SECTION 4 DRUM STORAGE

4.1. Operation of the Drum

Until now all operations, involving both instructions and the data to be worked on, have been considered as being carried out in the immediate access store. The immediate access store is, of course, the fastest and most flexible means of handling data. While, however, the store capacity of 1024 words is a large one, this is obviously insufficient to carry all the data required in a normal commercial application. Some form of backing up storage is therefore required to supplement the core store.

In the EMIDEC system additional storage is provided in two forms, on the magnetic drum and on magnetic tape. Magnetic tape gives unlimited storage since any number of tapes may be used, but it provides access to stored words in serial order only. To give backing-up storage with random access. the magnetic drum is employed, and by the use of additional drums random access storage of up to 65,536 words may be obtained.

The EMIDEC drum is manufactured in two sizes, one being 8" long, and the other 13". Each has a diameter of 8" and the large drum has twice the capacity of the small drum, the total storage on the former being 16,384 words, and on the latter 8,192 words. In describing the drum hereafter in further detail, only the large drum will be referred to, similar remarks being applicable to the small drum, allowing for the appropriate size amendments.

The drum surface is coated with magnetic oxide. This coating may be magnetized positively or negatively in discrete "spots", so that each "spot" may represent a binary "one" or "zero", that is, a binary bit. The bits on the drum are arranged in "tracks" each "track" being a complete circumference of the drum. There are 266 such tracks from the top to the bottom of the drum, and the number of bits on each track is 2304, i.e. sufficient to store 64 words of 36 bits.

Ten of the drum tracks are used as engineering service tracks; there are five different tracks, each being duplicated as a precautionary measure against loss of information. The five tracks are:-

1. Clock Track
2. Word Marker Track
3. Block Marker Track
4. Block Number Track
5. Monitor Service Track

The drum clock track is used to provide the clock for the whole of the computer, and therefore regulates the whole of the machine timing. It is possible for the computer to be used without a drum, but in such a case the clock will be provided by an oscillator. The timing of the computer is further dealt with in Section 9.

The other service tracks are used for locating addresses on the drum, but they operate automatically and are not relevant for programming purposes, so will not be considered in any further detail.

There remain 256 tracks for storage of working data or programs, giving a total storage capacity of 16,384 words on one drum and a total possible storage of 65,536 words on four drums which is the maximum that may normally be fitted on one computer.

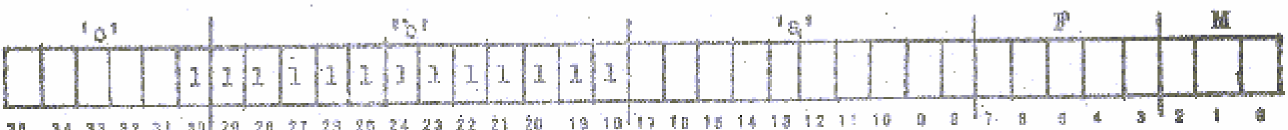
While, by use of the drum-store more extensive random-access storage is available it should be made clear that any work to be done on stored data must be done in the core store and no arithmetic or other work can be done on the drum itself. The procedure is for data to be read into the core-store, then transferred to the drum for storage and later recalled into the core store for working or for output. Data is transferred to and from the drum by means of read/write heads. These heads are arranged round the perimeter of the drum with one head for each track. As the drum revolves the appropriate head can select any point on a track to start reading or writing. For convenience in handling, data transfers are made in blocks of four words, and any number of blocks up to 16 (i.e. a complete track) may be transferred by one instruction. With one head for each track, transfer time is comparatively fast, though some waiting time is necessarily involved in selecting the appropriate block from a track. The average time for carrying out a transfer of a four-word block is 16 msec. and for the transfer of a complete track of 16 blocks 37.5 msec. (See also Section 9).

4.2. Programming and Instructions

From the point of view of the programmer, the drum store may be regarded as 256 tracks each containing 16 4-word blocks of storage, any one of which may be directly addressed. A number of blocks up to 16 can also be addressed in one instruction, but any one instruction may only refer to one track. If the number of blocks called for from a particular point on a track should overrun the end of the track then the additional blocks will be read, not from the following track, but from the beginning of the same track.

