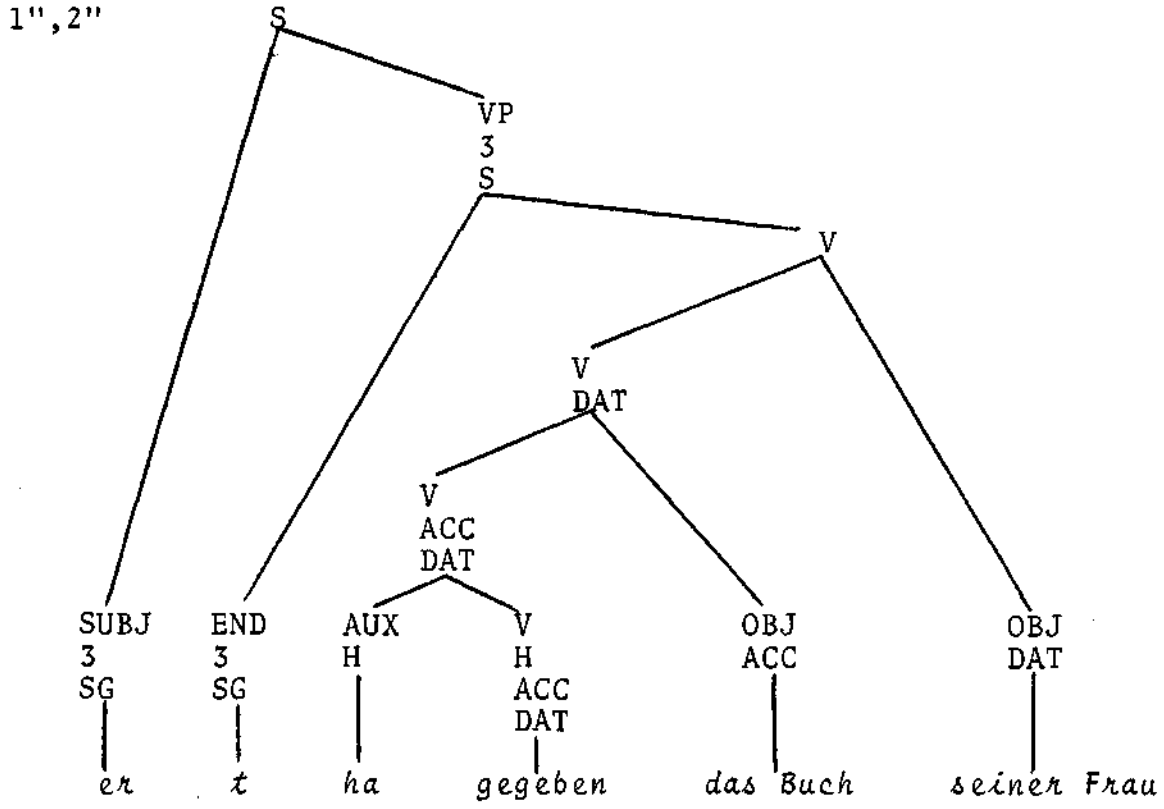
2')  S → OBJ  AUX  SUBJ  OBJ  PASTPART
         DAT  H    3     ACC  H
              3    SG         ACC
              SG   DAT

