

Architecture of the English Electric KDN2, KDF6 and KDF7 computers.

Overview.

The KDN2 (1962), KDF6 (1963) and KDF7 (1965) family of computers were relatively small machines, of which the KDN2 and KDF7 were developed by English Electric for process control applications. In contrast, the KDF6 was marketed as an 'office data processing system'. For more substantial commercial data-processing applications at this time, the English Electric KDP10 and KDF8 computers were available – see *Our Computer Heritage* sections N3.

Each KDN2 computer cost about £25K, though site-specific instrumentation generally added considerably to the total installation costs. Each KDF6 cost about £60,000 and many KDF6s were installed in banks and similar commercial data-processing organisations. The lists of installations are given in *Our Computer Heritage* section N2X1.

General comments on process control applications.

The English Electric company was well-placed to appreciate the needs of industrial process control. Its own huge portfolio of engineering products spanned everything from electronics to heavy machinery, from fighter aircraft to marine and railway engines. In its Stafford factory was located English Electric's *Mining and Metals Industries Process Control Section*. It was not surprising that many KDN2 computers were installed in the iron and steel industry.

The KDN2 computer that was installed at the slabbing mill at Colville's steel works at Ravenscraig in Motherwell towards the end of 1962 provides an example of the evolution of equipment in a process control environment and the consequential need to reconfigure or redeploy the computer.

Bill Jack, who was a control systems engineer, spent his time between English Electric at Kidsgrove and Colvilles at Ravenscraig supervising the installation of the KDN2. He remembers that the KDN2 computer at Ravenscraig had an interesting career. "The initial slab identification system was eventually altered by the Production Control Department which rendered the inflexible computer system inoperable without extensive modification to the hardware configuration. So the KDN2 was then considered for an application to assist the melting shop to compute the additions during the steelmaking process but attempts to extend the role of the computer met with limited success. Around late 1969 or early 1970 Colvilles' process automation department were looking to replace the sequence control system on a reversing Roughing Mill at Ravenscraig. It was decided to utilise the KDN2 for this purpose which involved interfacing it with special control hardware ... As far as I know the KDN2 spent its old age happily sequencing the Roughing Mill".

KDN2 overall architecture.

According to an English Electric brochure (publication DP/104) the KDN2 is a “moderately-priced small-scale general- purpose computer, especially suitable for data-logging and process control”. The basic clock-rate is 140 KHz and serial arithmetic is used. Primary storage is a ferrite core store of 15 microsec. cycle time, expandable in increments of 512 18-bit words to 4,096 words. Magnetic tape units can be added to a KDN2. Standard basic peripherals include a paper tape reader and punch (20 characters/sec) and a 10 characters/sec. electric typewriter. In addition, faster paper tape equipment, card readers and punches, lineprinters and binary and decimal keyboards can be added. “For real-time control applications, special input/output equipment can be provided together with analogue-to-digital and digital-to-analogue conversion units”.

The KDN2 used transistor technology and printed-circuit boards called *datapacks*. The KDN2 central processor cabinet contains 252 *Datapacks*, where each Datapac is a pair of printed-circuit boards mounted back-to-back, bonded to a common set of gold-plated connectors. The Arithmetic Unit has four addressable registers, with facilities for double-length (ie 36-bit) working.

The KDN2 has a single-address instruction format. Of the 18-bit instruction, six bits are employed for the op code (giving a theoretical maximum of 64 functions) and 12 bits are used to specify the operand address in the core store. The usual add, subtract, multiply and divide operations are provided. There are both arithmetical and logical shift instructions. Three types of control transfer instructions are provided: unconditional jumps, jump if zero, jump depending upon the sign of the operand. At the time of writing, English Electric documentation describing the full instruction set has not been discovered.

Here are some sample instruction times:

Add/subtract and logical ops	175 microsecs. (18-bit aithmetic)
Jump	42 microsec.
Instruction modify:	168 microsec.
Multiplication:	average: 2.75 millisecs., maximum 5 millisecs.
Divide	5 millisec.
Input/output:	91 microsecs. per 6-bit character.

The KDF6 computer.

According to the 1963 sales brochure *English Electric KDF 6 Office Data Processing System*, “KDF 6 logical circuitry is based on the same plug-in element design incorporating the latest electronic techniques as used by KDF 9 and KDP 10”. The main store consists of (up to) 24K 18-bit words, which can be divided into three 6-bit characters called *triads*. (The KDF6 at the London Borough of Harrow only had 8K words of core store, of which half was used for code and half for data). The KDF6 peripherals are all compatible with the KDF 9 and KDP 10.

The KDF 6 had four programmer-accessible registers named A, B, C, D. Registers A and B can be concatenated as an extended register called X. A word could be interpreted as an integer, or as three six-bit characters ("triads"). In machine code an instruction was represented by two octal digits (six bits – allowing for up to 64 instructions) for the function code and four octal digits addressing an operand in main store (12 bits – allowing for 4096 locations). See Our Computer Heritage section N2X3 for the complete instruction set.

The monitor typewriter is a Friden Flexowriter. A 110 ch/s paper tape punch is offered, probably a typical TeleType Corporation BPRE punch unit as found on many British machines. The lineprinter operates at 900 lines per minute for numerical data, 600 lines per minute for alphabetic data. The symbol set comprises capital letters, decimal digits and 18 punctuation marks and symbols – ,;:."*-(/)&%#+=@. A maximum of four magnetic tape decks can be connected. Significantly, the sales brochures do not describe card readers, disc drives or graph plotters, all of which were available for the KDF 9, although the KDF 6 Programming Manual does mention the availability of a punched card reader.

The English Electric publication *Banking and KDF 6* gives an example configuration and work schedule for a bank holding 20,000 accounts. The configuration consists of one KDF 6, four magnetic tape decks (33,000 ch/sec transfer rate), one magnetic tape switch unit, one 600/900 lines per minute lineprinter and one 1,000 ch/sec paper tape reader. It further explains that the magnetic tape switch unit allows offline printing of data from magnetic tape. For off-line printing the unit can be set up with up to 25 templates of customised stationery, to be filled in by data read off the magnetic tapes.

The first KDF 6 was delivered to National and Grindlay's Bank, London, in December 1963 and served the Bank until its replacement by an IBM 370/135 at the end of 1974. See OCH section N2X5 for the complete KDF6 delivery list of about 14 machines.

The KDF7 computer.

Approximately eleven examples of the KDF7 were installed, mostly for industrial process control applications. One of these installations was at Colvilles' Ravenscraig steelworks controlling soaking pits. Around 1967/68 the KDF7 was then given the additional task of data logging on the 6-stand rolling mill, collecting data to establish the parameters for a planned M2140 mathematical set up model. The data was output onto paper tape and transferred to an English Electric LEOIII 32 computer. The KDN7 performed its task admirably.

Fawley Power Station in Hampshire provides a striking example of the quantity of site-specific input/output that might be needed to be connected to a process control computer. At Fawley, a separate English Electric KDF7 computer was used to control each of Fawley's four oil-fired electricity generators. Tony Watkins, who was the Control and Instrumentation Maintenance Engineer at Fawley from March 1965 onwards, remembers that "many instrument systems were duplicated, one for conventional display and recording in the central control room with the other input to

the KDF7s. Consequently there were over 23,000 pieces of instrumentation equipment installed”.

At the time of writing, no English Electric technical manuals have come to light that give details of the KDF7’s internal register layout and instruction repertoire. Until fresh evidence comes to light, it might be assumed that the KDF7 was an upgraded version of the KDN2 computer.