POUGHKEEPSIE
Department 539
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FILE MEMO

SUBJECT: High-Speed Disks

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The following description of the high-speed disks is proposed as an addition to Chapter 7 of the 7000 Manual.

1. Description

High-speed disks provide large capacity external storage to supplement internal core memory with emphasis placed on high rates of data transmission. Each disk unit has a capacity of 4,194,304 (2^{22}) words. Data may be transmitted between external storage and internal memory at a rate of one full memory word in about 3.5 microseconds.

A high-speed disk system consists of up to 32 magnetic disk units and a common disk control unit. Because of the high data transmission rate, this system has to be attached to the high-speed exchange. Each of the 32 disk units has its own channel address and thus can be addressed directly by means of the left effective address of an instruction, even though all the units share a common control unit. However, only one disk unit at a time can be engaged in data transmission. Simultaneous reading and writing on one unit, or reading or writing on more than one unit at one time is not possible.

A single disk unit consists of 37 usable magnetically coated disks mounted on a common shaft. The shaft is driven at a constant speed of 1800 rpm. The 37 disks are divided into two sets of 37 disk faces each. Each of these sets is equipped with a corresponding set of 37 read-write heads, so that there is one head permanently associated with each disk face. One set of the 37 disk faces covers all the even numbered tracks while the other set covers all the odd numbered ones. Two consecutively numbered tracks thus never are located on the same disk unit. This arrangement enables the positioning of heads on the next track during the time the previous track is read or written.

Every data word transferred to or from the high-speed disks is accompanied by the 8 ECC (Error Checking and Correction) bits used within the 7000 system. Information is handled in bytes of 37 bits each and is recorded simultaneously on all the 37 parallel disk faces. 32 of these bits are data bits and are made up of one half of a memory word; the remaining 5 bits consist of 4 ECC bits and one parity bit. A 64 bit word is thus read or written in two consecutive bit positions on a disk face. The 8 ECC bits of a memory

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word are divided in two groups of 4 bits each and are associated with a byte in such a way that it is possible later in the ECC checker to correct up to two errors in one data word. If two errors in one word occur, the ECC system assumes that the two errors were made on the same disk face, i.e., the two erroneous bits are always separated by 31 correct bits. No error correction takes place in the high-speed exchange itself.

Each disk unit is subdivided into a number of addressable locations called arcs. An arc contains 1024 words and is the smallest addressable storage unit in the high-speed disk system. There are 8 arcs to a track and 512 concentric tracks in a pair of disk faces, including an even-numbered and an odd-numbered disk face. Since a memory word is handled in two bytes and each byte is recorded in parallel over the 37 disk faces, an arc can be considered as a cylindrical storage surface, extending axially over the 37 disk faces and extending in the angular dimension over 2048 bits. Arcs are numbered consecutively from track to track as 0 through 4095, a total of 2^{12} arcs. Since there are 1024 (2^{10}) words per arc, there are 8192 (2^{13}) words per track and a disk unit can contain a total of 4,194,304 (2^{22}) words. The maximum high-speed disk system thus has a capacity of 134,217,728 (2^{27}) words, consisting of 64 data bits each. The arc numbers do not extend to the next disk unit.

The access time in the high-speed disk system depends upon the mode of operation and the difference between the presently selected and the desired addresses. When non-sequential access to any track is desired, positioning of the heads may take up to 175 milliseconds. This is the time required to move the heads from the innermost to the outermost track, or vice versa. In addition, a maximum of 34 milliseconds, the time necessary for one revolution, may be required to reach the desired starting point within a track. The time required to move the heads to an adjacent track in an odd-numbered or even-numbered set is not more than the time required for one revolution. Thus it is possible to transfer data to or from sequentially numbered arcs without waiting for access to new tracks.

2. Keys and Lights

The high-speed disks do not have any keys and lights other than those required for customer engineer control. The power for the disks is turned on and off together with power for the main computer. The high-speed disks do not require operator access, and they can be installed outside of the operating area.