3')  S → OBJ  AUX   SUBJ  PASTPART
          DAT  S     3     S
               3     SG    DAT
               SG
```

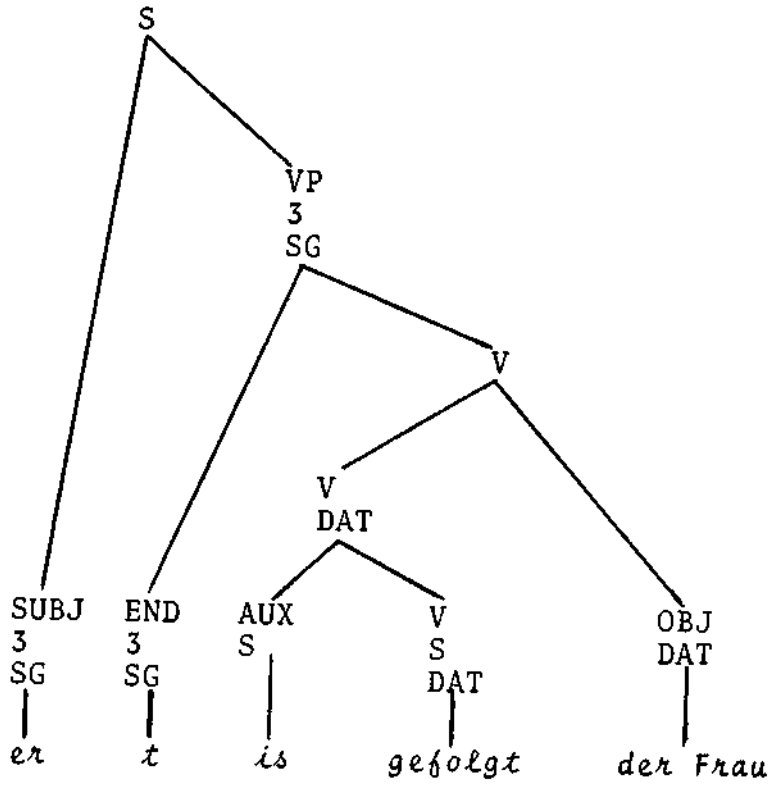
4') S → OBJ AUX SUBJ PASTPART
DAT H 3 H
3 SG DAT
SG

5') S → OBJ AUX SUBJ PASTPART
ACC H 3 H
3 SG ACC
SG

As we can observe, each change in word order (sentences 1 and 2), syntactic agreement (sentences 3 and 4) or government (sentences 4 and 5) had to be analyzed by a new sentence rule.[10] The corresponding standard representations, however, permitted a far more economic analysis.



3''


S
VP
3
SG
V
V
DAT
SUBJ
3
SG
END
3
SG
AUX
S
V
S
DAT
OBJ
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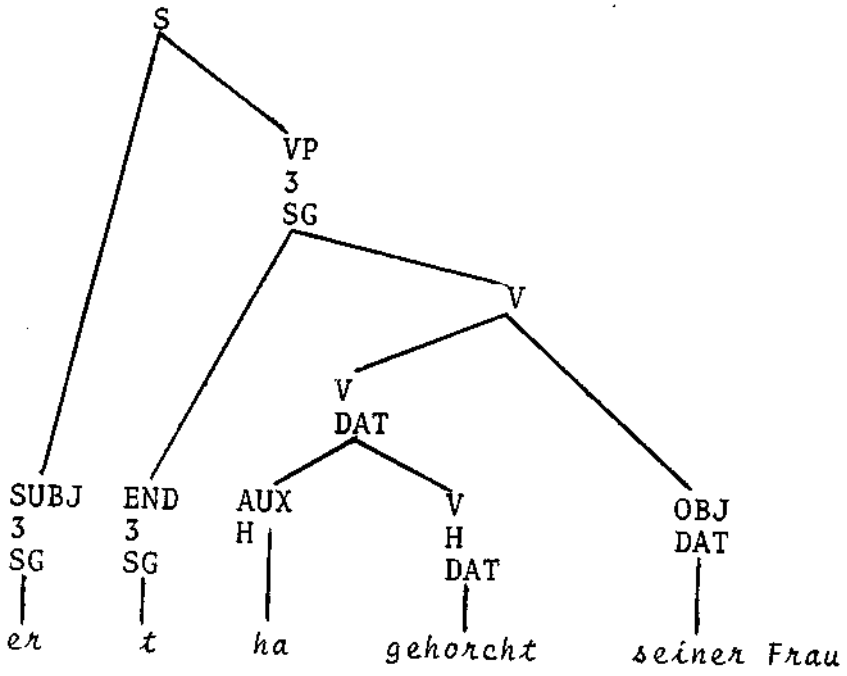
er
t
is
gefolgt
der Frau

4''


S
VP
3
SG
V
V
DAT
SUBJ
3
SG
END
3
SG
AUX
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er
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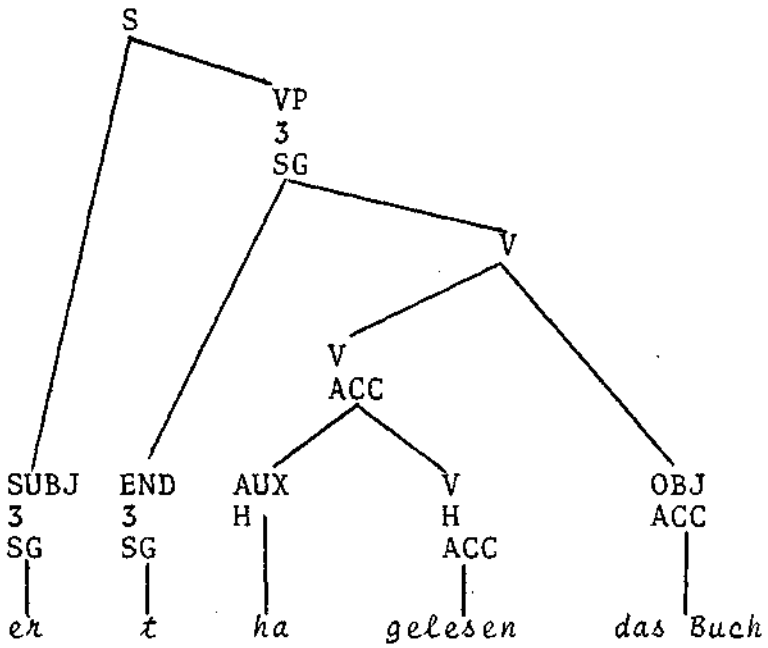
gehorcht
seiner Frau

5"



Firstly, it will be noticed that permutations as in sentences 1) and 2) were reduced to the same representation. Secondly, it was possible to concatenate the verb with its immediately contiguous elements, dropping with each concatenation the information that was necessary for the concatenation. This resulted in a considerably smaller number of grammar rules.

Note that all four readings have in common the rules $S \rightarrow \underset{3\ SG}{SUBJ}\ \underset{3\ SG}{VP}$ and $VP \rightarrow \underset{3\ SG}{END}\ V$. Sentences 1), 3) and 4) also have in common the rule $V \rightarrow V\ \underset{DAT}{OBJ}\ \underset{DAT}{.}$[11] It was, finally, possible to treat discontinuous lexical items as one piece and assign them a new, their correct, syntactic interpretation.[12] Thus the rule

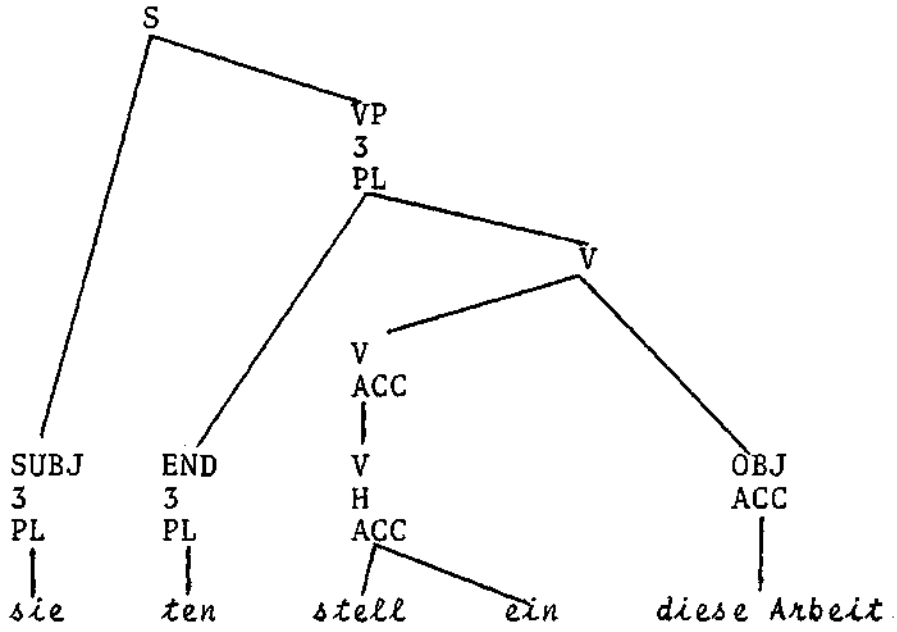
$S \rightarrow OBJ(4)\ \underset{ACTIVE}{PRED(2)}\ SUBJ(l)\ PRFX(3)$ - the desired order of the constituents is given in parentheses - interpreting sentences such as

6) *Diese Arbeit stellten sie ein = They discontinued this work.*

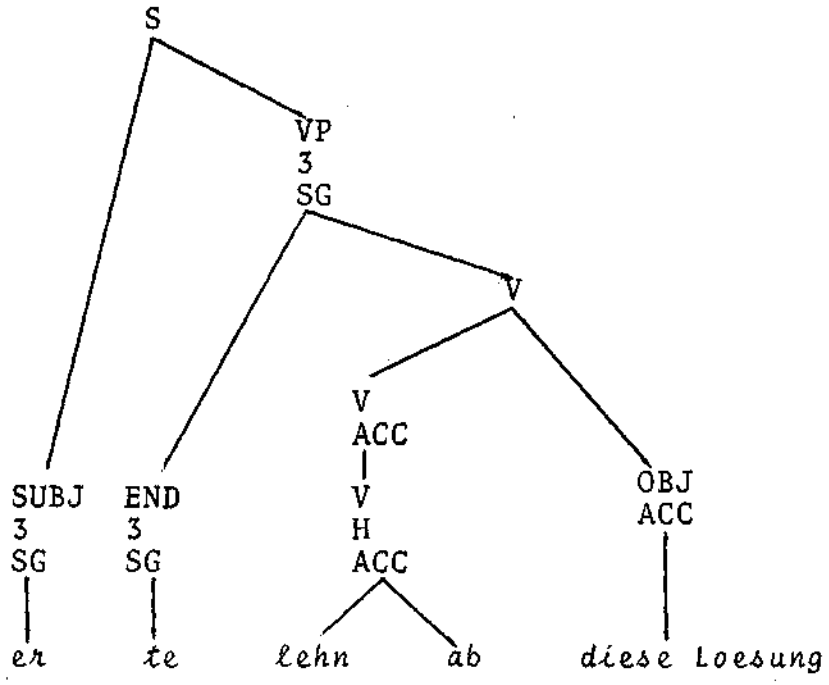
7) *Diese Loesung lehnte er ab = He rejected this solution.*

generated the standard strings given in the tree diagrams below.[13]

6''

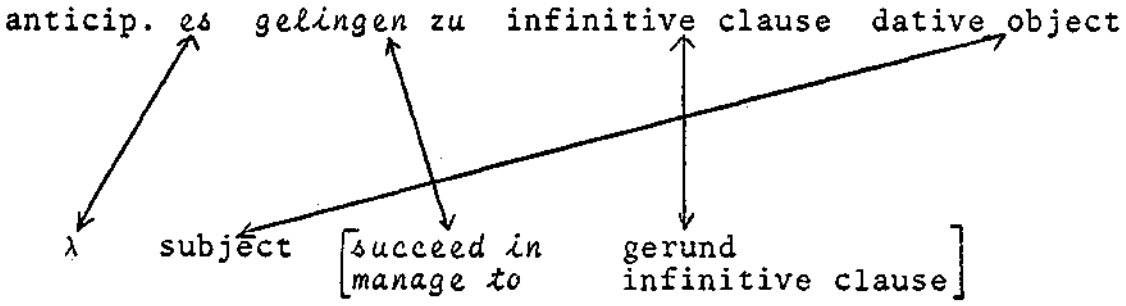


7''



IV The Selection of Translation Equivalents

The possibility of associating more comprehensive syntactic information with lexical pieces in standard strings as a consequence permitted an improved selection of translation equivalents. The list in Figures 7-1 through 7-6 contains a number of German items with their selection restrictions and the particular translations associated with each selection restriction. The lexical items are listed in the order in which they occur in the translated text. The selection restrictions which apply to the text are given a check mark. No semo-syntactic features, like HU, AN, AB (human, animate, abstract) were taken into account when performing the translation; for those features, cf. my appended paper "Requirements for Machine Translation: Problems, Solutions, Prospects."
The translation possibilities which resulted from the performed subclassification are indicated by light broken lines; the ones selected, by heavy underlines.[14] Of particular interest is one of the translations for *gelingen* (sentence 494, Figure 7), which permitted the mapping represented by the following diagram.



"*Breit* + unit of measure" could be mapped into *"wide* + unit of measure" or "unit of measure + *in width", Zuordnung zu* into *relation to* or *connection with.* The noun phrase *lange Zeit* could be recognized as an adverbial of extension in time instead of as an object due to the feature TIM.

V Paraphrases

In order to show the variety of translations or paraphrases possible over standard strings, a number of non-ad-hoc systematic synonymy relationships were defined for English resulting in the paraphrases given in Figures 3 and 4. Synonymy relationships were defined between lexical pieces and between syntactic structures. Examples of the latter are the active : passive transformation, the perfect tense : past tense transformation[15] and the noun-pre-modifier : noun-post-modifier transformation. Trivial examples of lexical paraphrases were simple synonymy substitutions like *get : obtain, prominence : protuberance,* or *circle : ring;* less trivial examples were *lunar : moon, solar : sun, luminous : light, bright :(to) shine, manage to* (+ infinitive) : *succeed in* (+gerund). The effect of the syntactic classification of lexical items which had been defined as synonymous resulted in a selection of only those syntactic superstructures which interpreted them. Thus syntactic superstructures which were interpreted by the same normal form expression (translation term) but which could not form a well-formed tree with the selected lexical items were filtered out during the production phase.[16] The

effect of this filtering function is shown for two examples in Figure 6; the sequence of normal form expressions S108, S100, S108, S104, L176, S104, L125 (to be read from top to bottom, left to right) simultaneously represents the four paraphrases *the solar disk, the disk of the sun, the sun's disk, the sun disk.*[17]

VI Translations

The simulated standard representation of the German original text (Figure 1) is given in Figure 2. The computer output, the mechanical translations, is shown in Figures 4-1 through 4-9. The translations in Figures 5-1 through 5-3 show an approximation to English normal word order. A more precise rendering would have required a separate processing stage, a rearrangement part. This stage seemed unnecessary for the purpose of the experiment since it is a simple reversal of the generation of standard strings from surface strings. A surface representation of the English translations of the German corpus is given in Figures 3-1 through 3-2.

The translation was performed using some of the then existing LRC analysis and translation algorithms. These, in order to speed up the actual processing time, stored in core all readings found. Whenever the number of readings exceeded the space allotted for them, certain readings were irretrievably dropped. If those readings were needed during the production phase, the corresponding German lexical or syntactic structures were used

instead. This effect is noticeable in the occurrence of asterisked items in the English translations (also items, given in script in Figure 3), in the occurrence of the German standard order in noun phrases,[18] which is different from the defined English standard order, or simply in the ungrammaticality of the generated sentence.

VII Conclusion

In spite of the improved translation capabilities through translation over standard structures, the number of rules necessary, using context-free grammars with simple vocabulary symbols, was felt to be unnecessarily high. The changes made to remedy this deficiency are described in Lehmann/Stachowitz 1970, Vol. II.

FOOTNOTES

1 Thus the meaning of the noun *man* is different from that of the verb *man*, the meaning of the 'non-human' noun *conductor* different from that of the 'human' noun.

2 Woerterbuch der deutschen Gegenwartssprache, herausgegeben von Ruth Klappenbach und Wolfgang Steinitz, Akademieverlag Berlin, 1968 ff.

3 An Advanced Learner's Dictionary by Hornby, Gatenby and Wakefield, London, Oxford University Press, 1948.

4 This nominalization of the *that*-clause can be interpreted as a counterexample to various claims:
1) The combined claim that transformations are meaning-preserving and nominalizations are derived transformationally from sentences;
2) that semantic interpretations apply to deep structures before non-lexical transformations have applied.
Other verbs which behave like *observe* are *remark* and *notice*. Note that *watch* cannot occur in the environment "*that* S".

5 A comprehensive statement on the algorithms of the Linguistics Research System as used until May 1968 is given in Chapter VIII of Final Report, Linguistic Information Processing Study, DA 36-039 AMC-2162(E), 1 May 1965 - 30 April 1966; and Dynamic Adaptive Data Base Management Study, DA 28-043 AMC-02276(E), 16 May 1966 - 15 May 1967, The University of Texas, Linguistics Research Center, Austin, Texas, November 1968.

6 A comprehensive description of the problems encountered can be found in Lehmann/Stachowitz: Research in German-English Machine Translation on Syntactic Level, Vol. II, The University of Texas at Austin, August 1970.

7 Research performed during Spring of 1968 has led to the design of completely new analysis and translation algorithms which process context-free grammars with complex terminal and non-terminal symbols. Cf. Lehmann/Stachowitz 1970 and the appended paper "Requirements for Machine Translation: Problems, Solutions, Prospects."

8 Constituents in a rule consequent were assigned a predetermined order to permit the translation of sentences whose constituents could occur in different surface orders, e.g. *Mark bewunderten sie = Sie bewunderten Mark = They admired Mark.*

9 The LRC verb dictionaries only contained descriptors per-

taining to paradigmatic information. The verb constituents in those rules thus did not contain the descriptors pertaining to case government or auxiliary agreement information.

10 A trivial improvement for rules 1' and 2', resulting from the concatenation of the participle with the contiguous object before concatenating the new constituent with the other sentence constituents, was not possible in the earlier LRC system due to the ordering instructions attached to each constituent. Cf. Lehmann/Stachowitz, 1970, pp. T1 - T59.

11 The affixes are actually represented by "dummy" terminals; these are again replaced by the proper affixes during the output phase. Cf. Lehmann/Stachowitz 1970.

12 The translation of verb-prefix combinations, which occur discontinuously in German main clauses, would have required sentence rules in which the actual prefix would have had to be mentioned as a feature of the constituents involved. For example, *Diese Loesung schlug er vor (He proposed this solution)* would have had to be analyzed by a rule containing as constituents:

OBJ	PRED	SUBJ	PRFX.
ACC	VOR	3	VOR
	ACC	SG	
	3		
	SG		

Each change of prefix would have required a new sentence rule, e.g. *Diese Loesung nahm er an (He accepted this solution)*:

OBJ	PRED	SUBJ	PRFX.
ACC	AN	3	AN
	ACC	SG	
	3		
	SG		

Such rules, of course, were never written.

13 Compare the translation equivalents *einstellen = suspend, ablehnen = refuse* in contrast to the translation of the corresponding simple verbs *stellen = put, lehnen = lean.*

14 In cases where the actually performed subclassification did not suffice to distinguish between different meanings of an item (e.g. *erhalten* with the readings *preserve, maintain* vs. *receive, obtain*), the translation given in the February 1966 translation was accepted. Cf. also footnote 21.

15 This paraphrase was defined to permit the translation of

the German perfect tense as in sentence 492 into both English present perfect and past tense.

16 One can interpret a sequence of normal form expressions as instructions to generate a tree by attaching the top node of a substructure to a non-terminal node of another structure, provided the respective labels are identical. The sequence of normal form expressions interpreting a tree thus imposes a well-formedness condition on the construction of all sentence trees with that normal form reading. Cf. also McCawley 1968.

17 The letter S stands for "non-lexical (syntactic) tree", the letter L for "lexical tree". The numbers were assigned in ascending order beginning with 100. These expressions can, of course, be replaced by meaningful expressions which can be interpreted as the vocabulary symbols of an interlingua or universal grammar.

18 The English subject *B. Edlen* in sentence 494 corresponding to the German dative object appeared in the position for "indirect object" whenever a necessary structure was dropped.

19 Figure 3: Only the paraphrases given in Figures 4-1 through 4-7 are given here. The items in script do not occur in any translation; the items in parentheses were provided as optional translations. The repeated "optionality" of *the* is due to the fact that it was not provided as a lexical equivalent of German /der/ but supplied by means of a syntactic normal form expression which should have been based on the non-encoded information that some nouns may optionally occur without *the*, like *earth*, *the earth*. The equivalents *completely*, *wholly*, *entirely*, *very* were not subclassified for adjective vs. participle modification (sentence 486). *Luminous corona* (sentence 492) results from an incorrect rule.

20 Figure 7: This translation, not given in any dictionaries, was provided in the February 66 translation.

21 The selection of the correct translation equivalent for this pattern depends on the understanding of the sentence.

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GERMAN CORPUS

999,487
DIE LINIEN DES WASSERSTOFFS, DES HELIUMS UND VIELER METALLE TRETEN HIER AUF.

999,488
WENN DIE MONDSCHEIBE DIE SONNE GANZ VERDECKT, ERSCHEINT EIN ROTER 10 -- 15 BOGENSEKUNDEN BREITER RING UM DIE SONNE.

999,489
DAS IST DIE CHROMOSPHAERE MIT DEN PROTUBERANZEN.

999,490
WEITER AUSSEN SCHLIESST ALS SILBERWEISSER LICHTSCHWACHER SAUM DIE SONNENKORONA AN.

999,491
IN DER CHROMOSPHAERE FINDET MAN HAUPTSAECHLICH WASSERSTOFF-, HELIUM- UND KALZIUMLINIEN, ABER AUCH SPEKTRALLINIEN ANDERER METALLE.

999,492
IM LICHTE DER KORONA SIND MEHRERE HELLE SPEKTRALLINIEN AUFGEFUNDEN WORDEN, DEREN ZUORDNUNG ZU BEKANNTEN ELEMENTEN LANGE ZEIT UNBEKANNT BLIEB.

999,494
ERST IM JAHRE 1941 GELANG ES B. EDLEN IN UPSALA DIESE SPEKTRALLINIEN IN GEEIGNETEN IRDISCHEN LICHTQUELLEN ZU ERHALTEN.

999,486
DIE HELLEN LINIEN DER DAMPFFOERMIGEN SONNENATMOSPHAERE KANN MAN IN DER SOGENANNTEN UMKEHRENDEN SCHICHT, EINER SCHMALEN DAMPFHUELLE OBERHALB DER AEUSSEREN SONNENBEGRENZUNG, DER PHOTOSPHAERE, FUER EINIGE WENIGE AUGENBLICKE BEOBACHTEN, WENN BEI EINER SONNENFINSTERNIS DER FORTSCHREITENDE MOND GERADE EBEN NOCH EINEN GANZ SCHMALEN RAND DER SONNENOBERFLAECHE AUF DER EINEN SEITE FREI LAESST (SOG. FLASHSPEKTRUM).

Fig. 1

German Standard Strings

