Notes on the State of Digital Computing in the U.S.S.R.

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This paper, which was presented at the Harrogate Conference of The British Computer Society on 6 July 1960, gives an informal account of the state of computing in the U.S.S.R. as it appeared during a visit of 14 days to Moscow in June 1960.

Introduction

The main reason for the visit was that a National-Elliott 803 Computer was exhibited at the Polytechnical Museum as part of the Scientific Instrument Manufacturers Association's exhibition in Moscow.

The number of technical visits possible was limited, partly due to the difficulty of arranging such visits, and partly due to lack of time. However, three such visits were made and are described.

The difficulty in arranging visits first showed itself in England, when approaches were made through numerous channels which did not give very encouraging results. When personal contact was established in Moscow, visits to the Computing Centre of the Academy of Sciences and the Institute of Automatics and Telemechanics were arranged, although it is not clear which approach had, in fact, borne fruit.

We were told that some reticence was shown over visits to digital computers since, from a hardware point of view, the computers were about four years behind those produced in this country.

This note is divided into two parts, the first describing the interest shown in the National-Elliott 803 computer at the exhibition. A great part of this interest would, I am sure, have been shown in any British transistorized computer which had been shown in the exhibition. The second part describes the equipment we saw, and goes some way in explaining the interest shown in our machine.

The Exhibition

The interest shown at the exhibition was quite unlike anything experienced anywhere else. The general visitors had no conception of an exhibition being staged in order to sell equipment: they looked upon the whole affair as being for their own education, and consequently they expected to be given information down to the minutest detail about every aspect of the machine. It was felt to be quite normal to draw mechanical details, take cine-films, and generally probe right into the fundamentals of a machine.

The attendance was also very much greater than one would have expected at a corresponding exhibition in Britain, so much so that towards the end of the exhibition people were struggling with the police to get into the exhibition building. Everybody wanted to collect literature, so that supplies of pamphlets had to be conserved very carefully and, in fact, there was an alarming tendency for onlookers to tear off program tapes as they emerged from the reader.

Another difficulty was to know to whom one was talking, both because dress is rather more standardized than in the West, and also because of the language barrier. Consequently it was rather difficult when somebody said he would "buy this machine," to know whether he had the authority to do so. One was dumbfounded to find out afterwards that he is a Minister.

Interest in the computer centred around three points, the first being the general construction, from such details as the bends introduced for styling purposes, to the details of the cooling arrangements and the plugs and sockets. The second aspect was the tremendous interest in the magnetic-core store. We were told that there was no core store in Russia greater than 2,000 words, and thus the 4,096 words of the 803 was of great interest to them. The number of requests which we received to open up the matrix box became quite wearing. The last point was the mechanical equipment, where again we had continual requests to take the covers off Creed equipment in order to try to satisfy the desire for complete information.

Visits

The first visit was to the Computing Centre of the Academy of Sciences where we saw two computers, BESM 2 and URAL 1. BESM 2 is a vast machine, and has very much of the air of EDSAC 1 about the whole installation. There are some 3,500 valves in the machine and it has a dissipation of about 50 kW. However, the ideas incorporated in the machine are much more advanced than EDSAC 1, it being, amongst other things, a floating-point machine. It is interesting to note that one of the demonstration programs was playing tunes, which shows that in some things East and West are not too far apart.

The operating times for BESM 2 are:

Addition Subtraction	70 μsec
Multiplication	240 μsec
Division	270 μsec

This means that the machine is quite fast. The core store is of 2,000 words with a 10 μsec cycle time, and there are two magnetic drums, each of 6,000-word capacity, as backing-up storage. Block transfers of up to 2,000 words take place between the core store and magnetic drums. Punched cards are used for input, and for output together with a strip printer which has a very advanced specification. The printer has a row of 16 characters which are printed at 20 lines a second. It was attached to the computer but was not actually working. We were told that it still gave quite a lot of trouble.

