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COVER SHEET FOR TECHNICAL MEMORANDUM

TITLE— No. 1 ESS - Ways of Increasing Throughput of DAC Message Store - Part II

MM 64 - 2423 - 2

CASE CHARGED— 39215-25

DATE— March 3, 1964

FILING CASES— 39215-2

AUTHOR— L. E. Gallaher

FILING SUBJECTS—
Memories
Sequential Memories

ABSTRACT

This memorandum describes a method of queueing that is adaptable to the Burroughs Disc File. The organization of information storage on the discs is presented. This organization, along with queueing, provides sufficient throughput to meet the DAC system requirements.

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MM— 64-2423-2

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BELL TELEPHONE LABORATORIES
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SUBJECT: No. 1 ESS - Ways of Increasing Throughput of DAC Message Store - Part II - Case 39215-2

DATE: March 3, 1964

FROM: L. E. Gallaher

MM-64-2423-2

MEMORANDUM FOR FILE

Introduction

This memorandum is the second of the two memoranda* discussing techniques for increasing the throughput of the Message Store for the Data Switching System. The first memorandum covered the basic idea of queueing and its application to the Bryant Drums. This memorandum discusses a queueing system for the Burroughs Disc File.

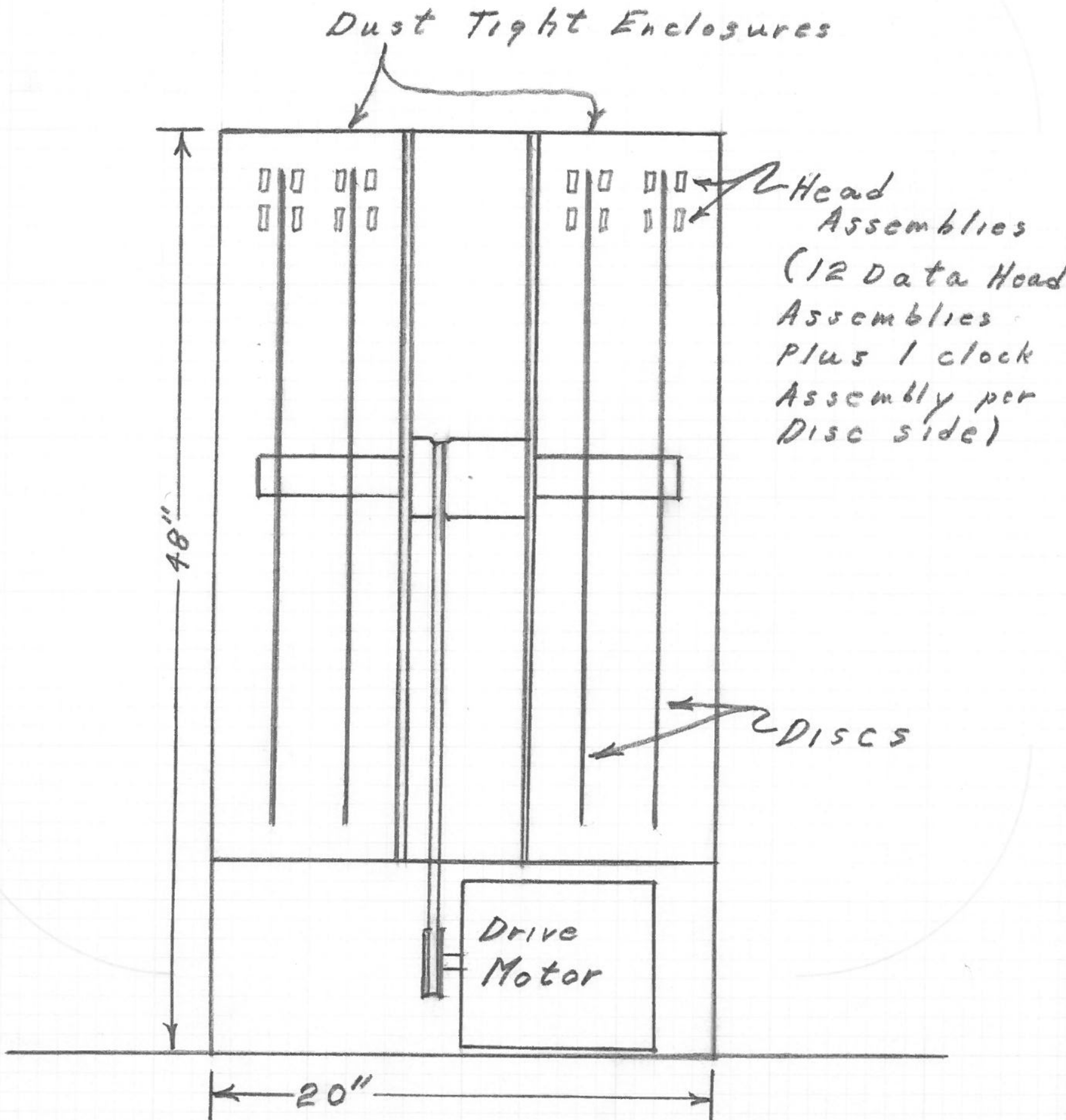
Disc File Background

The Burroughs Disc File has a data head for each data track making it adaptable to the queueing concepts as discussed in Part One.

A total of 1200 active data heads and tracks is provided in each memory unit. These heads are multiple flying units with 13 heads mounted in each data head block. Each memory unit contains four discs as shown in Figure 1. The discs are mounted 2 on each side of the bearing housing with the drive motor mounted below the main frame and connected by belts to the disc shaft. The speed of rotation is about 1500 rpm. The discs on each side are closed in a dust-tight cover to protect the discs and heads from possible damage and minimize maintenance.

