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ABSTRACT

1. 1401 Core Stretching for Table Look-Up
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3. Unique table look-up techniques are described emphasizing compactness, speed and flexibility.

The discussions cover a single character conversion technique, a randomizing and chaining approach and a multipass procedure for tables exceeding core storage capacity.

The single character conversion uses the four bit arithmetic of the 1401 core addressing scheme. This is illustrated by an example of binary to octal transformation. The randomizing and chaining technique continues this example by converting the octal to 7094 language mnemonics.

The multipass approach, illustrated by an editing problem, utilizes the tape load mode to identify errors with wordmarks.

INTRODUCTION

This paper is intended to acquaint the reader with some unusual approaches to three widely different table look-up requirements. It is improbable that the reader will be confronted with similar problems on identical hardware, however, he may be able to use a variation of the techniques discussed here. Therefore, the following hardware requirements should not be interpreted as limitations to the application of these techniques. The illustrations used require a 1401 with 8000 positions of storage and the Advanced Programming Package. In addition, the first two examples need the Column Binary Feature.

THE SINGLE CHARACTER CONVERSION TECHNIQUE

To illustrate this technique, let us assume a 1401 Utility Program is needed to print an octal dump of a binary tape written by the IBM 7094. Since the 7094 has a 36-bit binary word, a word is written on tape as six binary characters of six bits each. The binary to octal conversion routine must therefore substitute for every character read in from tape, two octal digits representing three binary bits each. This conversion can be accomplished rapidly by employing the 1401 core addressing scheme.

A brief review of the makeup of the 1401 core storage address codes is desirable. The 1401 has a three character address. The numeric values of the three characters range from 000 to 999, thereby specifying one out of 1000 locations. The zone bits over the hundreds' and units' positions of the address indicate by modulus 16 arithmetic (figure 1) which of the sixteen groups of 1000 core locations is designated. The zone in the units position of the address specifies which quadrant of 4000 storage locations is referenced, while the zone in the hundreds position determines which group of 1000 locations is referenced within a quadrant.

The binary character to be converted is used to formulate a unique core address, which then locates the proper two digit octal representation in a table (figure 2). Ideally this character is placed directly in the hundreds position of an index register used to access the table. This will not work in all cases, however, since only forty of the sixty-four possible character configurations are valid storage address codes. To clarify this procedure let us first examine how this technique works for the forty valid address codes.

The table of two digit octal constants for these forty character configurations is distributed from locations 4087 to 7987, separated by increments of 100 locations (figure 2). For the conversion, index register 1 is preset to a value of 087 (step 1) and the character to be converted is moved into the hundreds position of the index register (step 2), thereby replacing the zero. The contents of index 1 can now range from a value of 087 to 3987, depending upon the bit configuration of the character to be converted. Now a move instruction is executed as shown (step 3).

MCW 4000 + X1, 0210

The two digit octal constant, located at the effective address of 4000 plus the contents of index 1, is thereby moved to the print area. For example, an input character with a bit configuration of a "D" causes the following to take place:

- Step 1. Index 1 = 087
- Step 2. Index 1 = D87 or 3487
- Step 3. MCW 4000 + 3487, 0210

This generates an effective address of 7487 and the octal constant in the table at this address should be 64, as illustrated below.

<u>BIT IDENTITY</u>	<u>BIT STATUS</u>	<u>BCD ADDRESS VALUE</u>	<u>OCTAL VALUE</u>
B	ON	} 3	} 6
A	ON		
8	OFF		
4	ON	} 4	} 4
2	OFF		
1	OFF		

Since the zone bits of any character to be converted are always valid, a legitimate storage address code can be identified by determining that the numeric portion of the character is a value from 0 to 9. For each of the twenty-four characters that do not fit this category, the exact bit configuration of the numeric portion of the character must be determined. This is accomplished through a series of bit tests (see flowchart figure 3) and index register 1 is then preset according to the following table.

