[From: *Journal of the Franklin Institute*, March 1954,p.257-260.]

Electronic Translation.—Russian was translated into English by an electronic "brain" recently for the first time, in a demonstration at IBM World Headquarters in New York.

Brief statements about politics, law, mathematics, chemistry, metallurgy, communications and military affairs were submitted in Russian by linguists of the Georgetown University Institute of Languages and Linguistics to the famous 701 computer of the International Business Machines Corporation. And the giant computer, within a few seconds, turned the sentences into easily readable English.

A girl who didn't understand a word of the language of the Soviets punched out the Russian messages on IBM cards. The "brain" dashed off its English translations on an automatic printer at the breakneck speed of two and a half lines per second.

More than sixty Russian sentences were given to the "brain" altogether. All were translated smoothly in a demonstration performed jointly by Georgetown and IBM as a phase of IBM's endowed research in computation.

A handful of men had been individually engaged in research at various institutions for almost a decade to make a machine convert the meaning of words clearly from one language to another. No practical results were achieved until Georgetown a year and a half ago enlisted the aid of the most versatile electronic "brain" extant, the IBM 701.

This amazing instrument was interrupted in its 16-hour-a-day schedule of solving problems in nuclear physics, rocket trajectories, weather forecasting and other mathematical wizardry. Its attention was turned at brief intervals from these lightninglike numerical calculations to the altogether different consideration of logic in an entirely new and strange realm for giant electronic data processing machines: the study of human behavior—specifically, the human use of words. The result, as publicly proved, was an unqualified success.

"The potential value of this experiment for the national interest in defense or in peace is readily seen," Prof. Leon Dostert, Georgetown language scholar who originated the practical approach to the idea of electronic translation, declared to the group of scientists and United States government officials who witnessed the demonstration.

"Those in charge of this experiment now consider it to be definitely established that meaning conversion through electronic language translation is feasible."

Although he emphasized that it is not yet possible "to insert a Russian book at one end and come out with an English book at the other," Doctor Dostert predicted that "five, perhaps three years hence, interlingual meaning conversion by electronic process in important functional areas of several languages may well be an accomplished fact."

"Another obstacle to inter-cultural communication will then have been removed—another step taken toward greater comprehension," he noted. "For it is through the print of language that man has ever sought to communicate more widely with his contemporaries, more completely with posterity. Multilingualism has, in part, hindered this quest. Electronic language translation is another stride forward in man's effort to reach his neighbors."

"Concretely, if electronic language translation makes possible, in due course, the translation into the languages of the less developed areas of the world, of the basic references and scientific literature in existence in Western languages, this in itself would be significant. The value to research of having current literature in scientific fields readily and promptly available in various idioms is another practical objective."

So far as IBM's big 701 was concerned, the demonstration could have been carried out with English and any one of a number of languages. Russian was chosen by the Georgetown linguist because present-day understanding of the Soviet by western countries is impeded by the relatively small number of students of Russian as opposed to a steadily growing

accumulation of Russian textual material whose true significance cannot even be estimated until its content can be converted into English.

This overflowing reservoir of data about the Soviet Union is not the work of spies. It consists of openly published material available in or from Russia to any interested party: books and magazines, newspapers, technical journals.

The scientists interested in translating this material electronically have no warlike intent whatever. Their whole purpose is to improve communication. They chose scientific and technical subjects as their first source because that type of writing is done with words having highly specialized meanings, and it is possible to predict that if a word appears in a certain context the chances of its having a certain meaning are extremely high.

The same probabilities of accurate prediction occur in other fields of technical writing, such as medicine and engineering. Consequently, Doctor Dostert assumes that electronic translation will begin with separate dictionaries for each technical area, and that as experience with them grows, enough will be learned to permit accurate translation of our common everyday language, in which are such illogical and unpredictable words as "char-leyhorse."

"Charley" is a nickname for Charles. "Horse" is a type of quadruped. But "charleyhorse" does not mean a horse named Charley. It means a muscular contraction which may take place in the calf. And "calf" in this context does not mean the offspring of a cow.

What the electronic translators have actually done is to create an entirely new electronic language. They have taken normal words and attached to them tags or signs which give each word a precision it does not usually possess. These signs actually denote rules of grammar and meaning. Although only six rules were used in the demonstration, the six were enough to cover all the words in all the sentences the 701 was asked to translate.