Each disc face is divided into three data zones plus one clock zone. Each data zone contains 50 tracks while 6 tracks are provided in the clock zone. Actually 52 tracks are located in each data zone but two are allotted by the manufacturer as spares and wiring is provided to only 50 heads per zone. The zone locations are shown in Figure 2. Two clock channels per disc side are assigned to each data zone, providing a bit clock and a word clock per zone. As used by Burroughs each disc face is treated as a separate memory with a new address search required whenever data is to be transferred from a different zone or disc face.

*Part I - MM-64-2423-8 - December 30, 1963



Not to Scale

ISSUE	ENGR	TITLE	BELL TELEPHONE LABORATORIES INCORPORATED
Fig 1	LEG	Disc Memory Unit End View	SHEET
	DRAWN 3 15 64		NO. OF SHEETS PER SET

The discs are capable of recording better than 1000 bits per inch with NRZ (non-return to zero) recording, with less than a 50% reduction in readout amplitude from that obtainable at low bit densities.

Proposed Storage Organization for DAC

The proposed storage arrangement is designed to optimize the throughput of data with queueing and at the same time, to hold the bit densities as close as practical to those normally used by the Burroughs Corporation. Basically, each disc face is divided into 16 identical sectors, one of which is shown in Figure 3. The zone divisions are identical to the zone division of Figure 2. The angular subdivision of the sector is of more importance. The larger sector is the data section while the smaller sector is the control section. Thus on each disc there are 16 data sections and 16 control sections. Furthermore, the storage arrangement is such that all disc faces are essentially at the same relative position (relative to their data heads) at any given time. That is, when a particular data head on either side of disc one is entering the data section of sector 3, all heads of all discs are entering the data section of sector 3.

The time required to cross a data section is 2290 μsecs, a control sector 210 μsecs (assuming exactly 1500 rpm for the disc rotational speed).

This organization is designed so that during the control section, any data head can be selected, and during the data section, one block (32 words of 24 bits) of data can be transferred to or from the message store. The data block transferred could be any block of data in that sector of the entire disc file.

