[*Research*, vol.10, part 10 (1957), pp.383-389]

MACHINE TRANSLATION OF LANGUAGES

I. K. BELSKAJA

Academy of Sciences, U.S.S.R.

This paper attempts to outline, from a linguistic point of view, some of the recent achievements of the machine translation research group of the U.S.S.R. Academy of Sciences.

THE MECHANIZATION of language translation appears first to have been proposed somewhat before the time of the electronic computers*. It was not until these high speed data-handling devices became available, however, that the idea could be made reality.

In recent years a considerable number of papers dealing with the machine translation problem has been published. Research in this field is being carried out by several research centres in different countries.

INTRODUCTION

The first experiments in machine translating from English into Russian were carried out at the Institute of Precise Mechanics and Computing Technique of the Academy of Sciences late in 1955. A detailed description of these experiments can be found in the paper presented by Dr I. S. MUKHIN at the London convention on Digital Computer Techniques[1], April, 1956.

Our early version of the machine translation dictionary included 952 English words along with their 1073 Russian equivalents. At the present time 5000 words are entered into the dictionary, 2500 of them being English words, and the rest are their Russian equivalents. It must be admitted that this vocabulary is sufficient for translating publications in mathematics only, for which purpose it has been compiled.

From the very beginning machine translation was restricted to scientific texts, and for two reasons: linguistically, the difficulties here are very notably less, and, practically, the translation of scientific publications is by far the most urgent problem of the day. As to the grammar part of the translation programme it has very little, if at all, been affected by the fact that a very limited field, that of mathematics, had been chosen for machine translation. Indeed, the grammatical programme has proved to be universally applicable.

Special experiments were made in order to find out whether the same grammatical programme can be applied to a text having as little to do with mathematics as, say, an article from *The Times*† or a passage from Charles Dickens *(Table 1)*. The experiments have proved the success of our ideas on the possibility of having a universal grammatical programme for the machine translation of any two languages; in the vocabulary field a series of specialized dictionaries, covering different fields of human activities, are unavoidable. Our general principles have withstood another test: they were extended to cover machine translation from languages differing from English, in structure, as much as Japanese, Chinese and German. These experiments having been successful; the principles may be considered as basic in the solution of the machine translation problem.

GENERAL CONSIDERATIONS

The problem of language translation by machine has often been compared with those recently solved in cryptography. The disappointment of those who proceeded in their machine translation investigations from these premises was unavoidable.

Still popular with some of the investigators in the field of machine translation is the idea that to translate from one language into another one needs 'to descend from each language to the common base of human communication—the real but as yet undiscovered universal language—and then re-emerge by whatever particular route is convenient' to the other individual languages[2].

Different attempts to construct a universal language—such as B. RUSSELL'S and S. WHITEHEAD'S 'logical language'[3], 'informational languages'[4] or different international languages, say, Esperanto, Interlingua, *etc*—have proved but a failure in so far as none of those universal languages can render everything we find expressed in a natural language. It is, therefore, hopeless to believe that an artificial language can help in machine translating from natural languages.

At the present state of our translation investigations, bilingual machine translation appears to be the most promising approach to the problem, the information necessary for carrying out the translation being obtained from lexical and

*As early as 1933 the first design of an automatic dictionary was proposed by P. P. TROJANSKY (*U.S.S.R. Patent* N40995).

† The translation to be found in reference 1.

Table 1. The words underlined in the English text were either not found in the machine translation dictionary at all or their meanings were different from those required in the present text

′ My entrance, and my saying what I wanted, roused her. It disturbed the Doctor too, for when I went back to replace the candle I had taken from the table, he was patting her head, in his fatherly way, and saying he was a merciless drone to let her tempt him into reading on; and he would have her to go to bed.

But she asked him, in a rapid, urgent manner, to let her stay . . . And as she turned again towards him, after glancing at me as I left the room ... I saw her cross her hands upon his knee, and look up at him with the same face, something quieted, as he resumed his reading.

It made a great impression on me, and I remembered it a long time afterwards, as I shall have occasion to narrate, when the time comes.'

'Мой приход и то, что я сказал, что яхотел, взволновали ее. Это расстроило доктора тоже, т.к. когда я пришел обратно, чтобы заменить свечу, которую я взял со стола, он отечески поглаживал ее голову и говорил, что он был бессердечным негодяем, который позволил ей склонить его читать дальше. И он бы хотел, чтобы она пошла спать.