<u>BIT POSITIONS</u>	<u>8</u>	<u>4</u>	<u>2</u>	<u>1</u>	<u>INDEX 1 SETTING</u>	<u>BCD</u>
	OFF	OFF	OFF	OFF	590	BLANK
	ON	OFF	ON	ON	090	11
	ON	ON	OFF	OFF	190	12
	ON	ON	OFF	ON	290	13
	ON	ON	ON	OFF	390	14
	ON	ON	ON	ON	490	15

Now only the zone of the character to be converted is moved over to the hundreds position of index register 1, and the octal digits can now be set in the print area with the same move instruction used for the valid address code characters.

The flowchart (figure 3) explains the detailed instruction logic and the core storage layout (figure 2) shows the table distribution and values for the first 1000 locations.

This illustration used a binary to octal transformation, but there are other conversion requirements which fit this table look-up approach. A few examples are listed here.

1. Five or eight channel paper tape conversion to BCD characters.
2. Fixed point binary numbers to decimal integers.
3. Conversion of column binary cards to row binary cards.

This technique can be adapted to a 1401 with 4000 core storage positions by one additional test on the "B" bit. This would cut the table distribution area to 2000 positions. On the surface, it may seem poor utilization of core storage to distribute a 128-position table over 4000 positions of core; however, the space between the table constants is available for program instructions and other constants, and can be used efficiently.

THE RANDOMIZING AND CHAINING APPROACH

This approach is an adaptation of the RAMAC method for randomizing and chaining disk records. To illustrate this technique, we will assume that the octal words assembled from the binary tape in the previous example are actually 7094 program instructions. It is therefore desirable for the programmers that the appropriate 7094 mnemonic language codes are printed with the octal words to facilitate program debugging. A 1401 routine is needed to look up the mnemonic designation for the octal operation code.

The basic 7094 operation code consists of the second, third and fourth octal digits of each word. The first digit of each word is called the prefix, and with the exception of six instructions, the prefix will always be either 0 or 4, commonly referred to as positive or negative. As there are no eights or nines in the octal system, the other three digits can range in value from 000 to 777. Many of these numbers do not constitute legitimate 7094 operation codes. Some combinations are valid only if the prefix is positive, and some only if the prefix is negative, while some other operation codes represent instructions in both the positive and negative form. Certain operation codes are more complex and require that other digits be decoded for proper instruction execution. These are not relevant to this discussion and they will be disregarded. They can be treated by exception or as variations to this table look up approach.

The table of mnemonic language codes is again located in the upper 4000 positions of storage (figure 2). To accomplish the table look up, the three digit operation code is randomized by multiplying by a factor of 5. The answer is a minimum of 0000 and a maximum of 3885. This number must be converted to a three character core storage address. By examining the thousands' position of the result, index register 1 is set according to the following table.

<u>THOUSANDS' POSITION</u>	<u>INDEX 1</u>	<u>NUMERIC EQUIVALENT</u>
0	00 †	4000
1	†0 †	5000
2	0̄0 †	6000
3	+0 †	7000

The three low order positions of the multiply field are then added to the contents of index 1, thus providing a three character 1401 core storage address equivalent to 4000, plus the result of the multiplication. This address will be the test position for each operation code. If there is no wordmark associated with the

test position address, the operation code is not valid. The 7094 word is therefore a data word and a mnemonic interpretation is not printed. When a wordmark is present at the test location, the octal code represents a legitimate instruction. Further tests on this position establish the condition for which this operation code is valid, as indicated below:

1. A "B" bit (-) indicates the operation code is valid only if the prefix is negative.
2. Both "A" and "B" bits (+) indicate the operation code is valid only if the prefix is positive.
3. A "1" bit indicates the operation code is valid for both a positive and a negative prefix.