```
  JOB PROOF G-TXT RETRIEVAL OF 30.JANUARY.'67
PAGE 1

0001 999,486,RST,011867
0002    *MAN* ** *KANN* *EN* *BEOBACHT* *N* *LINIE* *ATMOSPHAERE* *N*
0003 *SONNE* ** *EN* *DAMPFFOERMIG* ** *DER* ** *EN* *HELL* ** *DIE*
0004 *IN* *SCHICHT* *,* *HUELLE* *DAMPF* ** *OBERHALB* *BEGRENZUNG*
0005 *N* *SONNE* ** *EN* *AEUSSER* ** *DER* ** *,* *PHOTOSPHAERE* *DER*
0006 *,* *EN* *SCHMAL* ** *EINER* *EN* *END* *KEHR* *UM*(PFX) *EN*
0007 *SOGENANNT* ** *DER* ** *FUER* *E* *BLICK* *N* *AUGE* ** *E*
0008 *WENIG* *E* *EINIG* ** ** *WENN* *MOND* *E* *END* *SCHREIT* *FORT*
0009 ** *DER* ** *T* *LAESS* *FREI* *RAND* *OBERFLAECHE* *N* *SONNE* **
0010 *DER* ** *EN* *SCHMAL* *GANZ* ** *EINEN* *AUF*(PP) *SEITE* *EN*
0011 *EIN* ** *DER* ** *NOCH* *EBEN* *GERADE* ** *BEI* *FINSTERNIS* *N*
0012 *SONNE* ** *EINER* ** *(* *UM*(FLX) *SPEKTR* *FLASH* ** *SOG.* **
0013 *)* ** *,* ** *.*

0001 999,487,RST,011867
0002    *N* *LINIE* *UND* *,* *S* *WASSERSTOFF* *DES* *S* *HELIUM*
0003 *DES* *E* *METALL* *ER* *VIEL* ** ** *DIE* ** *EN* *TRET* *AUF*
0004 *HIER* ** ** *.*

0001 999,488,RST,011867
0002    *RING* *,* *ER* *BREIT* *N* *SEKUNDE* *BOGEN* ** *---* *10*
0003 *15* ** *ER* *ROT* ** *EIN* ** *T* *ERSCHEIN* *UM* *SONNE* *DIE*
0004 ** *WENN* *SCHEIBE* *MOND* ** *DIE* ** *T* *VERDECK* *SONNE*
0005 *DIE* *GANZ* ** ** *,* ** *.*

0001 999,489,RST,011867
0002    *DAS*(D) ** *IST* *CHROMOSPHAERE* *DIE* *MIT* *EN* *PROTUBERANZ*
0003 *DEN* ** ** *.*

0001 999,490,RST,011867
0002    *A* *KORON* *N* *SONNE* ** *DIE* ** *T* *SCHLIESS* *AN* *ALS*
0003 *SAUM* *ER* *LICHTSCHWACH* *ER* *SILBERWEISS* ** *AUSSEN* *ER*
0004 *WEIT* ** ** *.*

0001 999,491,RST,011867
0002    *MAN* ** *ET* *FIND* *, ABER AUCH* *N* *LINIE* *UND* *,* *-*
0003 *WASSERSTOFF* *-* *HELIUM* *KALZIUM* ** *HAUPTSAECHLICH* *N* *LINIE*
0004 *AL* *SPEKTR* *E* *METALL* *ER* *ANDER* ** ** *IN* *CHROMOSPHAERE*
0005 *DER* ** ** *.*

0001 999,492,RST,011867
0002    ** *SIND* *WORDEN* *GE* *EN* *FUNC* *AUF* *N* *LINIE* *AL*
0003 *SPEKTR* *E* *HELL* *E* *MEHRER* ** *I* *E* *LICHT* *A* *KORON*
0004 *DER* ** *M* ** ** *ZUORDNUNG* *ZU* *EN* *ELEMENT* *EN* *BEKANNT*
0005 ** ** *DEREN* ** *BLIEB* *BEKANNT* *UN* ** *ZEIT* *E* *LANG* **
0006 ** *,* *.*