The machine also has four magnetic-tape mechanisms which look rather primitive. The tape is ¼ in. wide and has two pairs of tracks for reading, one pair in the forward direction and one pair in reverse.

Another interesting point about BESM 2 is the extensive use of screened leads. Practically all logic wiring was carried out in screened cable which has a capacity of 100 pfd. per metre, which was rather surprising. The staff said that they felt that this was, in fact, not necessary. They quoted 2,000 hours as the average life of a valve, although there were some special trustworthy valves with a life of 10,000 hours—an interesting parallel with the work in this country. The reliability of computers is measured in hours per day of useful computing, and the BESM 2 was said to give 18 useful hours each day. They reckon on having three hours each day for routine maintenance. On the other hand, URAL 1 was quoted as giving 22 hours per day of useful computing, with routine maintenance on Mondays.

One significant fact which came up during discussion was that the Chinese have made a copy of BESM 2 in one year from scratch. This is remarkable since, before doing this, the Chinese were evidently not active in the computer field at all.

We were shown a display of magnetic cores used in Russian systems, the smallest of which was only 0·9 mm in outside diameter, which is rather smaller than the smallest at present used in this country. The thickness of ferrite appeared to be rather less than in British cores, but we were not able to establish whether this was for a technical reason or in order to get a larger hole so as to ease threading. The finish on these cores appeared to be rather rough, and the consequent lack of homogeneity may be the underlying reason for their being unable to make matrices to store more than 2,000 words.

URAL 1 presented rather a mystery, since it is at least five years old and, although it has only a 1,000-word drum store, it is very much in the same class as the Elliott 402 and IBM 650 computers. The construction is not so neat, and it uses large valves of the 6SN7 type, but nevertheless it does not represent a four-year lag. All operations take 10 msec except division, which takes 20 msec, since it is a drum machine with a single-address order structure. There are some 900 valves and 5,000 diodes, with a total dissipation of 7½ kW. We were rather surprised when we were told that the surface of a drum lasts for only four months.

It was interesting to note that their circuit philosophy is rather different from that practised in this country. They have the very simplest power supplies, with only electro-mechanical stabilization of the mains input, using transformers, rectifiers and presumably condensers (we did not see any condensers), and they use circuitry which is extremely tolerant to power-supply variation

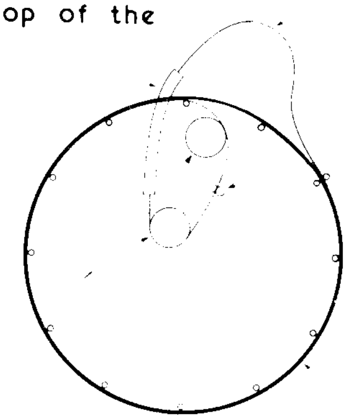

Fig. 1.—Principle of magnetic-film mechanism

and ripple. They felt that perhaps they would have to rethink this philosophy when they began to use transistors more extensively.

Input to the machine is by punched photographic film, read with photo diodes in a similar way to that used in the Zuse machines. This film was used instead of paper tape because the quality of available paper is not sufficiently homogeneous. The input rate is quite fast at 75 words per second. We were told that test programs punched on this film can be used for about one year. The tape-editing equipment for this medium is rather massive and not very flexible. All work on the computer is carried out in duplicate and the results compared before being accepted.

There is a single magnetic-film mechanism which uses 35 mm magnetic film, produced in both Russia and East Germany, in the form of a loop, as shown in Fig. 1. The film moves at 70 cm per second and the maximum loop size is 300 metres. One reason for having the continuous loop would appear to be that the mechanism is non-reversible. The heads run in contact with the film, and they do have flaws in the film surface which cause errors. These errors are checked in the arithmetic unit as the transfers take place.

Whilst at the Computing Centre we were able to arrange to visit the Scientific Pavilion at the Permanent Exhibition in which the first model of URAL 2 was being prepared, although it was not yet on view to the public. The Permanent Exhibition sets out to display Soviet achievement in all spheres, and it is usual to have the very latest equipment on view rather earlier than is customary in this country. For instance, a TU104 jet airliner was on display in its entirety for people to walk through and examine.