Within a sector, the data is organized as shown in Figure 3. In Zone 1, three blocks per track are provided; Zone 2 has four blocks per track; Zone 3 has five blocks per track. Moreover, the words of each block on each track are interleaved. Thus for Zone 1, Track 0, the sequence of words within a data section is:

Word 0 of Block 0
Word 0 of Block 1
Word 0 of Block 2
Word 1 of Block 0
etc.

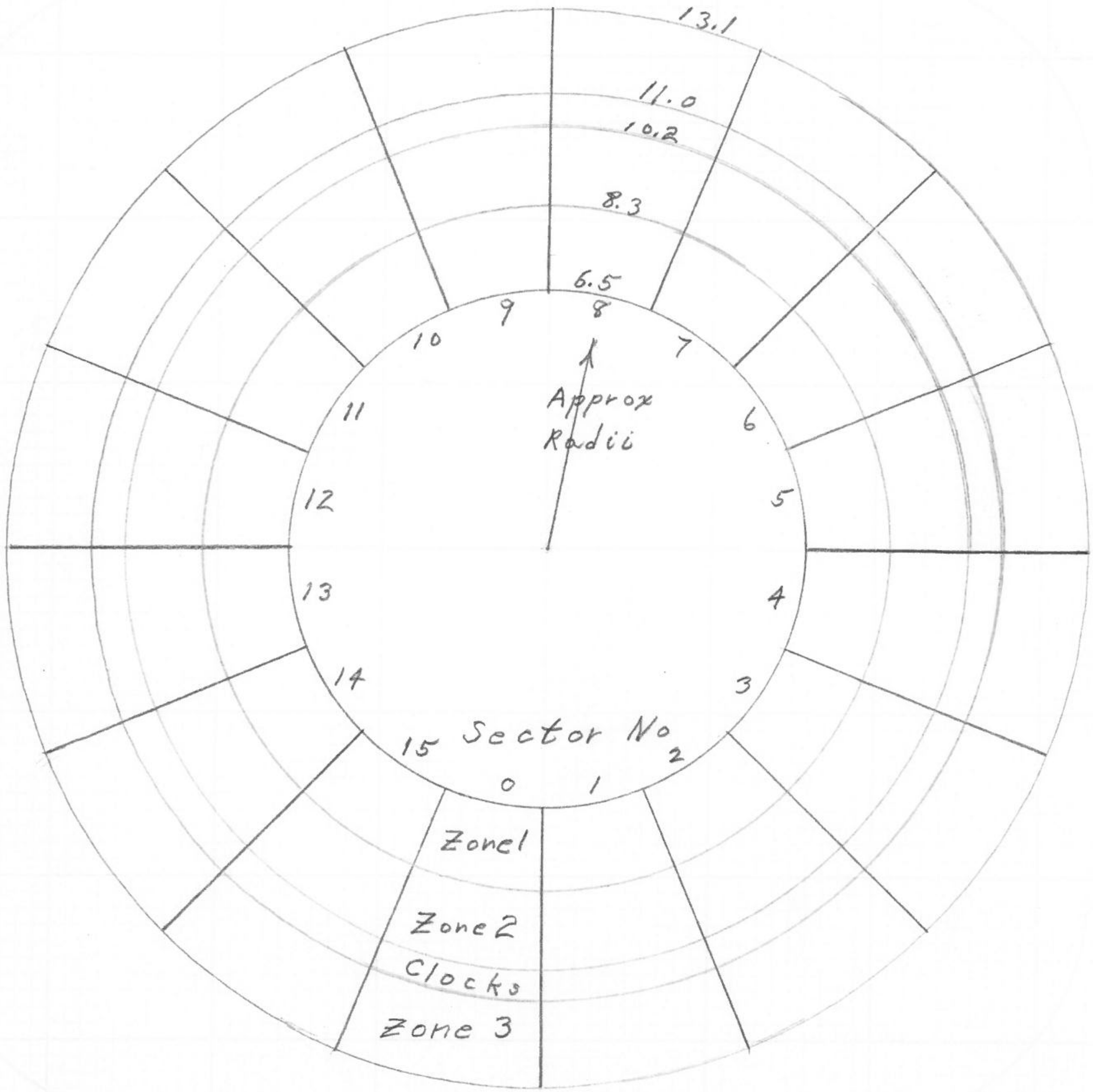


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Fig 2	LEG	Zone and Sector Divisions on Disc Face	SHEET
	DRAWN 3/17/64		NO. OF SHEETS PER SET