0001 999,494,RST,011867
0002       *ES* ** *GELANG* *ZU*I *EN* *ERHALT* *N* *LINIE* *AL* *SPEKTR*
0003 *DIESE* *IN* *N* *QUELLE* *LICHT* ** *EN* *ISCH* *IRD* *EN* *GE* *EI
0004 *EIGN* ** ** ** *B. EDLEN* *IN* *UPSALA* ** *I* *E* *JAHR* *1941*
0005 *M* *ERST* ** ** *.*
```

Fig. 2

Figure 3-1

English Paraphrases of German Corpus in Surface Representation[19]

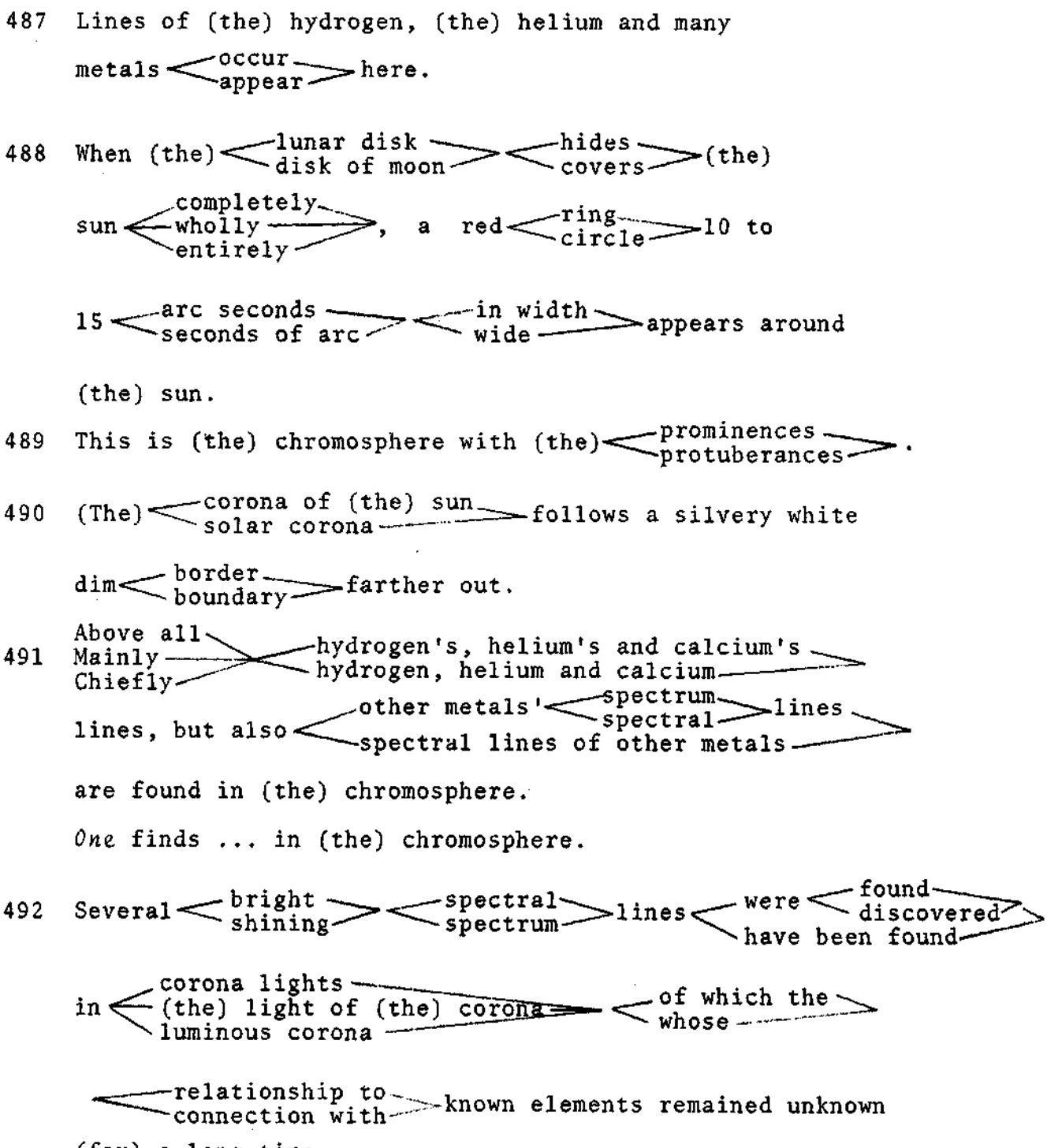
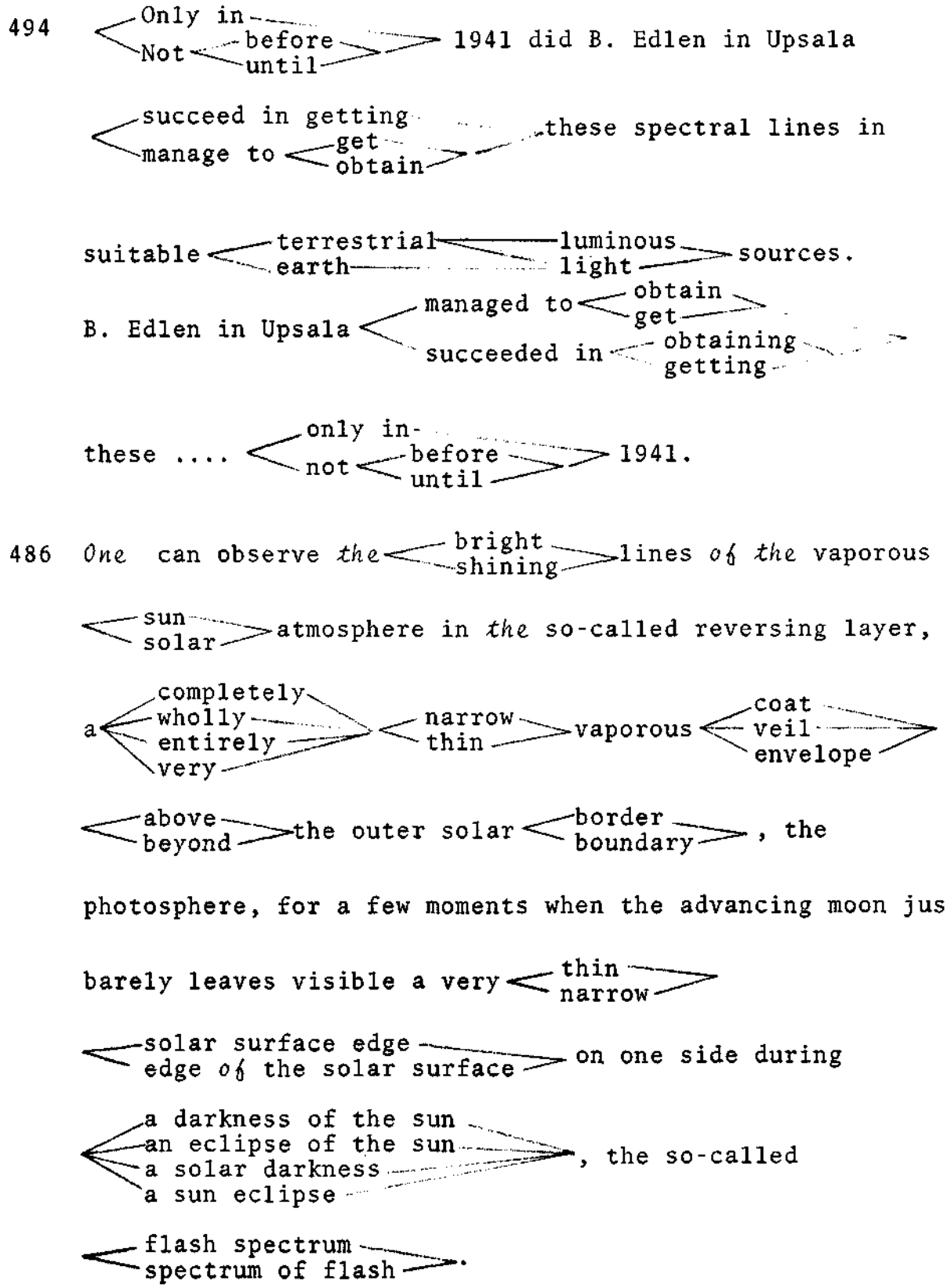


Figure 3-2


494
Only in
Not
before
until
1941 did B. Edlen in Upsala
succeed in getting
manage to
get
obtain
these spectral lines in
suitable
terrestrial
earth
luminous
light
sources.
B. Edlen in Upsala
managed to
obtain
get
succeeded in
obtaining
getting
these ....
only in
not
before
until
1941.
486 One can observe the
bright
shining
lines of the vaporous
sun
solar
atmosphere in the so-called reversing layer,
a
completely
wholly
entirely
very
narrow
thin
vaporous
coat
veil
envelope
above
beyond
the outer solar
border
boundary
, the
photosphere, for a few moments when the advancing moon just
barely leaves visible a very
thin
narrow
solar surface edge
edge of the solar surface
on one side during
a darkness of the sun
an eclipse of the sun
a solar darkness
a sun eclipse
, the so-called
flash spectrum
spectrum of flash
.

```
99487CC1     OF HYDROGEN, HELIUM, AND MANY S METAL ES LIN OCCUR HERE .

99487001     OF HYDROGEN, HELIUM, AND MANY S METAL ES LIN APPEAR HERE .

99487001     OF THE HYDROGEN, HELIUM, AND MANY S METAL ES LIN OCCUR HERE .

99487001     OF THE HYDROGEN, HELIUM, AND MANY S METAL ES LIN APPEAR HERE .

99487001     OF THE HYDROGEN, THE HELIUM, AND MANY S METAL ES LIN APPEAR
99487002   HERE .

994870C1     OF HYDROGEN, HELIUM, AND MANY S METAL ES LIN  OCCUR HERE ** *.*

99487001     OF THE HYDROGEN, HELIUM, AND MANY S METAL ES LIN OCCUR HERE *.*

99487001     OF HYDROGEN, HELIUM, AND MANY S METAL ES LIN *DIE*  OCCUR  HERE
99487002   ** ** *.*

994870C1     OF THE HYDROGEN, HELIUM, AND MANY S METAL ES LIN  APPEAR  HERE
99487002   ** ** *.*
```

Fig. 4-1

```
99488C01    A RED 10 TO 15 ARC S SECOND IN WIDTH E CIRCL S APPEAR AROUND
99488C02  SUN WHEN AR LUN DISK S COVER SUN LY WHOL , .

99488C01    A RED 10 TO 15 ARC S SECOND IN WIDTH E CIRCL S APPEAR AROUND
99488C02  SUN WHEN AR LUN DISK ES HID SUN LY WHOL , .

99488C01    A RED 10 TO 15 ARC S SECOND IN WIDTH E CIRCL S APPEAR AROUND
99488002  THE SUN WHEN AR LUN DISK S COVER SUN LY WHOL , .

99488C01    A RED 10 TO 15 ARC S SECOND IN WIDTH E CIRCL S APPEAR AROUND
99488C02  THE SUN WHEN AR LUN DISK ES HID SUN LY WHOL , .