If only one form of the operation code is valid, then the mnemonic equivalent is located in the four core locations preceding the test address. Therefore, if the prefix satisfies the condition, the mnemonic constant can be moved to the appropriate position in the print area. The word is again assumed to be a data word if the prefix is not of the same sign as the test position stipulates.

When both forms of the operation code are valid, a chain core storage address is provided in the three storage positions preceding the test address. This chain address is moved into index register 1. For the positive prefix, the mnemonic language code is located in the four positions preceding the chain address, while for the negative operation code, the mnemonic equivalent is found in the four positions following the chain address. A simple test on the prefix of the 7094 word will therefore determine which mnemonic (using index 1) is to be moved to the print area.

It is interesting to note the distribution pattern of the mnemonics in the table area (figure 2). Two fields of ten characters each, from position 36 to 45 and from positions 86 to 95 in every hundred core locations, remain entirely free. In addition, the areas from 396 to 485 and from 896 to 985 remain free for every thousand core locations. This, of course, is the result of multiplying an octal number (containing no eights and nines) by a factor of five. It makes it possible to combine the binary to octal conversion table of the previous discussion with the mnemonic language table.

The obvious merit of this table look-up procedure is speed, but also important is the resulting savings in core storage. The vacant areas resulting from the unused octal operation codes are first packed with the chained mnemonic codes. The remaining free areas can be used for other constants and program instructions, although care must be taken to avoid setting a wordmark in a test position for a superfluous operation code.

THE MULTIPASS TABLE LOOK-UP

The illustration used to explain this multipass technique for tables exceeding core storage capacity is an editing program pertaining to airline passenger statistics. The program has to verify the accuracy of the input information and provide a record of the errors found. The tape records to be edited are summaries of airline passenger routings. The information is in coded form as illustrated by the following example:

LGA FA CHI PJ LAX

These passengers flew from New York (LGA) to Chicago (CHI) by Fictitious Airlines (FA) and from Chicago to Los Angeles (LAX) by Phantom Jetlines (PJ). The editing checks required are as follows:

1. Do the abbreviations represent legitimate city and carrier codes?
2. Do these airlines run a regularly scheduled flight for the cities reported in the routing?

The table used to edit the tape records frequently has to be revised as new airports are opened and flight itineraries are altered. This makes it practical to keep the table information in punched cards, so the table can be easily updated to reflect the changes. The table cards consist of the city code, followed by the identifying codes of the airlines providing service to that city. The cards are grouped together alphabetically by the first letter of the city code to decrease processing time in the edit phase. The entire table cannot fit into core storage at one time, yet a tape data record may contain any of the city codes. For this reason, the data tape must be passed once for each section of the table loaded.

The program consists of a loading routine and an edit routine. The loading routine loads each city as a table segment of variable length. The length of each segment is determined by the number of airlines servicing the city. The total number of characters occupied by each table segment is inserted in the first three characters of the segment. This is analogous to the usual procedure for formatting variable lengths tape records. The segment length is followed by the city code, behind which are placed the applicable airline codes.

The loading routine has several other important functions. It must initialize a sequence of twenty-six constants which represent the starting core locations for each group of city codes with the same first letter. These constants allow the edit routine to limit its search for a matching city code by examining only that section of the table pertaining to cities with the same initial code letter. The twenty-six constants each have a test character associated with it. This test character is coded by the loading routine. It will indicate to the edit routine whether that group of table cards has been completely loaded in the table, is partially loaded in the table, or is not in core for this edit pass.

The loading routine must accumulate a count of the table area loaded, and compare this to a constant designating the total amount of core storage available for the table. When the table area is filled, or all the cards are processed, the loading routine passes control to the edit routine.