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7 11/16

10 5/8

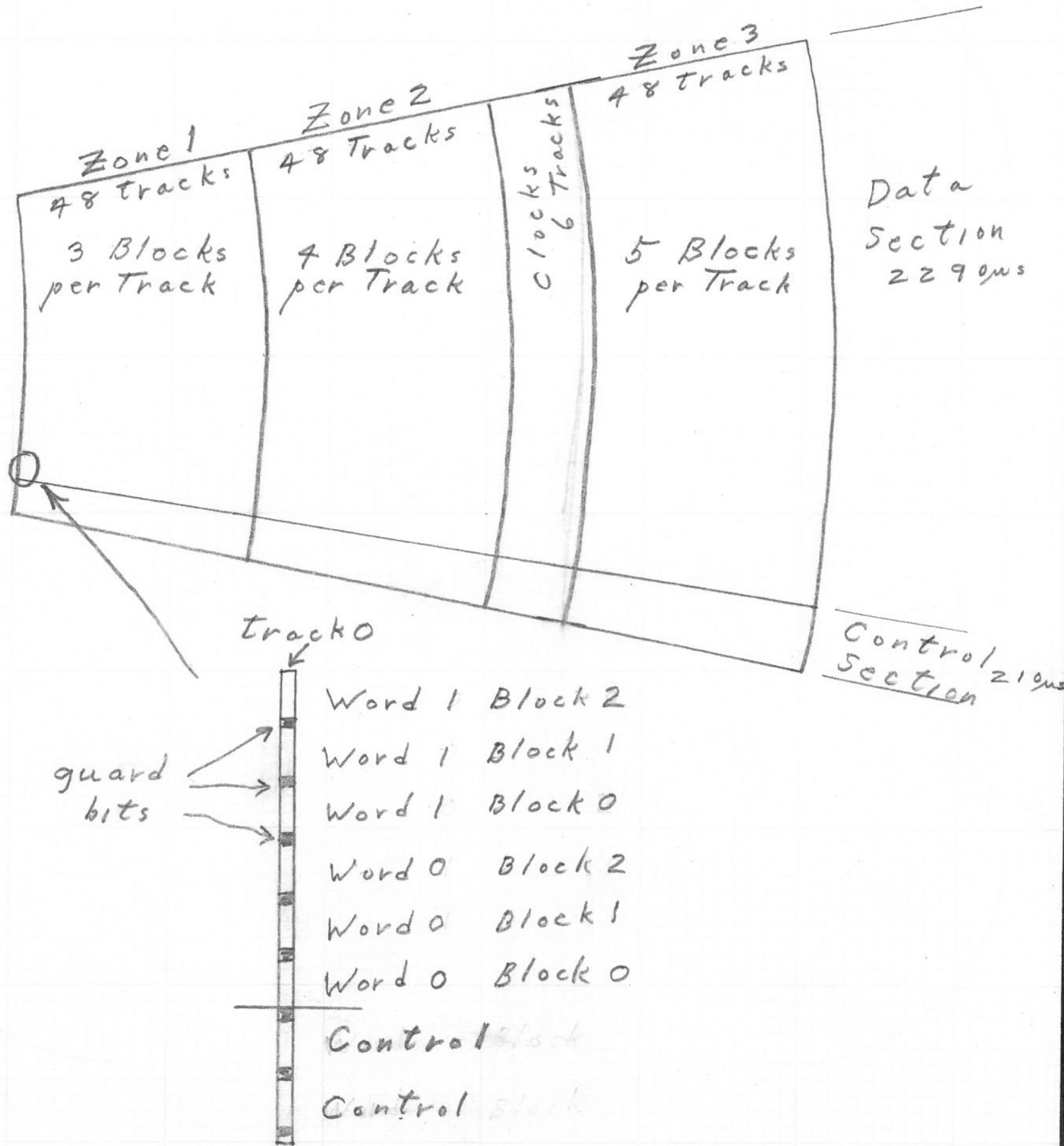

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Fig 3	LEG	Disc Sector Utilization	SHEET
	DRAWN		NO. OF SHEETS PER SET

Each word is written as a series string of 24 bits on a track. Two guard bits are used to separate each word from its adjacent word. Since NRZ recording is to be used, the first guard bit time is used to turn the read or write current off or on. The second guard bit is always recorded as a one so that the first flux change on readout will be known to be a zero. Thus each Zone 1 data track contains 2,494 bits per data sector or a bit frequency of 1.09 mc. Bit frequencies for Zones 2 and 3 are 1.45 mc and 1.82 mc respectively.

The word transfer rate, because of the word interleave, is the same regardless of the zone. At the disc nominal rotational speed of 1500 rpm, the word transfer rate is one word every 71.5 µsec or one word for thirteen 5.5 µsec system cycles. Since the speed tolerance is about ±5%, the word transfer rate may run as high as one word for 12 system cycles or as low as one for 14 system cycles.

This storage arrangement provides for the storage of 73,728 blocks of data, or about 56.7 million bits of data. In terms of usable system information storage, this amounts to nearly 3000 messages of 250 words assuming a waste factor of 32% and a packing of 3 characters per memory word.

Queueing Applied to the Disc File (Proposal Three)

The queueing system best adapted to the disc file is an extension of the system Proposals One and Two discussed in Part I. The queueing system suggested is a queue of 16 instructions corresponding to the 16 sectors around the drum. The instruction for a given sector could be for any block within that sector and would not be limited to odd or even as in Proposal Two for the drum. Two queueing lists would still be provided in the Buffer Store so that one can be prepared by the system while the other is being executed by the Buffer Control - Message Store complex.

