IBM Systems Reference Library

Sort 7
Specifications and Operating Procedures
IBM 1401 and 1460

Program 1401-SM-060

This reference publication contains the specifications and operating procedures for the Sort-7 program. The *Specifications* section describes the sorting technique, the tape-loadable and user-programming features of the program, file requirements and control cards.

The *Operating Procedures* section contains the instruction for transferring Sort 7 to tape and for executing the Sort-7 program. A description of the Sort-7 program deck, system preparation, and a list of halts and messages are also included.

Schematics of Type A and Type B standard tape labels are given in the *Appendix* to this publication.

For a list of associated publications and abstracts, see the *IBM 1401/1460 Bibliography*, Form A24-1495.

Contents

Sort 7 for the IBM 1401 and 1460 Data Processing Systems provides the user with the ability to sort records that are stored on magnetic tape. The sorted records are arranged in collating sequence, either ascending or descending, according to the control data within the records.

Control cards, prepared by the user, modify the generalized Sort 7 program to fit the requirements of a specific sort application. The Sort 7 program can be loaded from cards or tape. An optional program, supplied with Sort 7, modifies the card-oriented Sort 7 program and transfers it to tape.

Sort 7 performs tape sorting in two steps. The first step, phase 1, is an internal sort. This means that a number of records in random order are read into core storage from an input tape and then rearranged internally into the desired sequence. As the sequences *(strings)* are developed, they are written alternately on two output tapes if four tape units are used in the operation, or in rotation on three output tapes if six tape units are used.

The second step, phase 2, consists of a series of merge passes that results in a sequential tape file. If four tape units are used for sorting, a 2-way balanced merge or a multiphase merge can be performed. The multiphase merge option reduces overall sort time when fixed-length records are being sorted. If six tape units are available, a 3-way balanced merge can be performed.

The Sort-7 program:

- Sorts blocked or unblocked records.
- Sorts fixed- or variable-length records (except for the multiphase option that sorts only fixed-length records).
- Sorts according to control data contained in as many as ten fields of each record.
- Sorts on either numeric or alphameric control data.
- Sorts records in ascending or descending order. The collating sequence is given in the *System Operation Reference Manual: IBM 1401 and 1460 Data Processing Systems,* Form A24-3067.
- Allows the user to insert routines that are to be executed during the Sort 7 program run.
- Processes standard 120-character (Type A) and 80-character (Type B) header and trailer labels on the input file, if desired.
- Labels output tapes, if desired, in accordance with control-card information.
- Provides a checkpoint routine that periodically writes the contents of core storage on tape and enables the user to stop and restart the program at various stages.
- Sorts as many records at sort blocking as will fit on either one or two reels (depending upon whether four or six tape units are used) of magnetic tape. Input records may be contained on a maximum of 99 reels.

    Note: In this publication, the term *standard tape labels* (header or trailer) refers to Type A and Type B labels. See the tape IOCS specifications publication (See *Related Information*) for a description of label processing. Also, see Figure 19: *Schematics of Type A and Type B Labels.*

Machine Requirements

The minimum machine requirements for the Sort 7 program are:

An IBM 1401 system with:

- 8000 positions of core storage.
- Four IBM 729II, 729IV, 729V, or 7330 Magnetic Tape Units; five units are required if Sort 7 is to be loaded from tape.
- IBM 1402 Card Read-Punch.
- IBM 1403 Printer Model 2, or IBM 1404 Printer.
- High-Low-Equal Compare special feature.
- Advanced Programming special feature.
- Sense switches.

An IBM 1460 system with:

- 8000 positions of core storage.
- Four IBM 7330, 729II, 729IV, 729V, or 729VI Magnetic Tape Units; five units are required if Sort 7 is to be loaded from tape.
- IBM 1402 Card Read-Punch.
- IBM 1403 Printer Model 2.
- Indexing and Store-Address-Register special feature.
- Sense switches.

Three tape units are required to transfer the Sort 7 program from cards to tape. Sense switches A, C, E, and F are used for the Sort 7 tape build job.

Five tape units are required if the Sort 7 program is to be loaded from tape.

Sense switches B, C, D, E, F, and G are used by the Sort 7 program. These switches permit operator intervention and options during the running of the program.

Related Information

The following SRL publications contain information that is related to the use of the Sort 7 program:

Input/Output Control System (on Tape) Specifications and Operating Procedures for IBM 1401 and 1460, Form C24-1462.

Autocoder (on Tape) Language Specifications and Operating Procedures for IBM 1401 and 1460, Form C24-3319.