Но она быстро, настойчиво попросила его позволить ей остаться ... И когда она опять повернулась к нему, посмотрев на меня в то время как я покидал комнату ... я увидел, что она скрестила руки на его колене и смотрела на него с тем же самым выражением лица, несколько успокоенная, в то время как он возобновил свое чтение.

Это произвело большое впечатление на меня, и я помнил это потом долгое время, как я буду иметь случай рассказать, когда придет время '.

CHARLES DICKENS *David Copperfield,*
Chapter XVI

grammatical analysis of the source-language. In future, when machines will be used for multilingual translation the inter-language problem may well arise. However, for the reason mentioned already, it seems doubtful if an artificial language will be used for the purpose. Thus even in the case of multilingual machine translation the linguistic analysis of the text remains a most important factor.

A DICTIONARY FOR MACHINE TRANSLATION

A machine translation dictionary does not differ basically from the usual type. The main difference lies in that it should provide every meaning of the words stored in it with a set of instructions for its application. The two independent sections of a machine translation dictionary are those of ' source language' and of ' target language', the former section having a dictionary of polysemantic words as a subsection.

Every word of the source language sentence is found in the dictionary by the operation of comparison, performed by the computer, grammar affixes of the words having been discarded if necessary[1]. A word not found in the dictionary is printed in Latin script (see *Table 2),* the structural meaning of the unfamiliar word being, nevertheless. defined and later utilized in the grammatical analysis of the sentence.

The very first problem that a compiler of a machine translation dictionary has to face is the volume of words to be stored. Quite a number of authors expressed their doubts as to whether a dictionary required for an adequate machine translation would not be much too voluminous for the existing storage devices[5,6]. Various methods have been evolved for reducing the number of words to a size that can be handled[7,8]. The following two methods seem most advisable.

(1) division of the dictionary into a series of independent dictionaries, specialized as to field;

(2) division of the two different sides of the word, *i.e.,* its lexical individuality and grammatical categorization, with only the former side being reflected in the dictionary.

The latter division means the rejection of the suggestion to store in the machine translation dictionary inflected forms of the same word.

Practical experience in machine translation from different languages into the Russian language has led us to the conviction that a dictionary of 6000 words is quite sufficient for translating any mathematical text. It seems very reasonable to expect that other fields will not require much larger vocabularies either. A specialized dictionary can further be divided into three independent sections.

Table 2. Words not found in the dictionary are printed in Latin script

(1) All the previously outlined methods for determining a numerical value for a definite integral are based on equidistant values of the variable—
Все previously намеченные методы для определения численного значения для определенного интеграл а основываются на equidistant значениях переменной.

(2) Ultimately, therefore, the error has one sign and increases exponentially—
В конечном счете, therefore, ошибка имеет один знак и increases по экспоненциальному закону.

((1) technical words, which, in our case, is mathematical terminology, amounting to 400 words in the English section of the dictionary;

(2) non-technical monosemantic words, amounting to 1800 words in the English section of the dictionary;

(3) polysemantic words, amounting to 300 words in our English dictionary.

These again can be stored and handled independently.

Rejection of the once popular idea of storing in the machine translation dictionary all or most of the inflected forms[5] is largely a matter of principle. Distinction between lexical and grammatical means of expression in language is essential if the system is expected to reflect, and indeed cope with, the flexibility of language. Whatever can be formulated into grammatical rules need not be stored in the dictionary. In consequence, a word need not be entered into the dictionary more than once except for the case of irregular changes in the word. This is the case with personal pronouns, *e.g.,* I and me, he and him, *etc,* numerals one and first, two and second compared with regular changes like four and fourth, *etc.* Other examples are the verb 'to be' —am, is, are, was, were, been, being—and the verb 'to have'—had, has; modal verbs such as can (could), may (might), *etc;* and irregular verbs to write (wrote and written), to bind (bound), to come (came), to get (got), *etc**.

Another suggestion we have come to reject is that of storing in the dictionary word stems as apart from a list of grammatical affixes*. The reason is that preliminary grammatical information, required of the dictionary by subsequent programmes of grammatical analysis, cannot be supplied unless whole words are stored in the dictionary.