99488C01    A RED 10 TO 15 ARC S SECOND IN WIDTH RING  S APPEAR AROUND THE
99488002  SUN WHEN AR LUN DISK S COVER SUN LY WHOL , ** *.*

99488001    RED 10 TO 15 ARC S SECOND IN WIDTH S RING *EIN*  S APPEAR
99488C02  AROUND THE SUN *WENN*  THE AR LUN DISK S COVER SUN LY WHOL *,* **
99488003  *.*

99488001    RED 10 TO 15 ARC S SECOND IN WIDTH S CIRCLE *EIN*  S APPEAR
99488002  AROUND SUN WHEN AR LUN DISK S COVER SUN ELY COMPLET , ** *.*

99488C01   *RING*  RED 10 TO 15 OF ARC S SECOND IN WIDTH ** *EIN*  S APPEAR
99488C02  AROUND THE SUN WHEN THE AR LUN DISK S COVER SUN LY WHOL , ** *.*

99488001   *RING* *,*  10 TO 15 OF ARC S SECOND E WID *ER* *ROT* **  A **
99488002  *T*  APPEAR *UM* *SONNE* *DIE* ** *WENN*  THE AR LUN DISK S COVER
99488003  THE SUN LY WHOL *,* ** *.*

99488001   *RING* *,*  10 TO 15 OF ARC S SECOND E WID  RED ** *EIN*  S
99488C02  APPEAR AROUND THE SUN WHEN AR LUN DISK S COVER SUN ELY ENTIR , **
99488C03  *.*

99488C01   *RING* *,* *ER*  WID  ARC S SECOND  TO  10  15 ** *ER* *ROT* **
99488002  A ** *T* *ERSCHEIN* *UM* *SONNE* *DIE* ** *WENN*  THE AR LUN DISK
99488003  S COVER SUN ELY COMPLET *,* ** *.*

99488C01   *RING* *,* *ER* *BREIT*  OF ARC SECOND *--*  10 *15*
99488C02  ** *ER* *ROT* ** *EIN*  S APPEAR AROUND SUN WHEN AR LUN DISK ES
99488003  HID SUN ELY COMPLET , ** *.*

99488C01   *RING* *,* *ER* *BREIT*  OF ARC SECOND *--*  10 *15*
99488C02  ** *ER* *ROT* ** *EIN*  S APPEAR AROUND SUN WHEN AR LUN DISK ES
99488C03  HID SUN ELY ENTIR , ** *.*

99488001   *RING* [illegible] *ER* *BREIT*  OF ARC SECOND *--* *10* *15* ** *ER*
99488002  *ROT* ** *EIN*  S APPEAR AROUND SUN *WENN*  OF MOON DISK ES HID
99488003  SUN ELY COMPLET *,* ** *.*

99488001   *RING* [illegible] *ER* *BREIT* *N* *SEKUNDE* *BOGEN* ** *--* *10* *15*
99488002  ** *ER* *ROT* ** *EIN*  S APPEAR AROUND SUN WHEN OF MOON DISK ES
99488003  HID SUN VERY , ** *.*
```

Fig. 4-2

```
99489001    THIS IS CHROMOSPHERE WITH S PROMINENCE .
99489001    THIS IS CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS THE CHROMOSPHERE WITH S PROMINENCE .
99489001    THIS IS THE CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS THE CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS THE CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS THE CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS THE CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS CHROMOSPHERE WITH S PROMINENCE *.*
99489001    THIS IS CHROMOSPHERE WITH S PROTUBERANCE *.*
99489001    THIS IS CHROMOSPHERE WITH THE S PROMINENCE .
99489001    THIS IS CHROMOSPHERE WITH THE S PROTUBERANCE .
99489001    THIS IS CHROMOSPHERE WITH THE S PROTUBERANCE .
99489001    THIS IS CHROMOSPHERE WITH THE S PROTUBERANCE .
99489001    THIS IS CHROMOSPHERE WITH THE S PROTUBERANCE .
99489001    THIS IS CHROMOSPHERE WITH THE S PROTUBERANCE .
99489001    THIS IS THE CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS THE CHROMOSPHERE WITH S PROTUBERANCE .
99489001    THIS IS THE CHROMOSPHERE WITH THE S PROMINENCE .
99489001    THIS IS THE CHROMOSPHERE WITH THE S PROTUBERANCE .
99489001    THIS IS THE CHROMOSPHERE WITH THE S PROTUBERANCE .
```

Fig. 4-3

```
99490001    AR SUL CORONA S FOLLOW  AS A SILVERY E WHIT DIM BOUNDARY
99490002  FARTHER OUT .

99490001    THE AR SOL CORONA S FOLLOW  AS A SILVERY E WHIT DIM BOUNDARY
99490002  FARTHER OUT .

99490001    AR SOL CORONA S FOLLOW  AS A SILVERY E WHIT DIM BOUNDARY
99490002  FARTHER OUT *.*

99490001    THE AR SOL CORONA S FOLLOW  AS A SILVERY E WHIT DIM BOUNDARY
99490002  FARTHER OUT *.*

99490001    AR SOL CORONA  S FOLLOW  AS A SILVERY E WHIT DIM BORDER FARTHER
99490002  OUT ** *.*

99490001    OF THE SUN CORONA  S FOLLOW   AS A SILVERY E WHIT DIM BORDER
99490002  FARTHER OUT ** *.*

99490001    OF SUN CORONA S FOLLOW  AS A SILVERY E WHIT DIM BOUNDARY
99490002  FARTHER OUT *.*
```

Fig. 4-4

```
99491CC1    ARE FOUND LY CHIEF HYDROGEN, HELIUM, AND CALCIUM ES LIN, BUT
99491CC2  ALSO OTHER S' METAL AL SPECTR ES LIN IN CHROMOSPHERE .

99491CC1    ARE FOUND LY MAIN HYDROGEN, HELIUM, AND CALCIUM ES LIN, BUT
99491CC2  ALSO OTHER S' METAL AL SPECTR ES LIN IN CHROMOSPHERE .

99491CC1    ARE FOUND LY CHIEF HYDROGEN, HELIUM, AND CALCIUM ES LIN, BUT
99491CC2  ALSO OTHER S' METAL AL SPECTR ES LIN IN THE CHROMOSPHERE .

99491CC1    ARE FOUND LY MAIN HYDROGEN, HELIUM, AND CALCIUM ES LIN, BUT
99491CC2  ALSO OTHER S' METAL AL SPECTR ES LIN IN THE CHROMOSPHERE .

99491CC1    ARE FOUND LY CHIEF HYDROGEN, HELIUM, AND CALCIUM ES LIN, BUT
99491CC2  ALSO OTHER S' METAL AL SPECTR ES LIN IN CHROMOSPHERE *.*

99491CC1    ARE FOUND LY MAIN HYDROGEN, HELIUM, AND CALCIUM ES LIN, BUT
99491CC2  ALSO OTHER S' METAL AL SPECTR ES LIN IN CHROMOSPHERE *.*

99491CC1   *MAN*  S FIND LY MAIN HYDROGEN, HELIUM, AND CALCIUM ES LIN, BUT
99491CC2  ALSO OTHER S' METAL AL SPECTR ES LIN IN CHROMOSPHERE **.**

99491CC1   *MAN*  S FIND LY CHIEF HYDROGEN, HELIUM, AND CALCIUM ES LIN, BUT
99491CC2  ALSO OTHER S' METAL AL SPECTR ES LIN  IN CHROMOSPHERE ** ** *.*

99491CC1   *MAN*  S FIND  BUT ALSO  ES LIN  AND  HYDROGEN, HELIUM  S
99491CC2  CALCIUM  LY MAIN  OF OTHER S METAL AL SPECTR ES LIN  IN
99491CC3  CHROMOSPHERE ** *.*

99491CC1   *MAN*  S FIND  BUT ALSO  ES LIN  AND *,*  S' HYDROGEN  S'
99491CC2  HELIUM  S' CALCIUM  LY MAIN  OTHER S' METAL AL SPECTR ES LIN  IN
99491CC3  CHROMOSPHERE ** *.*

99491CC1   *MAN* ** *ET* *FIND*  BUT ALSO  ABOVE ALL HYDROGEN, HELIUM, AND
99491CC2  CALCIUM ES LIN  AL SPECTR E LIN  OTHER S METAL **  IN
99491CC3  CHROMOSPHERE ** ** *.*

99491CC1   *MAN* ** *ET* *FIND*  BUT ALSO *N* *LINIE*  AND  ( *-*
99491CC2  *WASSERSTOFF*  S HELIUM  S CALCIUM *HAUPTSAECHLICH*  OTHER S'
99491CC3  METAL UM SPECTR ES LIN  IN THE CHROMOSPHERE ** *.*
```

Fig. 4-5

```
99492001    WERE ED DISCOVER SEVERAL ING SHIN AL SPECTR ES LIN *I* CORONA
99492002  S LIGHT *M* ** **  WHOSE RELATIONSHIP TO N KNOW S ELEMENT ED
99492003  REMAIN UN N KNOW FOR A LONG E TIM , *.*

99492001    WERE ED DISCOVER SEVERAL ING SHIN AL SPECTR ES LIN *I* CORONA
99492002  S LIGHT *M* ** **  WHOSE CONNECTION WITH N KNOW S ELEMENT ED
99492003  REMAIN UN N KNOW FOR A LONG E TIM , *.*

99492001    WERE ED DISCOVER SEVERAL ING SHIN AL SPECTR ES LIN *I* CORONA
99492002  S LIGHT *M* ** **  OF WHICH THE RELATIONSHIP TO N KNOW S ELEMENT
99492003  ED REMAIN UN N KNOW FOR A LONG E TIM , *.*

99492001    WERE ED DISCOVER SEVERAL ING SHIN AL SPECTR ES LIN *I* CORONA
99492002  S LIGHT *M* ** **  OF WHICH THE CONNECTION WITH N KNOW S ELEMENT
99492003  ED REMAIN UN N KNOW FOR A LONG E TIM , *.*

99492001    WERE FOUND SEVERAL ING SHIN AL SPECTR ES LIN  IN  OUS LUMIN
99492002  CORONA ** *M* ** **  WHOSE RELATIONSHIP TO N KNOW S ELEMENT  ED
99492003  REMAIN UN N KNOW FOR A LONG E TIM ** *,* *.*

99492001    HAVE BEEN FOUND SEVERAL ING SHIN AL SPECTR ES LIN  IN  CORONA S
99492002  LIGHT *M* ** **  WHOSE CONNECTION WITH N KNOW S ELEMENT  ED
99492003  REMAIN UN N KNOW FOR A LONG E TIM ** *,* *.*

99492001    HAVE BEEN FOUND SEVERAL ING SHIN AL SPECTR ES LIN  IN  CORONA S
99492002  LIGHT *M* ** **  OF WHICH THE RELATIONSHIP TO N KNOW S ELEMENT
99492003  ED REMAIN UN N KNOW FOR A LONG E TIM ** *,* *.*

99492001    HAVE BEEN FOUND SEVERAL ING SHIN AL SPECTR ES LIN  IN  CORONA S
99492002  LIGHT *M* ** **  OF WHICH THE CONNECTION WITH N KNOW S ELEMENT
99492003  ED REMAIN UN N KNOW FOR A LONG E TIM ** *,* *.*


99492001    WERE ED DISCOVER SEVERAL BRIGHT AL SPECTR ES LIN IN OF CORONA
99492002  LIGHT **  CONNECTION WITH N KNOW S ELEMENT  WHOSE  EC REMAIN  N
99492003  KNOW *UN* **  A LONG E TIM ** *,* *.*

99492001    WERE ED DISCOVER SEVERAL BRIGHT AL SPECTR ES LIN IN OF CORONA
99492002  LIGHT **  RELATIONSHIP TO N KNOW S ELEMENT  WHOSE  ED REMAIN  N
99492003  KNOW [redacted] **  A LONG E TIM ** [redacted]*.*

99492001    [redacted]ERE ED DISCOVER  ES LIN  UM SPECTR  BRIGHT  SEVERAL  IN  OF
99492002  CORONA LIGHT ** **  RELATIONSHIP TO  ELEMENT  N KNOW **  WHOSE
99492003  ED REMAIN  N KNOW *UN* **  TIM  LONG ** *,* *.*

99492001    WERE ED DISCOVER SEVERAL BRIGHT AL SPECTR ES LIN IN THE OF
99492002  CORONA LIGHT **  RELATIONSHIP TO  N KNOW S ELEMENT **  WHOSE **
99492003  *BLIEB*  N KNOW *UN* **  FOR A LONG E TIM ** *,* *.*

99492001    WERE ED DISCOVER SEVERAL BRIGHT AL SPECTR ES LIN IN THE OF
99492002  CORONA LIGHT **  CONNECTION WITH  N KNOW S ELEMENT **  WHOSE **
99492003  *BLIEB*  N KNOW *UN* **  FOR A LONG E TIM ** *,* *.*

99492001    WERE ED DISCOVER SEVERAL BRIGHT AL SPECTR ES LIN IN OF THE
99492002  CORONA LIGHT **  CONNECTION WITH  N KNOW S ELEMENT **  WHOSE **
99492003  *BLIEB*  N KNOW *UN* **  FOR A LONG E TIM ** [redacted]*.*
```

Fig. 4-6

```
99494001    B. EDLEN DID MANAG TO GET THESE AL SPECTR ES LIN IN SUITABLE
99494002  IAL TERRESTR OUS LUMIN S SOURCE IN UPSALA NOT UNTIL 1941 .

