game of chess, for example, there are so many possible sequences of moves (about 10^{120}) that it has been estimated that the time needed to explore all the possibilities exceeds the remaining lifetime of our sun. The project has a target of producing a machine that can make 100 million logical inferences (i.e. can apply 100 million rules) per second. This is referred to as 100 million LIPS (Logical Inferences Per Second).

Another way in which speed could be improved would be by hard-wiring the software functions into the design of the chip, instead of loading them into memory and processing them by means of a general purpose chip. This erosion of the distinction between hardware and software is one of the most interesting aims of the project. There already exist 'associative' memories that have logical search circuits built into the memory cells. These devices can locate a piece of data from the meaning of the data alone — without the need to specify a memory address.

Such advances will speed up the interaction of the logical processors with the data banks. Hard-wiring programming routines into a computer is reminiscent of early computers such as ENIAC (see page 140), but the Fifth Generation machines will diverge from the architecture of von Neumann in one fundamental respect. They will feature many distinct processors all working simultaneously (in parallel), rather than having just one central processing unit. This requires much more care in the timing and control of internal operations but will remove the restriction on speed that the sequential execution of instructions imposes. The internal language chosen for the KIPS is PROLOG, which is a language developed in France and Britain and based on predicate logic. But KIPS will have the ability to communicate in many tongues with its users.

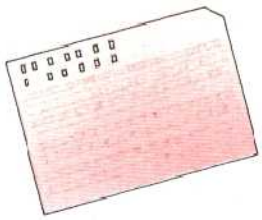
Translation of continuous human speech is another of the project's goals, with an immediate aim of 95 per cent accuracy. At present the ability to recognise even individual words from different speakers lags far behind the manifest success of synthetic speech. However, the NEC Corporation of Japan has already succeeded in creating a machine that can recognise continuous speech. A limitation of this system is that it can recognise the voice of only one individual, and each word must be previously recorded so that the computer can remember and later recognise the speech pattern.

As to the written word: the project is preparing a 100,000 word Japanese/English dictionary and program that it is hoped will permit a translation accuracy of 90 per cent.

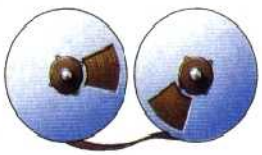
Japan has precedents in successful long-term research projects: the PIPS (Pattern Information Processing Systems) project of the 1970's is proving useful in the development of visual data banks and user-friendly interfaces. A KIPS will have to be able to look at an image and extract the salient features and outlines in order to make any preliminary sense of it. On the Tokyo underground there is already a machine that can do this: it scans passageways with a video camera and produces a flow pattern of passengers through the subway system.

Information technology represented an $88 billion business in the USA in 1983, and with employment in the manufacturing industry likely to decline in the same way as that in agriculture did earlier this century (from 40 per cent of the work-force on the land at the turn of the century to three per cent today), the community will move further towards an information society. In the light of this, Japan is doing something very ambitious with its Fifth Generation project. The plan is optimistic and includes a number of 'scheduled' breakthroughs that may or may not materialise (after all, the expected breakthrough in controlled nuclear fusion is still awaited). But it is a positive approach from a trading nation not dissimilar to our own. However, unlike Britain, whose investment in research and development has fallen over the last decade (from 2.32 per cent to 2.09 per cent of the GNP), Japan is speculatively investing in the future.

Generation Game

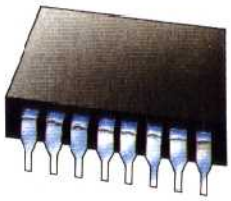


Round One
The first generation of electronic computers was developed around the technology of the thermionic valve. They had very little in the way of on-line memory, and data was generally stored on punched cards



Round Two
The second generation evolved out of the transistor, which increased the memory capacity, though off-line storage (in the form of magnetic tape) was still used

Round Three
The invention of the integrated circuit increased computer power dramatically, and was ultimately responsible for the microcomputer — characterised by the floppy disk drive



Round Four
We are now moving from the third to the fourth generation, which will be based on VLSI chip technology. The RAM memory will be so large that off-line storage will become less important

Round Five
The Fifth Generation of computers, being developed primarily in Japan, is really concerned with software rather than hardware. However, it is based on the assumption that user memory will be so large that program size will cease to be a consideration

KEVIN JONES