In addressing the drum, the numbering system is important, since the blocks are numbered in binary fashion from 0 upwards. The first block of the first track is therefore block 0, the last block of the first track is block 15, and so on up to the last block on the drum which block is 4095. If two or more drums are in use, they are numbered similarly, the first being drum 0, the second drum 1 and so on. In such a case the block numbers are continued serially from one drum to the next, the first block number on drum 1 being 4096, the last 8191 and so on. If one particular word is wanted from the drum, it is, of course, necessary to find the number of the block in which the word occurs, and then transfer the whole block.

The instructions used for transfers from and to the drum are numbered 15 and 16 respectively, the layout of the instruction being the same in either case. In the 'a' address is written the first register in the core store to which or from which the first word of the first block is to be transferred. For the purposes of drum transfer instructions the 'b' address is extended to cover digits D18 to D29. In this space is written the address of the drum block from or to which the first transfer is to be made. D18 to D29 is 12 binary digits so that the maximum figure in the 'b' address can be $2^{12}-1$ or 4095, which is the address of the last block on a drum. The number of the drum to be addressed is written in the 'c' address in digits D30 to D31. If, however, more than one drum is in use the blocks are numbered sequentially from one drum on to the next as has been shown, so that, for instance, the last block on the second drum is number 8191. Since, however, the digits denoting the drum number are immediately on the left of those denoting the block within the drum it makes no difference whether the drum and the block number are written, or whether the sequential number of the block within the whole drum system is used, for when converted to binary either combination will have the same effect. Thus for instance the last block on the second drum, is block 4095 of drum 1, or counting serially from block 0 of drum 0 it is block 8191. The binary for 4095 is 111111111111, so that in digits D30 and D31 may be written the drum number 1, and in digits D18 - D29 the above binary block number thus:-



It will be seen here that if the arbitrary division between digits 29 and 30 be ignored the whole binary number of 13 'ones' from D18 to D30 is equivalent to $2^{13}-1$ or 8191 i.e. the serial number of the block we require to address.

The number of four-word blocks to be transferred is specified in digits D32 to D35 (i.e. the c2 address). A maximum of 16 blocks may be transferred.

The maximum binary number which can be held in the four digits of the c2 address is 15. However a 16 in the c2 address will reduce the four digits to zero since 16 in binary is 10000 and the 'one' will overrun the end of the register. The computer is designed therefore to recognise 'zero' in the c2 address as a call for 16 blocks, and this may be effected by writing in the c2 address either 16 or 0—in fact 16 is always written.

To illustrate the uses of the drum transfer instructions, suppose we wish to transfer sixteen words from register 31 to 46 into the last sixteen words of drum storage on the second drum. Then we would write:-

		16		31		8188		4	
or									
		16		31		4092	1	4	

This transfers four blocks i.e. 16 words from registers 31 - 46 to blocks 8188 to 8191. It is important to note that the 'a' address refers to words, while the 'b' address refers to blocks. Should there be a requirement therefore for making successive transfers, it will be necessary to increase the register address by four each time the block address is increased by one.

To transfer back the contents of blocks 8188 - 8191 to registers 31 - 46 exactly the same form of instruction would be used except that the function would be 15 instead of 16.

It should perhaps be added that when drum transfers are made the source information, whether it be in the registers or on the drum, remains unchanged.

The number of blocks transferred is always as specified in the instructions, except that 16 blocks are transferred when 0 is specified. Normally the blocks are transferred in numerical sequence. However, it is not possible to change tracks in the middle of performing the function. If the 'end' of the track is reached the remaining number of blocks are transferred starting at the beginning of the track.

For example, if the first block number specified is 151 and the specified number of blocks to be transferred is 12 then track 17 of Drum 0 (blocks 144 to 159) is selected and blocks 151, 152, ..., 158, 159, 144, 145 and 146 are transferred.

No great difficulty should be encountered with drum storage, so long as care is taken with the numbering system and it is remembered that transfers must be made in a four-word block, and cannot overrun the end of a track. It should also be borne in mind that the time for transferring a drum block i.e. 16 milliseconds, is considerably greater than that for any other single computer operation, and drum transfers should therefore be kept to a minimum.