99494001    B. EDLEN DID MANAG TO GET THESE AL SPECTR ES LIN IN SUITABLE
99494002  IAL TERRESTR OUS LUMIN S SOURCE IN UPSALA NOT BEFORE 1941 .

99494001    B. EDLEN DID MANAG TO OBTAIN THESE AL SPECTR ES LIN IN SUITABLE
99494002  IAL TERRESTR OUS LUMIN S SOURCE IN UPSALA NOT UNTIL 1941 .

99494001    B. EDLEN DID MANAG TO OBTAIN THESE AL SPECTR ES LIN IN SUITABLE
99494002  IAL TERRESTR OUS LUMIN S SOURCE IN UPSALA NOT BEFORE 1941 .

99494001    B. EDLEN DID MANAG TO GET THESE AL SPECTR ES LIN IN SUITABLE
99494002  IAL TERRESTR OUS LUMIN S SOURCE IN UPSALA ONLY IN 1941 .

99494001    B. EDLEN DID MANAG TO GET THESE AL SPECTR ES LIN IN SUITABLE
99494002  IAL TERRESTR OUS LUMIN S SOURCE IN UPSALA ONLY IN 1941 .

99494001    B. EDLEN DID SUCCEED IN TING GET THESE AL SPECTR ES LIN IN
99494002  SUITABLE IAL TERRESTR OUS LUMIN S SOURCE IN UPSALA NOT UNTIL 1941
99494003

99494001    B. EDLEN DID SUCCEED IN TING GET THESE AL SPECTR ES LIN IN
99494002  SUITABLE IAL TERRESTR OUS LUMIN S SOURCE IN UPSALA NOT BEFORE
99494003  1941 .
```

```
99494001    ED SUCCEED IN  ING OBTAIN  ES LIN  UM SPECTR  OBSERV  IN
99494002  SOURCE  LIGHT  EARTH  SUITABLE ** **  B. EDLEN  IN  UPSALA **
99494003  ONLY IN 1941 ** *.*
```

```
99494001    ED MANAG TO  ING OBTAIN  AL SPECTR ES LIN  OBSERV  IN SUITABLE
99494002  IAL TERRESTR LIGHT S SOURCE **  B. EDLEN  IN UPSALA   ONLY IN
99494003  1941 ** *.*
```

Fig. 4-7

```
PATHS 1,1..1,2..2,1..2,2..3,1..3,2.....12,1..12,2

99486C01    *MAN* **  CAN  E OBSERV  ES LIN  AR SOL S ATMOSPHERE *EN*  OUS
99486C02   VAPOR ** *DER* **  ING SHIN *DIE*  IN  LAYER *,*  OUS VAPOR S
99486C03   ENVELOPE  BEYOND THE OUTER AR SOL BOUNDARY **  , PHOTOSPHERE,
99486C04   THIN  A  ING REVERS  SO-CALLED *DER* **  FOR A FEW S MOMENT
99486C05   WHEN ING ADVANC MOON ES LEAV E VISIBL A VERY THIN AR SOL SURFACE
99486C06   EDGE ON ONE E SID JUST LY BARE DURING A AR SOL DARKNESS ,
99486C07   SO-CALLED FLASH UM SPECTR, , ** *.*

99486CC1    *MAN* **  CAN  E OBSERV  ES LIN  AR SOL S ATMOSPHERE *EN*  OUS
99486CC2   VAPOR ** *DER* **  ING SHIN *DIE*  IN  S' LAYER *,*  OUS VAPOR S
99486CC3   ENVELOPE  ABOVE THE OUTER AR SOL BOUNDARY **  , PHOTOSPHERE
99486CC4   NARROW  AN  ING REVERS  SO-CALLED *DER* **  FOR A FEW S MOMENT
99486CC5   WHEN ING ADVANC MOON ES LEAV E VISIBL A VERY THIN AR SOL SURFACE
99486CC6   EDGE ON ONE E SID JUST LY BARE DURING A AR SOL DARKNESS ,
99486CC7   SO-CALLED FLASH UM SPECTR , ** *.*

99486001    *MAN* **  CAN  E OBSERV  ES LIN  AR SOL S ATMOSPHERE [redacted]  OUS
99486002   VAPOR ** *DER* **  BRIGHT *DIE*  IN  LAYER *,*  OUS VAPOR S
99486003   ENVELOPE  BEYOND THE OUTER AR SOL BOUNDARY **  , PHOTOSPHERE,
99486004   THIN  A  ING REVERS  SO-CALLED *DER* **  FOR A FEW S MOMENT
99486005   *WENN*  ING ADVANC MOON  ES LEAV E VISIBL A VERY THIN OF AR SOL
99486006   SURFACE EDGE  ON* SID  ONE  JUST LY BARE  DURING A AR SOL
99486007   DARKNESS  , SO-CALLED OF FLASH UM SPECTR, ** *,* ** *.*

99486001    *MAN* **  IS *EN*  OBSERV *N* *LINIE*  ATMOSPHERE *N*  SOL **
99486002   *[redacted]  OUS VAPOR ** *DER* ** *EN*  SHIN ** *DIE* *IN*  S LAYER  ,
99486003   ENVELOPE  VAPOR **  BEYOND  OUTER AR SOL BOUNDARY *DER* **  ,
99486004   PHOTOSPHERE *,*  THIN *EINER* *EN* *END*  REVERS *EN*  SO-CALLED
99486005   *** *DER* **  FOR A FEW S MOMENT ** *WENN*  ING ADVANC MOON
99486006   *DER*  ES LEAV E VISIBL  VERY THIN OF AR SOL SURFACE EDGE
99486007   *EINEN*  ON *SEITE*  ONE  JUST LY BARE **  DURING A AR SOL
99486008   DARKNESS **  , THE SO-CALLED OF FLASH UM SPECTR, ** *,* ** *.*

99486CC1    *MAN* ** *KANN* *EN* *BEOBACHT* *N* *LINIE*  SUN S ATMOSPHERE
99486CC2   *EN* *DAMPFFOERMIG* ** *DER* ** *EN* *HELL* ** *DIE* *IN*
99486CC3   *SCHICHT* *,*  OUS VAPOR VEIL *OBERHALB*  OUTER AR SOL BORDER
99486CC4   *UER* ** [redacted] *EN* *SCHMAL* ** *EINER*  *EN*
99486CC5   SO-CALLED ** *DER* **  FOR A FEW S MOMENT ** *WENN*  LUN *E*
99486CC6   *END*  ADVANC ** *CER*  ES LEAV E VISIBL A ELY ENTIR NARROW OF AR
99486CC7   [redacted] *AUF*(PP) *SEITE* *EN*  ONE ** *DER* **  JUST
99486CC8   LY BARE  DURING AN OF SUN ECLIPSE *(*  SO-CALLED OF FLASH UM
99486CC9   SPECTR *)* ** *,* ** *.*

99486001    *MAN* ** *KANN* *EN* *BEOBACHT* *N* *LINIE* *ATMOSPHAERE* *N* *S-
99486002   ONNE* ** [redacted] *DAMPFFOERMIG* ** *DER* ** *EN* *HELL* **
99486003   *DIE* *IN* *SCHICHT* *,* *HUELLE* *DAMPF* ** *OBERHALB*  AR SOL
99486004   BOUNDARY *EN* *AEUSSER* ** *DER* ** *,* *PHOTOSPHAERE* *DER*
99486005   *,* *EN* *SCHMAL* ** *EINER* *EN* *END*  *EN* *SOGENANNT* **
99486006   *DER* ** *FUER* *E*  MOMENT  A FEW ** *WENN* *MOND* *E*
99486007   *END* *SCHREIT* *FORT* ** *DER* ** *T* *LAESS* *FREI*  OF AR SOL
99486008   SURFACE EDGE  THIN  WHOL ** *EINEN* *AUF*(PP) *SEITE* *EN* *EIN*
99486009    *BEI*  AR SOL ECLIPSE *EINER* **  ,  OF FLASH UM SPECTR
99486010   SO-CALLED ** *)* ** *,* ** *.*
```

Fig. 4-8

```
PATHS 1,0,0,1-2,0,0,1---12,0,0,1-1,0,0,2-2,0,0,2---12,0,0,2

99486001    *MAN* **  IS  E OBSERV  ES LIN  ATMOSPHERE  SUN [redacted] OUS VAPOR
99486002   ** *DER* **  BRIGHT *DIE*  IN  LAYER  ,  ENVELOPE  OUS VAPOR
99486003   BEYOND  BORDER  SUN  OUTER *DER* **  , PHOTOSPHERE,  THIN  A  ING
99486004   REVERS  SO-CALLED *DER* **   FOR A FEW S MOMENT *WENN*  THE ING
99486005   ADVANC MOON  ES LEAV E VISIBL  EDGE  SURFACE  SUN *DER* **  THIN
99486006   COMPLET **  A  ON' SID  ONE  JUST LY BARE **  DURING  ECLIPSE
99486007   SUN  A **  , THE SO-CALLED OF FLASH UM SPECTR, ** *,* ** *.*

99486001    *MAN* ** *KANN* *EN*  OBSERV *N*  LIN  ATMOSPHERE *N*  SUN **
99486002   VAPOR ** *DER* **  BRIGHT *DIE*  IN  LAYER  (  COAT  OUS VAPOR
99486003   ABOVE  BOUNDARY  THE SUN  OUTER *DER* **  , THE PHOTOSPHERE,
99486004   NARROW  AN  ING REVERS  SO-CALLED *DER* **   FOR A FEW S MOMENT
99486005   *WENN*  ING ADVANC MOON  ES LEAV E VISIBL  EDGE  SURFACE  THE SUN
99486006   *DER* **  NARROW  ENTIR **  AN  ON  SID  ONE  JUST LY BARE **
99486007   DURING  DARKNESS  THE SUN  AN **  , THE SO-CALLED OF THE FLASH UM
99486008   SPECTR, ** *,* ** *.*