Systems of invariant as opposed to variant grammatical characteristics of the words have been worked out. The former are fixed in the dictionary, for which reason they are termed 'dictionary indications', whereas the latter are determined in the course of the grammatical analysis of the sentence, thus being termed 'non-dictionary indications'. 'Part-of-speech' indication is dominant not only among 'dictionary indications'—where it belongs—but among 'non-dictionary indications' as well (see *Table 3).*

It is but natural that both systems of indications should differ for different source or target languages. Noteworthy is the fact, however, that in each case grammatical characteristics can be specified which do not depend on sentence analysis but rather predict the ways and means of the subsequent analysis. This part of grammatical information can be stored in the dictionary along with the word concerned.

Another problem which requires mention in connection with the machine translation dictionary is that of adequately translating lexical meanings of the words. The difficulty here arises not only due to multiple meaning of many words—though this problem has caused much discussion among the machine translation investigators[10,11]. Context analysis of words in combination with special dictionaries for the different fields has proved a very effective method of solving this problem.

For quite a number of words the problem of multiple meaning is enormously simpler, when treated within this or that special field dictionary. Thus, for the word 'contribution' the following Russian equivalents are given in Miller's Anglo-Russian dictionary

contribution (n.)
- — содействие
- — вклад (денежный, научный и т.д.)
- — пожертвование
- — статья (для газеты, журнала)
- — сотрудничество (в газете и т.д.)
- — налог, контрибуция.

In a specialized dictionary the same word can be entered as a one-meaning word, 'добавление' (mathematics) or 'влияние' (physics), *etc.*

Context analysis of polysemantic words is equally effective in different languages. Some illustrations of context analysis as applied to English, Chinese and Japanese words are given in *Tables 4, 5* and *6* respectively. In most cases 'minor context' has proved quite sufficient

A still greater difficulty arises in so far as relative meanings of the words are concerned. The important point is that the determination of meaning in the machine translation dictionary does not only depend on semantic peculiarities of the source language but has to be made considering the semantic peculiarities of the target language concerned. Our problem is word meaning in the light of semantic correlations of the two languages involved. This brings us to the necessity of considering relative meanings.

By 'proper' meanings of the words we understand those meanings they have within the language where they belong, whereas 'relative' meanings are those they acquire when correlated with another language, for translation purposes. In many cases relative meanings do not coincide with proper meanings of the same word.

*This applies to modern English only. In discussing old English, these verbs would not be given more than one entry in the machine translation dictionary; the now irregular verbs were at that time well regulated into seven grammatical classes.

Table 3. Dictionary and non-dictionary indications of the Russian language

Dictionary indications	*Non-dictionary indications*
(1) noun	(1) case
(2) gender	(2) number
(3) declension	(3) syntactical function in the sentence
(4) type of stem	
(5) pronominal (or not)	
(6) indicates an animate object (or not)	
(7) proper noun (or not)	
(8) morphological group	
(9) syntactical group	
(1) adjective	(1) gender
(2) type of stem	(2) number
(3) prominal (or not)	(3) case
(4) ordinal (or not)	(4) syntactical function in the sentence
	(5) degree of comparison
	(6) short form (or not)

Thus, with Russian as target language, the English word 'good' acquires 'many' as its relative meaning in combination with the noun 'chance(s)'; this meaning we do not find among the proper meanings of 'good'. For example, the following relative meanings of English words, with Russian as target language

positive — значительный (=considerable)
dose — точный (=exact)
dose — малый (=small)

It is important that a dictionary, indeed any dictionary whether machine translation or not, compiled for translation purposes should give a list of relative meanings of the words, since these are actually used in any translation. A human translator, when not provided with this or that relative meaning of a word, can 'think it out', which the machine translator cannot do. Hence, in machine translations meanings have to be preliminarily 'thought out' up to where they actually suit the translation—in other words, relative meanings must be fixed.

Zero meaning is a particular case of the relative meanings of a word. It has been noticed that cases where every word of the source language sentence is translated by a separate target language word, are very rare. More often some of the words are omitted. These we term as words having 'zero meaning'. Thus, in the English sentence

'It is interesting to note how closely these findings parallel statistical studies . . .'*

the first five words become two if translated into Russian 'интересно отметить'. 'It', 'is' and 'to' have disappeared or, in other words, become zero—actually only partly zero. Had they lost their meaning completely, *i.e.,* both lexically and grammatically, we need not have introduced zero meaning' at all, but 'zero words' instead. This would have meant that such words are of no significance for the sentence and to say 'interesting note ..." is just the same as to say 'it is interesting to note ... '. This is not the case with the omitted words: having lexically zero meaning they retain their grammatical meaning none the less. Thus, with Russian or German as target language, one of the entries for the English preposition 'of' will be the following