URAL 2 is several times the size of URAL 1 but uses the same form of construction: it is 50 times faster, being able to do 12,000 additions per second, and has built-in floating point. It uses 2,000 valves and 18,000 diodes, and has the by now familiar 2,000 words of core store, backed up by two 8,000-word drums. The film mechanism was still incorporated but this time the specification had been improved. Also the strip printer used on BESM 2 was installed. We were told that URAL 4 is in the commissioning stage and is going to be a large-scale data processor, having up to 18 film mechanisms and 8 drums.

It is interesting to speculate why there is so large a gap between URAL 1 and URAL 2, because it seems that this is where much of the time has been lost. One possible reason is that transistors have taken much longer to get to a useful stage than was originally anticipated. The expected wait of two to three years has, in fact, spread to five years, and still it has not been possible to produce a transistorized machine. It should be emphasized here that the thought processes which go into these machines are definitely on a level with those going into British machines. Another possibility is that over the past years all the staff who were capable of looking after computers have been used to maintain those computers of the older types used in calculations for space and nuclear projects. If one considers the high-level staff that would be necessary to maintain five or six EDSAC 1's and eight ACE Pilot Models on a round-the-clock operating basis, one would get some idea of the maintenance effort that might be involved.

We were told quite definitely that there was no transistor machine in production yet. We did, however, see transistorized radio sets at the Permanent Exhibition, but this was the only evidence of transistorized equipment that we saw.

The Kiev computer, which is in the process of construction at the Institute of Automation of the Ukraine in Kiev, will be ready for use in about two years' time. This is a transistorized machine, and is intended for process-control work only, in much the same applications as the RW 300 and Panellit 609. (One report spoke of the Kiev machine costing £20,000, but this, I think, is very doubtful since reports from those who have seen the machine spoke of it as being very large.) There are also simpler data-logging machines which have specifications which read in quite familiar terms 200 points scanned at 5 points a second to an accuracy of 0·25%. Alarm scanning is included in the operations of the machine. Photographs of these machines show a family resemblance to the URAL machines.

Institute of Automatics and Telemechanics

At the Institute of Automatics and Telemechanics we saw three main types of equipment. First of all analogue computers, which were very similar in concept to those available in Britain and with a rather more finished appearance than their digital counterparts. Self-contained units of four or five amplifiers, which could be placed one on top of another to build up more powerful equipments, were used; these could, nevertheless, be used separately for small problems.