With this queueing system the system would probably prepare only one queue list at a time which should occur once each revolution of the disc file (40 msec). Thus the system would have to prepare a queue more frequently than with the other proposals, but need only perform a 1 out of 16 sorting rather than 1 out of 28 or 32. This is important in that the probability for filling a queue of 16 is higher than for filling a queue of 32 from a given work list.

A comparison of the throughput for the Burroughs Disc File (Proposal Three) with Proposal Two discussed in Part I is shown as Figure 4. For values of "c" (number of entries in the push-down list considered for filling the queues) less than 40, the throughput is better for Proposal Three. In terms of block transfers per revolution (BTR) Proposal Three throughput is always as high or higher than Proposal Two but the decreased rotational speed of the disc file relative to the drums results in lower throughput per unit time for large values of "c".

The values for BTR for Proposal Three are derived from the following equation:

$$BTR = B\left[1 - \frac{(B-1)^c}{B^c}\right]$$

where B is the number of sectors around the disc.

This equation is taken from equation (5), Part I, except that the factor of one half is removed from the equation since any of the sectors can be utilized in each revolution in Proposal Three whereas only one half could be used per revolution in Proposal Two. Thus, for B = 16, the above equation reduces to:

$$BTR = 16 - \left(\frac{15}{16}\right)^c$$

Summary

Proposal Three as used with the Burroughs disc file will provide a Message Store capable of storing more than 70,000 blocks of data with a throughput of 330 blocks per sec. This throughput corresponds to a data transfer rate at the DAC terminals of 90 thousand bits per sec. for two characters per memory word and 120 thousand bits per sec. for three characters per memory word. Since the three character packing seems most likely the disc system will be able to provide the 100 thousand bits per sec. throughput specified for the DAC system.