The edit routine accesses a city code in the tape record and looks it up in the table. It uses the first letter of the city code to determine which of the twenty-six constants, set up by the load program, is to be used. The test character is examined first to see if the city code group has been loaded. If this group is not in core, the edit routine proceeds to the next city code in the tape record. If the group has been loaded, the edit routine, using the appropriate constant, initializes the table index register to the starting core location for that city code group. After a city in the table has been checked for a match, the length of that table segment is added to the table index register. This provides access to the next city code in the table. When a match is found, the edit routine checks the carrier or carriers designated in the routing as servicing the city against the carriers listed in the table segment. The length of the segment, as specified in the first three characters, allows the edit routine to determine when all the airline codes have been examined. If no match is found for a city code, the test character for that group of cities must be checked to determine if the group was only partially loaded in the table. If this is the case, no error or completion indication is set.

The edit routine reads and writes the data tape records in the load mode for each pass of the tape. This enables it to indicate with wordmarks the codes already edited and the errors found. When a city code has passed the edit successfully, a wordmark is set under the high order position of the three character city abbreviation in the tape record. Errors are indicated in the following manner:

1. A city code not matched in the table has a wordmark set in each character of the code in the tape record.
2. An airline represented in the routing as servicing a city for which it is not listed in the table, causes wordmarks to be set in all positions of the airline and city code in the tape record.

At the end of each pass, tape switching occurs and control is returned to the load program.

			Hundreds	Units
A + A	= B	or	2	8
A + B	= AB	or	3	12
B + B	= No A No B	or	0	0
A + AB	= No A No B	or	0	0
A + No A No B	= A	or	1	4
B + AB	= A	or	1	4
B + No A No B	= B	or	2	8
AB + AB	= B	or	2	8

figure 1 - Modulus 16 Arithmetic

Reference: IBM 1401 Data Processing System - Reference Manual A24-1403-5

LEGEND: V = WORDMARK
O = NO WORDMARK ALLOWED
IN THAT POSITION

TABLE OF CCHAL
CONSTANTS
DATE 3996 →

APPLICATION	SYMBOLIC	DATA	LOCATION	WORD MARK
4000 - 4099	SYMBOLIC			
	DATA			
	LOCATION			
	WORD MARK			
4100 - 4199	SYMBOLIC			
	DATA	DSA TTR TRCA TRCC		
	LOCATION			
	WORD MARK			
4200 - 4299	SYMBOLIC			
	DATA	DSIA TIO LGAI PAI TIF TRCE TRCF TRCG TRCH TIR TEFA TEFB DSA DSA DSA DSA RFI SIR RNI RIR		
	LOCATION			
	WORD MARK			
4300 - 4399	SYMBOLIC			
	DATA	DSB TCB TCC TCD TCE TCF TCG TCH TIR TEFA TEFB DSA DSA DSA DSA TIO RIA		
	LOCATION			
	WORD MARK			
4400 - 4499	SYMBOLIC			
	DATA			
	LOCATION			
	WORD MARK			
4500 - 4599	SYMBOLIC			
	DATA	TIF PIA IIR IIL RFT LFT SIR SIL RNT LNT RIR RIL DSA CVRI TCOA TCNA		
	LOCATION			
	WORD MARK			
4600 - 4699	SYMBOLIC			
	DATA	TCOB TCNB TCC TENC TCD TEND TCE TCNE XCL -ACA TCOF TCNF TCOG TCNG TCOH TCNH		
	LOCATION			
	WORD MARK			
4700 - 4799	SYMBOLIC			
	DATA	TZE TNZ CVR CAQ TPL TMI TOV TNA MPY MPR FDH DFH CRQ -FDP DFDP		
	LOCATION			
	WORD MARK			
4800 - 4899	SYMBOLIC			
	DATA	TQB TQP +LBT PBT CHS EFTM SSP SSM ENK LETM IOT ESTM COM ECTM ETM LTM		
	LOCATION			
	WORD MARK			
4900 - 4999	SYMBOLIC			
	DATA			
	LOCATION			
	WORD MARK			