99486001    *MAN* ** *KANN* *EN* *BEOBACHT* *N* *LINIE* *ATMOSPHAERE*
99486002   *N* *SONNE* ** *EN* *DAMPFFOERMIG* ** *DER* ** *EN* *HELL* **
99486003   *DIE* *IN* *SCHICHT* *,*  OUS VAPOR COAT *UBERHALB*  AR SOL S
99486004   BORDER *EN* *AEUSSER* ** *DER* ** *,*  PHOTOSPHERE *,*
99486005   *EN* *SCHMAL* ** *EINER*   *EN* *SOGENANNT* ** *DER* ** *FUER*
99486006   *E* *BLICK* *N* *AUGE* **  *E* *WENIG* *E* *EINIG* ** **
99486007   *WENN*  THE ING ADVANC MOON ES LEAV E VISIBL A VERY THIN AR SOL
99486008   SURFACE EDGE ON ONE E SID JUST LY BARE DURING A AR SOL DARKNESS ,
99486009   THE SO-CALLED FLASH UM SPECTR, *,* ** *.*
```

Fig. 4-9

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99490001    AR SOL CORONA S FOLLOW  AS A SILVERY E WHIT DIM BOUNDARY
99490002  FARTHER OUT .

99490001    AR SOL CORONA S FOLLOW  AS A SILVERY WHITE DIM BOUNDARY FARTHER
99490002  OUT .

99490001    AR SOL CORONA S FOLLOW AS A SILVERY E WHIT DIM BOUNDARY FARTHER
99490002  OUT .

99490001    AR SOL CORONA S FOLLOW AS A SILVERY WHITE DIM BOUNDARY FARTHER
99490002  OUT .

99490001    SOLAR CORONA S FOLLOW  AS A SILVERY E WHIT DIM BOUNDARY FARTHER
99490002  OUT .

99490001    SOLAR CORONA S FOLLOW  AS A SILVERY WHITE DIM BOUNDARY FARTHER
99490002  OUT .

99490001    AR SOL CORONA S FOLLOW  AS A SILVERY E WHIT DIM BOUNDARY
99490002  FARTHER OUT *.*

99490001    AR SOL CORONA S FOLLOW  AS A SILVERY WHITE DIM BOUNDARY FARTHER
99490002  OUT *.*

99490001    AR SOL CORONA S FOLLOW AS A SILVERY E WHIT DIM BOUNDARY FARTHER
99490002  OUT *.*

99490001    AR SOL CORONA S FOLLOW AS A SILVERY WHITE DIM BOUNDARY FARTHER
99490002  OUT *.*

99490001    SOLAR CORONA S FOLLOW  AS A SILVERY E WHIT DIM BOUNDARY FARTHER
99490002  OUT *.*

99490001    SOLAR CORONA S FOLLOW  AS A SILVERY WHITE DIM BOUNDARY FARTHER
```

Fig. 5-1

```
99492002   LIGHTS *M* ** **  WHOSE RELATIONSHIP TO N KNOW S ELEMENT ED
99492003   REMAIN UN N KNOW FOR A LONG E TIM , *.*

99492001     SEVERAL ING SHIN AL SPECTR LINES WERE ED DISCOVER *I*  CORONA
99492002   LIGHTS *M* ** **  WHOSE RELATIONSHIP TO N KNOW S ELEMENT ED
99492003   REMAIN UN N KNOW FOR A LONG TIME , *.*

99492001     SEVERAL ING SHIN AL SPECTR LINES WERE ED DISCOVER *I*  CORONA
99492002   LIGHTS *M* ** **  WHOSE CONNECTION WITH N KNOW ELEMENTS ED REMAIN
99492003   UN N KNOW FOR A LONG E TIM , *.*

99492001     WERE ED DISCOVER SEVERAL ING SHIN SPECTRAL ES LIN *I*  CORONA
99492002   LIGHTS *M* ** **  WHOSE CONNECTION WITH N KNOW ELEMENTS ED REMAIN
99492003   UN N KNOW FOR A LONG TIME , *.*

99492001     SEVERAL ING SHIN SPECTRAL ES LIN WERE FOUND  IN  OUS LUMIN
99492002   CORONA ** *M* ** **  WHOSE RELATIONSHIP TO N KNOW ELEMENTS  ED
99492003   REMAIN UN N KNOW FOR A LONG E TIM ** *,* *.*

99492001     SEVERAL ING SHIN SPECTRAL ES LIN HAVE BEEN FOUND  IN  CORONA S
99492002   LIGHT *M* ** **  WHOSE RELATIONSHIP TO N KNOW S ELEMENT  ED
99492003   REMAIN UN N KNOW FOR A LONG TIME ** *,* *.*

99492001     SEVERAL ING SHIN SPECTRAL LINES WERE FOUND  IN  CORONA LIGHTS
99492002   *M* ** **  WHOSE CONNECTION WITH N KNOW ELEMENTS  ED REMAIN UN N
99492003   KNOW FOR A LONG TIME ** *,* *.*

99492001     SEVERAL ING SHIN SPECTRAL LINES HAVE BEEN FOUND  IN  CORONA
99492002   LIGHTS *M* ** **  WHOSE CONNECTION WITH N KNOW S ELEMENT  ED
99492003   REMAIN UN N KNOW FOR A LONG TIME ** *,* *.*

99492001     SEVERAL ING SHIN AL SPECTR ES LIN WERE FOUND  IN  CORONA LIGHTS
99492002   *M* ** **  OF WHICH THE RELATIONSHIP TO N KNOW ELEMENTS  ED
99492003   REMAIN UN N KNOW FOR A LONG TIME ** *,* *.*

99492001     SEVERAL ING SHIN AL SPECTR ES LIN HAVE BEEN FOUND  IN  CORONA
99492002   LIGHTS *M* ** **  OF WHICH THE RELATIONSHIP TO N KNOW S ELEMENT
99492003   ED REMAIN UN N KNOW FOR A LONG TIME ** *,* *.*

99492001     WERE ED DISCOVER  ING SHIN SPECTRAL ES LIN *E*  SEVERAL ** *I*
99492002   S' LIGHT  CORONA *DER* ** *M* ** **  RELATIONSHIP TO N KNOW
99492003   ELEMENTS  WHOSE  ED REMAIN UN N KNOW  A LONG E TIM ** *,* *.*

99492001     WERE FOUND SEVERAL ING SHIN SPECTRAL ES LIN *I* *E* *LICHT*
99492002   CORONA ** *M* ** **  RELATIONSHIP TO N KNOW S ELEMENT *DEREN*  ED
99492003   REMAIN UN N KNOW  A LONG TIME ** *,* *.*

99492001     WERE FOUND SEVERAL ING SHIN SPECTRAL LINES *I* *E* *LICHT*
99492002   CORONA ** *M* ** **  CONNECTION WITH N KNOW ELEMENTS *DEREN*  ED
99492003   REMAIN UN N KNOW  A LONG TIME ** *,* *.*
```

Fig. 5-2

```
99494001    B. EDLEN DID MANAG TO GET THESE SPECTRAL ES LIN IN SUITABLE
99494002  TERRESTRIAL OUS LUMIN S SOURCE IN UPSALA NOT UNTIL 1941 .

99494001    B. EDLEN DID MANAG TO GET THESE SPECTRAL ES LIN IN SUITABLE
99494002  TERRESTRIAL OUS LUMIN S SOURCE IN UPSALA NOT BEFORE 1941 .

99494001    B. EDLEN DID MANAG TO GET THESE SPECTRAL ES LIN IN SUITABLE
```