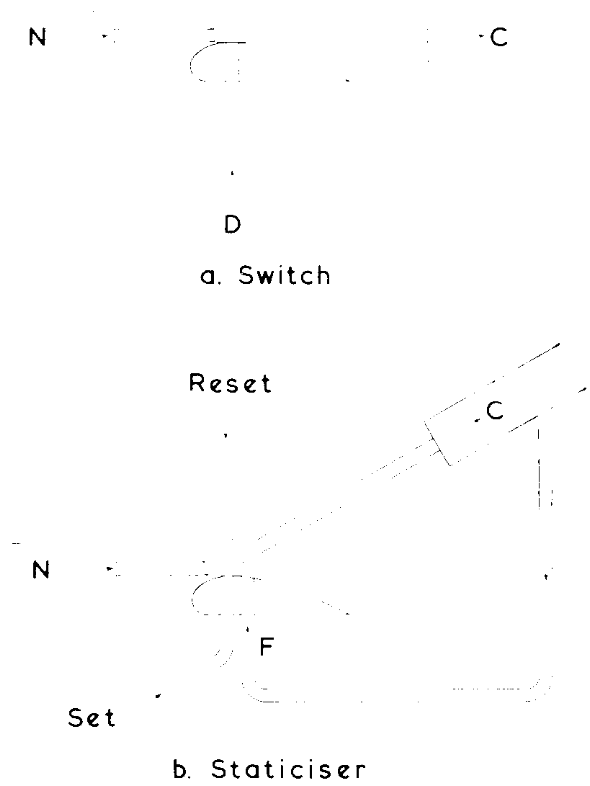

Fig. 2.—Principle of pneumatic equipment for performing logical operations

We also saw a great deal of work being carried out on optimizers of one kind or another. The work of Messrs. Feldbaum and Stakhovsky has been fairly well documented.* The extremum controllers appeared to have reached an advanced state of development, being packaged in a "plantworthy" form. We were told that these devices which are, in fact, single-variable optimizers, were installed in chemical plants. The 12-variable optimizer which we saw was an analogue device working with a plant simulator, and appeared to be intended entirely for the theoretical investigation of optimization.

Another very interesting, but entirely different, form of optimizer was nearing completion for optimizing Boolean expressions. This concept was very interesting, since the initial expression is punched on paper tape and read into the machine. The minimized expression is formed and punched out on paper tape. The importance of this is evident when one understands that their philosophy toward computer automation involves the premise that it is better to have special-purpose computers for each job than general-purpose computers.

* See "An Automatic Optimizer," by A. A. Feldbaum. *Automatica and Telemechanika*, Vol. 19, p. 8 (1958).

This means, of course, that the immense amount of special logical design work must be simplified as much as possible.

The third type of equipment we saw was that using pneumatic logic. There are two forms of this logic, one being a miniature version of semi-conventional pneumatic relays using diaphragms, the other, more advanced, scheme using the flow of jets of air past aerofoil sections. In Fig. 2a the jet from nozzle N can be switched from the collector C with a very sharp threshold, in the pressure of the deflecting jet D. It appeared quite impossible to obtain a position where the switching was only partially achieved. This principle could be developed into a staticizor of something of the form of Fig. 2b by the introduction of a feedback jet F.

It is perhaps worthwhile making the comment here that certain reports in the daily press have referred to this equipment as demonstrating that the Russian computer technology was ahead of that in Britain. Since the clock rate of this equipment is of the order of 1 cycle per second, it is hardly comparable with full-scale computer equipment. However, in the limited logical operations required in some plant applications, it will be very economical to avoid the conversion from a pneumatic control system to electrical form and back again.

Dissemination of Scientific Information

One very noticeable feature of scientific methods in Russia is the way in which scientific achievements are displayed to the public and, in particular, to groups of students. In the Polytechnic Museum, which would appear to be roughly equivalent to our Science Museum, the computer department had not only a display of old calculating machines and punched-card machinery, but in a further room there were very large graphic displays of the different functional units of computers. These were working demonstration models based on the URAL and BESM computers. There appeared to be an abundant supply of guides who were very well informed on the subject of the room which they looked after.

It was very evident from the questions asked at the exhibition that very large numbers of young people were receiving training in the use of computers.

It is also interesting to note that there is a vast effort on manual translation. Small books are constantly being published containing, in translation, collections of articles on a particular subject from Western periodicals. It is also fairly evident that very many Russians read English quite well, although they are reluctant to speak English.

We found no evidence that machine translation is used at all at this time.

Another method of dissemination of information is by the purchase of small numbers of English periodicals which are widely distributed in copied form.

Conclusions

The majority of interest in the application of computers appeared to be in the automation field—almost every inquirer, after hearing about the 803, came out with the question ". . . and what about when we wish to read flows, pressures, temperatures, into the machine: what do we do then?" There were a few occasions when people asked questions about using the machine for forms of clerical procedure. These procedures are, of course, essential even in the running of a completely automatic factory, and it was interesting to note that there are bonus and incentive schemes for workers in the Russian economic system.

The technology of computers in Russia seemed several years behind that of the Western world, but there are grounds for thinking that the logical thought behind computers, and their application, is comparable with present-day thought in Britain, and that the technology may be expected to advance very rapidly in the next few years.