Table 4. Illustration of context analysis—English

high
1(2,5) — Check up the word for the suffix -er
2(7,3) — Check up the following word for 'derivative'
3(4,4) — Develop the indication 'comparative degree'
4(8,5) — Check up the following word for 'order'
5(9,6) — Check up the following word for 'accuracy'
6(10.8) — Check up the following word for 'speed'
7(0,0) — ВЫСШЕГО ПОРЯДКА' (adjective + noun, neither declined)
8(0,0) — 'ВЫСОКИЙ' (adjective, hard—sibilant stem)
9(0,0) — 'БОЛЬШОЙ' (adjective, soft—sibilant stem);
10(0,0) — 'БЫСТРОДЕЙСТВУЮЩИЙ' (adjective, soft—sibilant stem);
['speed'—not to be translated]

Table 5. Illustration of context analysis—Chinese

1(5,2) — Check up the sentence (in the ← direction) for a word having the indication 'introductory verb'
2(6,3) — Check up the previous word for the indication 'full-stop'
3(7,4) — Check up the following word for the indication' noun ' or 'formula'
4(7,8) — Check up the previous word for the indication 'comma'
5(0,0) — ' ТОГДА' (conjunction, introductory)
6(0,0) — ' СЛЕДОВАТЕЛЬНО ' (parenthesis)
7(0,0) — ' ТО-ЕСТЬ ' (conjunction, introductory)
8(0,0) — zero meaning (particle)

Table 6. Illustration of context analysis—Japanese

1 (3,2) — Check up preceding word for 
2(4,5) — Check up following word for 
3(0,0) — 'ПОНЯТЬ' (verb, first conjugation, takes accusative case)
4(0,0) — 'НЕ СТОИТ СЧИТАТЬСЯ' (verb-complex)
5(0,0) — 'БРАТЬ' (verb, first conjugation, takes accusative case)

Science News, No. 41 Harmondsworth: Penguin Books Ltd. 1956

Table 7. Analysis of the English noun—development of case indication

18(19,20)	— Check up the noun for the indication of case being developed
19(34,0)	— Check up the indication of case for 'nominative'
20(21,22)	— Check up the noun for the ending ' 's or'
21(0,0)	— Develop the indication 'genitive case'
22(23,25)	— Check up the noun for the indication 'proper noun'
23(24,25)	— Check up the preceding word for a noun
24(0,0)	— Develop the same indication of case as has the preceding noun
25(26,32)	— Check up the next word (preceding or following) for a noun
26(31,27)	— Check up these nouns for at least one of them having the indication 'pronominal'
27(28,29)	— Check up the word preceding (→) these two nouns for a verb belonging to group 61 or 62, 64 or 65
28(0,0)	— Develop the indications of case as required by the verb
29(0,0)	— Develop the indication of 'genitive case ' for the first (→) noun and the indication of the case taken by the verb (preceding) for the second noun

Table 8. Adjective—Chinese analysis

1(0,2)	— Check up the adjective for all the necessary indications being developed
2(3,19)	— Check up the following word for the indication 'FwSA' (form-word of simple attribute)
3(4,11)	— Check up the word following this FwSA for the indication 'noun'
4(24,24)	— Develop the indication 'SA' (simple attribute)
	… … …
24(26,25)	— Check up the previous word for the indication ' FwSD' (form-word of superlative degree)
25(27,28)	— Check up the previous word for the indication ' FwCD' (form-word of comparative degree)
26(28,28)	— Develop the indication of 'SD'
27(40,40)	— Develop the indication of 'CD'
28(0,0)	— Take the indications of case, gender and number from the nearest noun (→) having the indication ' DA' (defined by adjective)

lexical characteristics: *zero meaning*
grammatical characteristics: *preposition, taking the genitive case*

Zero meaning is not only applicable to form-words, though this is generally the case, but to any word of a sentence. For example

make clear — объяснить +0
make ready — приготовить +0

In both cases words with zero meaning, *i.e. '* clear' and 'ready', serve as modifiers of the non-zero meaning of 'make'

make+clear — explain
make+ready — prepare.