The IBM "brain" could translate only because these rule-tags were hitched onto normal words. For the "brain" cannot think independently. It can only perform tasks in obedience to detailed instructions prepared by human minds. And the minds of the Georgetown linguists (Dr. Dostert was assisted by Dr. Paul Garvin, a member of his Institute staff, just as the enormous detail work at IBM was done by Mathematician Peter Sheridan, under the supervision of Dr. Cuthbert Hurd, Director of IBM's Applied Science Division) could not give the "brain" dependable instructions until they themselves had worked out foolproof means of telling in advance how to translate a word which had more than one meaning.

The six rule-tags were the solution. Those particular six were chosen because they have a broader effect on language translation than any other rules studied by the Georgetown linguists. Doctor Dostert estimates that it may take as many as one hundred rule-tags to translate scientific and technical literature in general. But, no matter how large the number becomes the six will remain basic.

The six rules govern transposition of words where that is required in order to make sense, choice of meanings where a word has more than one interpretation, omission of words that are not required for a correct translation, and insertion of words that are required to make sense.

Here is an explanation of the mechanics involved in the operation of one rule which governs transposition of words where such inversion is required in order to make sense.

We begin with the Russian *gyeneral mayor.* These two words must be reversed to arrive at the proper translation in English: *major general.*

The switch is assured in advance by attaching the rule sign 21 to the Russian *gyeneral* in the bilingual glossary which is stored in the machine, and by attaching the rule-sign 110 to the Russian *mayor.*

The stored instructions, along with the glossary, say "whenever you read a rule-sign 110 in the glossary, go back and look for a rule-sign 21. If you find a 21, print the two words that follow it in reverse order."

So the instant the "brain" is given *gyeneral mayor* to translate, it looks in

the glossary, finds the two words there, reads the rule-sign 110, goes back and finds rule-sign 21, and automatically acts accordingly—all in the twinkle of an eye.

One more example will suffice to make the procedure clear. For it, let us take the rule governing the choice of meanings of one Russian word through the word which precedes that word in the Russian sentence.

The Russian word *nauka* means *science* in English. The Russian word *o* can mean either *about* or *of.* The proper English translation of *nauka o* is *science of,* not *science about.* But how can the "brain" know that?

It knows because, in its Russian-English glossary, *nauka* has affixed to it the rule-sign 242 and *o* carries the rule-sign 141. And the instructions in the "brain's" memory say "whenever you read the rule-sign 141, go back and look for 241 or 242. If you find 241, select the first English translation and print both words in the order in which they appear in the Russian sentence. If you find 242, select the second English meaning." Consequently, when the computer is given *nauka o* to translate, it reads the 141, looks for and finds the 242, chooses the second meaning given for *o* which is *of* and prints correctly *science of.*

After the six rules were formulated as the foundation of electronic translation, the linguists tried them out on themselves. First they wrote out sentences in Russian. Then they wrote out instructions as to how the rule-signs could be placed in the Russian-English glossary to lead to the proper English translation. After that, they gave the Russian sentences and the instructions to government officials and others in Washington who knew nothing about Russian or electronic "brains." The officials followed the instructions and came up with the right translations.

The first step in preparing IBM's magical computer to repeat this human performance of a mechanical task was to write electronically, in plus and minus charges on a magnetic drum surface, 250 Russian words and their equivalents in English. Wherever a Russian word had more than one meaning, each meaning was given a rule-sign. This set of electronic words then constituted the dictionary to which the "brain" could refer.

The second step in preparing the 701 to translate was to store the detailed instructions—exactly like those the people in Washington had followed, except that these were written in electrical charges on the faces of cathode ray tubes in the 701's electrostatic memory.

All that remained to be done after that was to give the computer the Russian words to translate. The "brain" responded at the rate of one full sentence every six or seven seconds.

The experimental demonstration can be rated only as a scientific sample, or, as Doctor Dostert neatly phrased it, "a Kitty Hawk of electronic translation." Nevertheless, the success of the project contains enormous implications for both linguistics and electronics.

Students of language are now for the first time justified in undertaking serious study of language from a mechanical point of view. They have a practical reason now for trying to find out how language actually functions.

From the viewpoint of the electronic "brain," the language translation also has tremendous significance. It has been learned, for instance, that the formulation of logic required to convert word meanings properly even in a small segment of two languages necessitates two and a half times as many instructions to the computer as are required to simulate the flight of a guided missile.

What IBM's astonishing 701 actually did, in executing the Russian-English translation, was to create within itself a working model of another "brain" specially designed to handle logic instead of mathematics. Thus, the "brain" has crowned its previous reputation for superlative versatility with an even more lofty laurel. And in so doing it has produced its own "brain" child.