Fig. 5-3

```
99494002  TERRESTRIAL OUS LUMIN SOURCES IN UPSALA NOT UNTIL 1941 .

99494001    B. EDLEN DID MANAG TO GET THESE SPECTRAL ES LIN IN SUITABLE
99494002  TERRESTRIAL OUS LUMIN SOURCES IN UPSALA NOT BEFORE 1941 .

99494001    B. EDLEN DID MANAG TO GET THESE SPECTRAL ES LIN IN SUITABLE IAL
99494002  TERRESTR OUS LUMIN S SOURCE IN UPSALA NOT UNTIL 1941 .

99494001    B. EDLEN DID MANAG TO GET THESE SPECTRAL ES LIN IN SUITABLE IAL
99494002  TERRESTR OUS LUMIN S SOURCE IN UPSALA NOT BEFORE 1941 .

99494001    B. EDLEN DID SUCCEED IN TING GET THESE SPECTRAL ES LIN IN
99494002  SUITABLE TERRESTRIAL OUS LUMIN S SOURCE IN UPSALA NOT UNTIL 1941
99494003  .

99494001    B. EDLEN DID SUCCEED IN TING GET THESE SPECTRAL ES LIN IN
99494002  SUITABLE TERRESTRIAL OUS LUMIN S SOURCE IN UPSALA NOT BEFORE 1941
99494003  .

99494001    B. EDLEN DID SUCCEED IN TING GET THESE SPECTRAL ES LIN IN
99494002  SUITABLE TERRESTRIAL OUS LUMIN SOURCES IN UPSALA NOT UNTIL 1941

99494001    B. EDLEN DID SUCCEED IN TING GET THESE SPECTRAL ES LIN IN
99494002  SUITABLE TERRESTRIAL OUS LUMIN SOURCES IN UPSALA NOT BEFORE 1941
99494003  .

99494001    B. EDLEN DID SUCCEED IN TING GET THESE SPECTRAL ES LIN IN
99494002  SUITABLE IAL TERRESTR OUS LUMIN S SOURCE IN UPSALA NOT UNTIL 1941
99494003  .

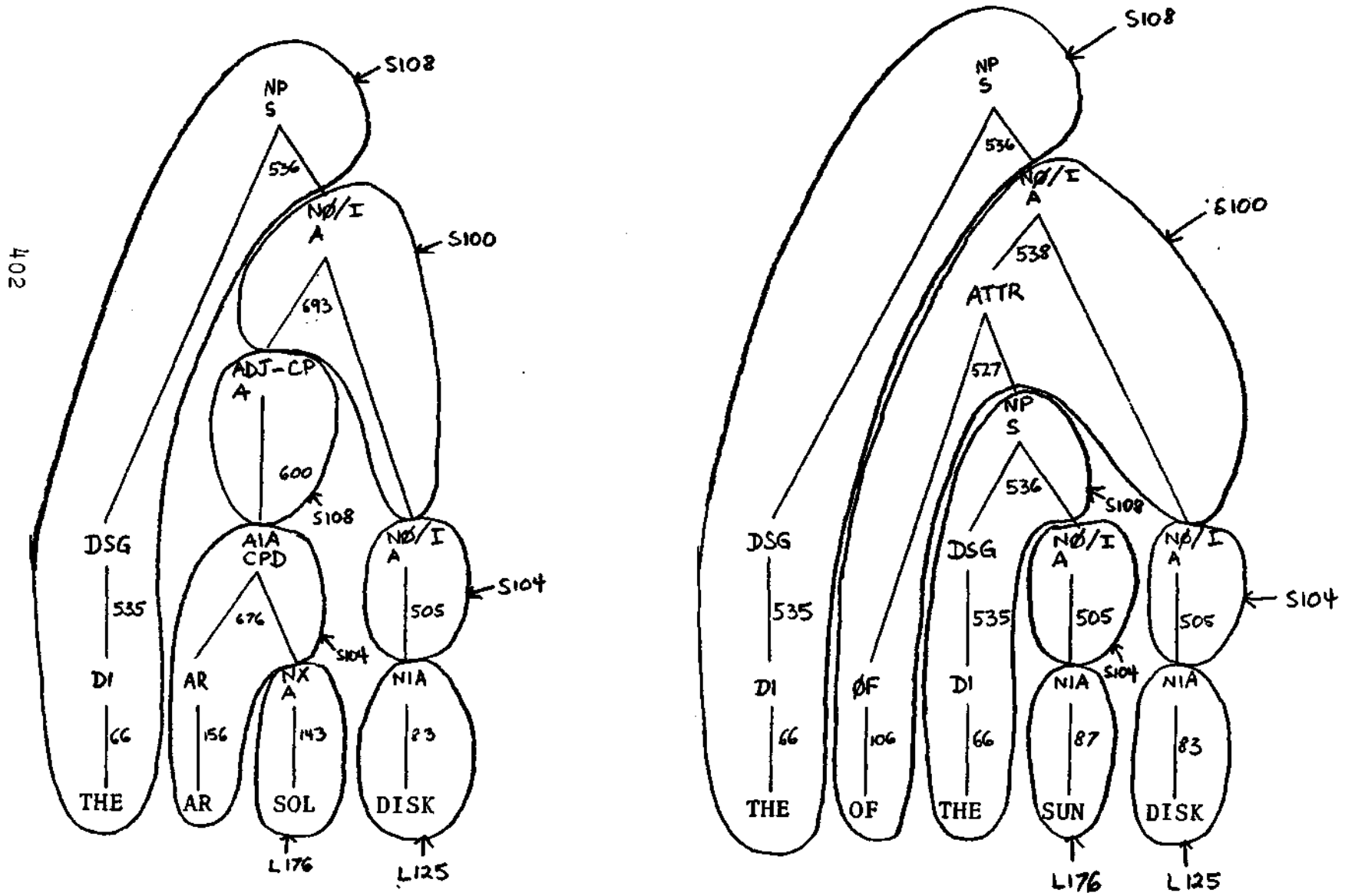
99494001    B. EDLEN DID SUCCEED IN TING GET THESE SPECTRAL ES LIN IN
99494002  SUITABLE IAL TERRESTR OUS LUMIN S SOURCE IN UPSALA NOT BEFORE
99494003  1941 .

99494001    B. EDLEN DID MANAG TO GET THESE SPECTRAL ES LIN IN SUITABLE
99494002  TERRESTRIAL OUS LUMIN S SOURCE IN UPSALA NOT UNTIL 1941 *.*

99494001    B. EDLEN DID MANAG TO GET THESE SPECTRAL ES LIN IN SUITABLE
99494002  TERRESTRIAL OUS LUMIN S SOURCE IN UPSALA NOT BEFORE 1941 *.*

99494001    B. EDLEN DID MANAG TO GET THESE SPECTRAL ES LIN IN SUITABLE
99494002  TERRESTRIAL OUS LUMIN SOURCES IN UPSALA NOT UNTIL 1941 *.*
```

Fig. 6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NØ/I
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S100
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S108
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CPD
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S104
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Figure 7-1

486 BEOBACHTEN:

1.✓ SBJ +HU ____ OBJ +ACC — observe, watch

Ex: Mark beobachtete Sylvia = Mark watched Sylvia.

2. SBJ +HU ____ OBJ +ACC +AB an OBJ +DAT +HU — observe in sb., notice in sb.

Ex: Mark beobachtete Zeichen von Triumph an Sylvia = Mark noticed signs of triumph in Sylvia.

3. SBJ +HU ____ ADV +MAN — observe

Ex: Mark beobachtet gut = Mark observes well.

4.✓ SBJ +HU ____ OBJ +ACC +AB — follow, obey, observe, respect, comply with

Ex: Die Roemer beobachteten das Gesetz = The Romans observed the laws.

FREILASSEN:

1.✓ SBJ +HU ____ OBJ +ACC +HU — free, set free, liberate

Ex: Mark liess Sylvia frei = Mark set Sylvia free.

2.✓ SBJ +HU ____ OBJ +ACC -HU — leave blank, leave open leave vacant, leave visible 20

Ex: Mark liess eine Zeile frei = Mark left a line blank.

487 AUFTRETEN:

1. SBJ +HU ____ OBJ +ACC +PO -AN — kick open

Ex: Mark trat die Tuer auf = Mark kicked the door open

2.✓ SBJ +AN ____ — step, tread, walk

Figure 7-2

Ex: Mark trat leise auf = Mark trod softly.

3. SBJ +HU ____ gegen OBJ +ACC — come up against, rise against, oppose

Ex: Die Griechen traten gegen die Tuerken auf = The Greeks rose against the Turks.

4. SBJ +HU ____ fuer OBJ +ACC — stand up for

Ex: Mark trat fuer Sylvia auf = Mark stood up for Sylvia.

5. SBJ +HU ____ vor OBJ +DAT +HU — perform before

Ex: Mark trat vor dem Koenig auf = Mark performed before the king.

6. SBJ +HU ____ als CMPL +NOM — figure as, pose as

Ex: Mark trat als Koenig auf = Mark posed as a king.

7. SBJ +AN ____ wie CMPL +NOM — behave like, act like

Ex: Mark trat auf wie ein Fuerst = Mark behaved like a duke.

8.✓ SBJ +AB ____ — occur, happen, arise, result, ensue, appear

Ex: Ein Fall von Cholera war aufgetreten = A case of cholera had occurred.

9.✓ SBJ +HU ____ — appear, perform, enter

Ex: Mark trat in einem Stueck auf = Mark appeared in a play.

488 ERSCHEINEN:

1.✓ SBJ ____ — appear, emerge

Ex: Ein Wagen erschien = A car appeared.

Figure 7-3

2. SBJ +HU ____ OBJ +DAT +HU — appear to sb.

Ex: Der Geist war Mark erschienen = The ghost had appeared to Mark.

3. SBJ ____ OBJ +DAT +HU ADJ — seem, appear, look

Ex: Die Loesung erschien Mark gut = The solution looked good to Mark.

BREIT:

1.✓ ____ ADV +MEAS — wide, in width

Ex: drei Meter breit = three meters wide

2. N +PO ____ — broad, wide, spacious, large, vast

Ex: ein breites Gesicht = a broad face

3. N +AB ____ — extensive

Ex: eine breite Darstellung = an extensive description

490 ANSCHLIESSEN:

1. SBJ ____ OBJ +ACC -AB — chain, connect, fasten with a lock

Ex: Mark schloss das Fahrrad an = Mark fastened the bike with a lock.

2. SBJ +HU ____ OBJ +ACC +AB — add

Ex: Mark schloss eine Bemerkung an = Mark added a remark.

3. SBJ ____ OBJ +ACC -AB an OBJ +ACC -AB — chain to, connect to, join to, link up with

Figure 7-4

Ex: Mark schloss das Fahrrad an den Zaun an = Mark chained the bike to the fence.

4.	SBJ	____	OBJ +ACC +AB	an	OBJ +ACC +AB	add to

Ex: Mark schloss die folgende Bemerkung an seine Rede an = Mark added the following remark to his speech.

5.	SBJ +AN	____	OBJ +REFL +ACC		OBJ +DAT +HU	accompany, join

Ex: Mark schloss sich Sylvia an = Mark joined Sylvia.

6.	SBJ +AN	____	OBJ +REFL +ACC	an	OBJ +ACC +HU	accompany, join

Ex: Mark schloss sich an Sylvia an = Mark joined Sylvia.

7.	SBJ -AN	____	OBJ +REFL +ACC	an	OBJ +ACC -HU	be adjacent to, border on

Ex: An Texas schliesst sich Oklahoma an = Oklahoma borders on Texas.

8.✓	SBJ	____	<u>follow</u>

Ex: Weiter aussen schliesst die Sonnenkorona an = The corona of the sun follows further out. 20

491 FINDEN:

1.✓	SBJ +HU	____	OBJ +ACC			<u>discover</u>, <u>find</u>, <u>come across</u>

Ex: Mark fand einen Diamanten = Mark found a diamond.

2.	SBJ +HU	____	OBJ +REFL +ACC	in	OBJ +ACC +AB	be reconciled with, resign oneself to, put up with

Ex: Mark fand sich in die Lage = Mark resigned himself to the situation.

3.	SBJ +HU	____	OBJ +ACC	ADJ		find, think, consider

Ex: Mark fand Sylvia huebsch = Mark considered Sylvia pretty.

Figure 7-5

492 ZUORDNUNG:

1.	____	zu	OBJ +HU+AB +DAT	assignment to, relationship to, connection with
2.	N +AB			coordination

ZEIT:

1.	N +TIM			time

494 GELINGEN:

1.	SBJ +AB	____	OBJ +DAT +HU		succeed in
2.	SBJ +AB	____			be successful, succeed, work
3.✓	es	____	zu INF	OBJ +DAT +AN	succeed in + Gerund, manage to + Inf.

Ex: Das Experiment gelang Mark = Mark succeeded in the experiment.

Ex: Das Experiment gelang = The experiment was successful.

Ex: Es gelang Mark, das Experiment durchzufuehren = Mark succeeded in performing the experiment.

ERHALTEN:

1.✓	SBJ	____	OBJ +ACC	get, obtain, receive; keep, preserve 21
2.✓	SBJ +HU	____	OBJ +ACC +HU	support

Ex: Mark erhielt ein Buch = Mark got a book.
Die Italiener versuchten, Venedig zu erhalten = The Italians tried to preserve Venice.

Ex: Mark erhielt seine Eltern = Mark supported his parents.

Figure 7-6

3.	SBJ +HU	____	OBJ von +ACC +HU	OBJ +DAT +AB	maintain sb. on, support sb. on

Ex: Mark erhielt seine Eltern von seinem mageren Gehalt = Mark supported his parents on his small salary.

4.	SBJ +HU	____	OBJ von +ACC +REFL	OBJ +DAT +AB	subsist on, support onself on

Ex: Mark erhielt sich von Almosen = Mark subsisted on alms.