The fact that translation is concerned with relative meanings of the words makes quite impractical the very idea of a monoglot pre- or post-editor of the machine translation text[12,13,14]. Nevertheless since language correlation depends on the objective

Table 9. Verb—Japanese analysis

16(17,38)	— Check up the verb for the ending 'y' or 'ey '
17(19,40)	— Check up the verb for the ending 'то ' and the following verb for the indication 'belongs to group C ' (verbs of thinking)
19(0,0)	— Develop the indication of ' infinitive '
	… … …
38(39,62)	— Check up the verb for the ending 'рэ' or 'парэ'
39(0,0)	— Develop the indication 'passive voice'
40(41,66)	— Check up the next ending for 'тос'
41(19,19)	— Put the verb 'намереваться ' right after our verb
	… … …
66(67,67)	— Develop the indication 'future tense'
67(68,69)	— Check up the sentence for the noun having the indication 'subject'
68(0,0)	— Take the indications of gender and number from the 'subject'
69(0,0)	— Develop the indications 'plural' and 'first person'

Table 10. Example of translation from the English

(1)	There is also the implicit type, where the unknown values are associated together by a system of simultaneous equations— Имеется также неявный тип, где неизвестные значения связываются вместе при помощи системы совместных уравнений.
(2)	We shall examine methods for solving definite problems which may be used for calculation— Мы будем исследовать методы для решения определенных задач, которые могут быть использованы для вычисления.
(3)	To illustrate the use of equation 54-4 we apply it to the approximate solution of the differential equation— Для того чтобы иллюстрировать применение уравнения 54•4 мы будем применять его для приближенного решения дифференциального уравнения.
(4)	These methods for finding solutions of a numerical equation are everywhere known— Эти методы для нахождения решений численного уравнения везде известны.
(5)	As another example of the use of this method we shall consider the elliptic equation— Как другой пример применения этого метода мы будем рассматривать эллиптическое уравнение.
(6)	These are curves (no solutions) on which y^1 is constant— Это кривые (не решения), на которых y^1 есть постоянная.

Table 11. Examples of translation from the Chinese

(1) 若M及N是相通的以ρ为标的哈方陣，則$S^{-1}M$及$S^{-1}N$是相通的以一为标的哈方陣。

Если M и N являются союзными матрицами Гамильтона, скаляр которых есть P, то $S^{-1}M$ и $S^{-1}N$ являются союзными матрицами Гамильтона, скаляр которых есть 1.

(2) 一哈方陣Δ若無迷向線，則称为定号哈方陣。

Если матрица Гамильтона не имеет изотропных линий, то она называется определенной матрицей Гамильтона.

(3) 由定理1祇須証明A是可逆的場合。

Согласно теореме 1 достаточно доказать случай, когда A является невырожденным.

(4) 最後，下述定理把哈方陣的化簡理論引为可逆的哈方陣的化簡化理論。

Наконец, следующая теорема сводит теорию упрощения матриц Гамильтона к теории • упрощения невырожденных матриц Гамильтона.

(5) 在討論实數域的性質之前，先研究n是偶數，S的指數是$v=\frac{n}{2}$的情況。

Прежде чем рассматривать свойства поля *x* вещественных чисел, исследуем случай, когда *n* является четным числом, а показатель *s* составляет $v=n/2$

(6) 如果把(三)里的(i)式看做只有一个未知數x的方程，我們就x去解它，便得出相当方程。

Если выражение (*i*) в П рассматривать как уравнение, которое имеет только одно неизвестное *x,* то мы, решая его относительно *x,* получим равносильное уравнение.

Table 12. Examples of translation from the Japanese

(1) 二つまたは二つ以上の変数の未知函数及びその偏導函数を含んだ方程式を偏微分方程式という。

Назовем уравнения, которые включали свыше двух или две неизвестные функции переменных и их частные производные, дифференциальными уравнениями в частных производных.

(2) また問題の性質上Uはx及びtについて連続でなければならない。

Далее U с точки зрения существа должно быть непрерывным относительно X и t.

characteristics of the languages concerned, there does seem much hope of working out an adequate system of language analysis which would enable us to mechanize completely the translation of languages.

GRAMMAR FOR MACHINE TRANSLATION

'One cannot speak or understand a language without "knowing" its grammar'[16]. Neither can one translate languages without grammar. Foreign language teachers are well acquainted with the fact that a student who is too lazy to learn grammar is very often unable to grasp the meaning of a sentence, although he easily manages to get the meanings of the words. To express a thought, one should not only make out the semantics of individual words, but analyse the correlations of words which arise in the very process of expressing thought.