L E Gallaher

HO-2423-LEG-VFP L. E. GALLAHER

Att.
Figures 1 - 4

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MM.

No. 1 ESS - Data Administration Center - Message Store Queueing - Case 39215-2 and 200513

FEB 11 1964

R. W. Ketchledge

MR. J. W. FALK (2):

A patentability study is requested for the queueing concept developed by Lee E. Gallaher of Department 2423. The work case on DAC is 39215-25.

Objective:

To increase the data throughput of a sequential memory.

Description:

Normally, the time required to gain access to a particular piece or block of data in a sequential access memory limits the throughput or rate of transfer from the memory. Thus if data with random addresses are requested from the memory, normally an average of only two or fewer data transfers can be obtained per memory period. A memory period is the time between two consecutive accesses of the same data bit. Thus for a drum with one head per track the memory period is the time for one revolution of the drum.

Queueing is used to organize the data transfer requests so that many units or blocks of data can be transferred to or from the memory unit in each memory period. Use is made of a buffer memory to hold the queue or work list that has been organized by a sorting process so that the orders in the queue or queues are arranged in the same order in which they become available in the sequential memory.

This is particularly useful in the case of a drum or disc memory having one head per track using block storage techniques. By arranging the block assignment so blocks on all tracks or groups of tracks start at the same time, then the queue list need only be ordered for the number of blocks in a track or track group, since we can equally well proceed to any track on the drum (except, of course, it is easier to stay on the last track used).

Technical Memorandum 63-2423-8 by L. E. Gallaher contains a description of queueing applied to a drum system.

Features:

It is believed that the concept of queueing a work list for a sequential memory allows such memories to be used in higher throughput applications than would be possible without such queueing.

Comparison:

Although there are many techniques for improving the data flow rate into a sequential memory, it is believed that the method proposed here is the only way of increasing the data flow rate both into and out of a sequential access memory.

Use:

The primary use of this method will be to increase the throughput of sequential memories used for file purposes. It is best suited for storage and retrieval of independent blocks of data such as would occur in a "store and forward" communication system.

Urgency:

The use of the above method is planned for the ESS-DAC Message Store in order to meet the system throughput objectives. The use of this method is imperative to the system.

Original signed by
R. W. Ketchledge

HO-2423-LEG-VFP R. W. KETCHLEDGE

Att.
Technical Memorandum MM-63-2423-8

DAC - Release of Technical Memoranda - Case 39215-1

JUN - 9 1964

MR. D. B. ERWIN
Assistant Superintendent
Development Engineering
WECo - Columbus, Ohio

In connection with Mr. K. L. Kleberdanz's function to perform liaison efforts between the Bell Telephone Laboratories and the Columbus Works regarding the DAC system, we are releasing to him the following technical memoranda:

MM 63-2423-8 No. 1 ESS Ways of Increasing Throughput of DAC Message Store Part 1 by L. E. Gallaher

MM 64-2423-2 No. 1 ESS Ways of Increasing Throughput of DAC Message Store Part 2 by L. E. Gallaher

In releasing this information it is understood that you will take the necessary precautions to prevent any compromise of this material with people outside the company, since knowledge of the circuits, equipment and technical content may impair our patent rights.

ORIGINAL SIGNED BY
C. P. MARCHETTO

C. P. MARCHETTO
Head
Electronic Switching Projects
Equipment Department

HO-2444-KLK-PAS

APPROVED:

Original signed by
R. W. Ketchledge

R. W. Ketchledge

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Messrs. L. E. Gallaher - HO ← THIS COPY FOR
J. P. Hoffmann - HO

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