3. Disk Operation under Computer Control

The present section describes the control and operation of the high-speed disk units. Emphasis in this description is placed on the peculiarities of the disk units themselves. Since the high-speed disks have to be attached to the high-speed exchange, the operational characteristics of the high-speed exchange also affect the operation of the disk system. This, in particular, applies to simultaneous operation of units and to the treatment of the control word. These peculiarities of the high-speed exchange are described in Section 6.8 of the 7000 Manual, dated 9/11/58, and are not repeated in this section.

As far as control of data transmission is concerned, there are no blocks defined by the high-speed disk system itself. The multiple flag is therefore ignored. A disk record may extend over any number of consecutively numbered arcs, and the amount of information which can be transferred with one READ or WRITE instruction is limited only by the capacity of the internal memory. The major restriction is that a block must start at the beginning of a disk arc, and it can not go beyond arc 4095, the last arc of a disk unit. If attempt is made to read or write beyond arc 4095, the EPK, Exchange Program Check, indication is given. If the number of words in a block is not a multiple of 1024, the remainder of the last arc used is erased on writing. A new block can not be placed closer than the next arc.

The starting arc for an operation involving data transmission is selected by means of a LOCATE instruction. The arc is identified by bits 38 through 49 in the right effective address of the instruction; the left effective address, as usually, contains the channel address and thus specifies the disk unit. The LOCATE instruction causes the heads to position to the desired track, whereupon an End of Operation and a Unit Signal indication are given. The starting arc within the track is retained within the disk unit.

A subsequent READ or WRITE instruction addressed to the same disk unit will cause data transfer to begin at the previously selected arc. Before the data transfer is initiated, the instruction, however, generally encounters an average delay of 17 milliseconds, the time required for a half revolution, in order to locate the specified arc on the track. From then on data transfer continues for as many words as specified in the control word, going to as many more arcs and tracks as necessary.

There are two ways of reducing the delay associated with locating the desired arc on the track. One method makes use of the gap between two consecutive arcs. At the end of a READ or WRITE operation the disk remains selected at the arc immediately following the last one used. If another LOCATE instruction is not given, the next READ or WRITE instruction will start data transfer at this arc. There is a gap of at least 100 microseconds between arcs,

which is normally long enough to allow the computer after receipt of an End of Operation indication to give another READ or WRITE instruction and to proceed without losing a disk revolution for access. When data transfer to or from a full track has been completed, the access mechanism is automatically positioned on the next track.

A second way of minimizing arc access time is provided automatically by the roll feature. If a full track of information is specified, reading or writing will begin at the very next arc to pass under the heads, continuing for one full revolution without switching tracks. The access time is then only that required to reach the next arc, an average of 2.1 milliseconds. For the roll feature to operate, it is necessary that

1. LOCATE specify a sector address which is 0, 8, or a multiple of 8 (the start of any track).

2. The CW specify a data word address which is 8192 or a multiple of 8192, and

3. the CW specify a word count of exactly 8192 (one full track).

If any of these conditions is not satisfied, the normal delays will be encountered.

When the roll feature is operating, memory addresses in the control word are modified so as to correspond to the data actually transferred. Data thus always appear in the correct locations after the transfer. However, since the transfer usually does not take place in the order specified in the original control word, the program should not attempt to alter the data being read or written this way while the operation is still in progress.

At the end of an operation using the roll feature, the disk unit remains positioned at the next track. A succession of READ or WRITE instructions satisfying the roll conditions will use successive tracks if no LOCATE instructions are given.

Because of the high data transmission rate, chaining and therefore skipping in the disk units is not permitted, and as in the case of multiple flag, the chain and skip flags in the control word are ignored.

A single disk unit can execute only one READ, WRITE or LOCATE instruction at a time. If the high-speed disk system contains more than one disk unit, any number of units can perform LOCATE operations simultaneously. It is also possible for one unit to be engaged in reading or writing while other units are executing LOCATE instructions. However, only one operation involving data transfer to or from the high-speed disks can take place at one time.

The COPY CONTROL WORD instruction also makes use of the data transmission facilities of the high-speed exchange, and therefore it can not be given when a disk unit is reading or writing. The peculiarities of the COPY CONTROL WORD instruction in the high-speed exchange are described in Section 6.8 of the 7000 Manual.

CONTROL instructions are not applicable to high-speed disks. Whenever a CONTROL instruction is addressed to a high-speed disk unit, an EPK, Exchange Program Check, indication is given.

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