The need for grammar in the case of machine translation is created not only by 'the practical impossibility of dealing with strings of words on a purely lexical basis'[8] by which 'the very limited storage facilities available at the time'[9] are mostly understood. It is as little brought about by the necessity to determine multiple meaning of the words[11].

Grammatical analysis for machine translation purposes is required in order to determine the grammatical form and function of the words in a sentence. 'The important point is,' said A. I. SMIRNITSKY, one of the most prominent Russian linguists, 'that language can in no way be regarded as an arithmetical sum of separate units, first of all, words'[15].

To understand a foreign language sentence, one has to translate the grammatical form no less than its lexical content, so as to have the corresponding target language sentence grammatically determined.

The machine translation grammar can be divided into two independent sections, these being source language analysis and target language synthesis. The source language analysis includes a series of programmes which provide every word of the sentence with a set of non-dictionary indications necessary for the construction of the target language sentence. The important factors in the analysis are the grammatical form and function of the source language words in the source language sentence, as well as their 'dictionary indications'. The analysis routines are illustrated in *Tables 7, 8* and *9,* by English nouns, Japanese verbs and Chinese adjectives.

The following symbols are accepted in the routines: *A(B,C)* means passing on to No. *B* in the case of the positive answer, whereas a negative answer will result in passing on to No. *C. A(B,B)* means passing on to No. *B* in both cases, whereas *A*(0,0) means that the final result has been found and further search is unnecessary.

The target language synthesis programme concerns itself with modifying the endings of the Russian words, with due provision for interchange of vowels and consonants, when required. Examples are given in *Tables 10, 11* and *12* of the type of translation obtained by application of the above mentioned procedures to the English, Chinese and Japanese languages. The sentences given in *Table 10* have been selected at random from those actually translated by machine in the course of our experiments*.

The routines for machine translation from Chinese and Japanese into Russian are now being checked. Experimental mechanical translations cited in *Tables 11* and *12* were obtained in the course of the 'checking' procedure by a human translator not knowing the above languages.

CONCLUSIONS

From little more than a scientific curiosity the idea of machine translation is fast becoming reality. The principles have been proved reliable, experimentally; it is therefore no exaggeration to state that the time has come to consider the opportunities for practical large-scale work in this field.

REFERENCES

[1] MUKHIN. I. S. *Proc. Instn elect. Eng.,* Digital Computer Supplement 103в (1956) 463
[2] WEAVER, W. *Machine Translation of Languages,* p. 23 New York: Wiley, 1955
[3] RUSSELL, B. and WHITTEHEAD, S. *Principia Mathematica* London: Cambridge University Press, 1950
[4] ЧЕРЕНИН, В. П. Некоторые проблемы документации и механизации информационных поисков Москьа: ИНИ, 1955
[5] BAR-HILLEL, Y. *American Scientist 42* (1954) 248
[6] BULL, E. *Problems of Vocabulary Frequency and Distribution* Massachusetts: Massachusetts Institute of Technology Mimeograph, June 1952
[7] OSWALD, V. *Microsemantics* Massachusetts: Massachusetts Institute of Technology Mimeograph, June 1952
[8] OETTINGER, A. *Machine Translation of Languages,* p. 47 New York: Wiley, 1955
[9] RICHENS, R. H. and BOOTH, A. D. *ibid,* p. 9
[10] OSWALD, V. *Word-for-Word Translation* Massachusetts: Massachusetts Institute of Technology Mimeograph, June 1952
[11] REIFLER, E. *Machine Translation of Languages,* p. 142 New York: Wiley, 1955
[12] — *Studies in Machine Translation, No. 1* Massachusetts: Massachusetts Institute of Technology Mimeograph, January 1950
[13] — *ibid, No. 3* Massachusetts: Massachusetts Institute of Technology Mimeograph, June 1952
[14] BAR-HILLEL, Y. *The Present State of Research in Machine Translation* Massachusetts: Massachusetts Institute of Technology Mimeograph, June 1952
[15] СМИРНИЦКПЙ, А. И., Вопросы языкознания *No.* 2(1956) 17
[16] FRIES, C. C. *The Structure of English* New York, 1952

*It is noteworthy that from the instant the English sentence is put into the machine, the entire translation process is carried out automatically, with no human intervention whatsoever.