Fold to Here **Figure 2**

Application _____ Date _____ Page _____ of _____
 Procedure _____ Drawn By _____

01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19

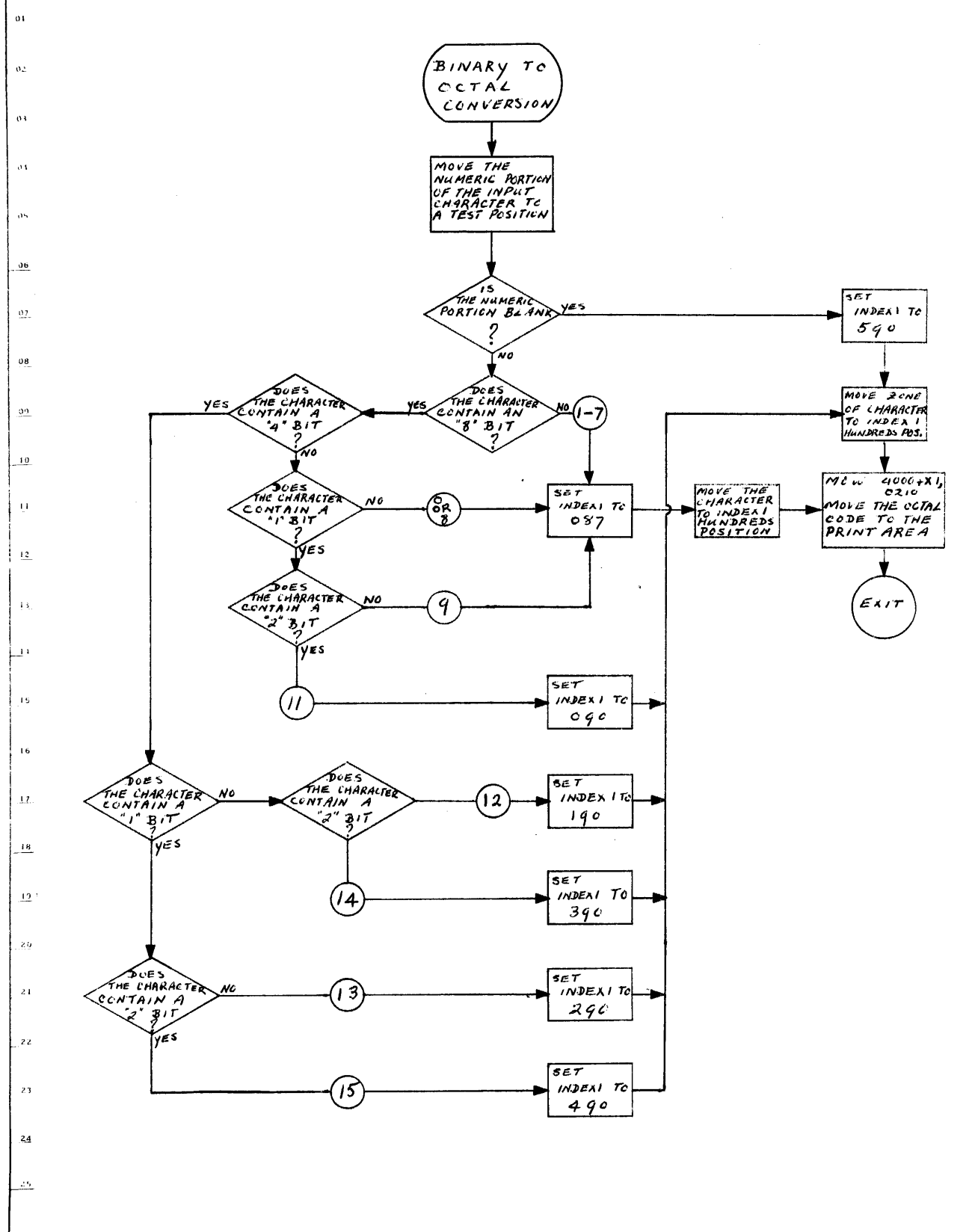


Figure 3