Sorting and Merging Techniques

The sorting technique used by Sort 7 during phase 1 consists of reading a number of records from the input file, arranging them in sequences, and writing these sequences on two or three output tapes. One, two, or three tape units are used for input, and either two or three for the phase 1 output. The tapes that contain phase 1 output are called *work tapes.*

Two input units are used if the records to be sorted are contained on two or more reels in a 4-tape sort. Three input units can be used if the records are contained on more than two reels in a 6-tape sort. Reading input records from more than one tape unit is done alternately from two units or in rotation from three units. For example, if three tape units are used to read input data from more than three reels, the Sort-7 program reads all of the records from the tape on the first tape unit. It then reads all of the records from the tape on the second tape unit, and then all of the records from the tape on the third tape unit. Provision is made to permit the operator to change input reels during phase 1 without interrupting the operation. Thus, on the second rotation, a fourth reel can be mounted on the first tape unit, a fifth reel on the second, and so forth, until the last reel of the file has been processed.

Any standard header and trailer labels on the input tapes are processed during phase 1. The retention-period field in each work-tape header label is checked if the user requests the checking in his control card.

The sorted sequences developed by phase 1 are merged into one sorted sequence during phase 2. A series of merge passes are required to complete the sort. The sorted records are reblocked according to the user's specifications and are written as one sequential file on one or more output tapes.

Any temporary header labels on the work tapes are processed at the beginning of phase 2. During the last merge pass, standard header and trailer labels are developed if the user requests them in his control cards.

Types of Merges

The user has the option of electing either a balanced merge or a multiphase merge during phase 2.

Balanced Merge

Normally, a balanced merge technique is used. The multiphase merge option is applicable only when fixed-length records are to be sorted on a four tape system.

When the merge is balanced, the number of input units equals the number of output units for each merge pass. The tape units used for phase 1 input become the output units for the first merge pass. All tapes used during the merging process are considered to be work tapes.

The balanced merge is called a 2-way merge when four tape units are used and a 3-way merge when six tape units are used.

Figure 1 shows the results of a phase 1 internal sort and the first two merge passes in a 3-way balanced merge. The merging process described in Figure 1 is repeated until one sequential file is developed.
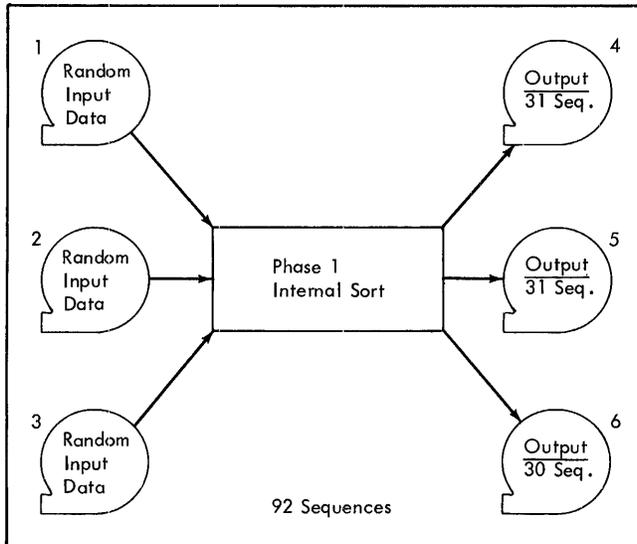
Multiphase Merge

The multiphase merge reduces the overall sorting time by 15% to 25% on four tape systems when the input files contain fixed-length records. The actual reduction in sort time depends on the randomness of the initial input data. The user specifies the multiphase merge option by turning sense switch C on before loading the Sort 7 program.

The multiphase merge is an unbalanced merge. That is, the number of input units does not equal the number of output units. The merging technique consists of a series of 3-way merges during which there are always three input units and one output unit.

Sort-7 phase-1 output is contained on two tape units regardless of the type of merging selected for phase 2. If a balanced merge is to be used, the merging process can begin immediately. However, when the multiphase merge program is to be used, the sequences must be redistributed onto three tape units before the merging can begin. The redistribution is done during an adjustment phase that follows phase 1 of the sort and actually performs the first phase of the multiphase merge.

Adjustment Phase

The redistribution of the sequences developed during phase 1 is done in accordance with certain calculated values. The calculations are performed using values from a program-generated table shown in Figure 2. Initially, a_1, b_1 and c_1 in the table are assigned values of 1. Because N at any table level is equal to the sum of a_1, b_1 and c_1 at that level, N equals three at the first level and then $N + 3c_1$ equals six. Higher table levels are generated using the previous level a_1, b_1 and c_1 values. At any table level after the first, a_1 is equal to c_1 of the level immediately preceding; b_1 is equal to the

Phase 1 — Internal Sort

Unit 1: Random Input Data
Unit 2: Random Input Data
Unit 3: Random Input Data
Phase 1 Internal Sort
Unit 4: Output 31 Seq.
Unit 5: Output 31 Seq.
Unit 6: Output 30 Seq.
92 Sequences

1. Sorts random data on unit 1 and writes the first sequence on unit 4, the second on unit 5, the third on unit 6, and repeats the process until all the sequences have been written.

2. Sorts random data on unit 2 and writes the first sequence on unit 4, the second on unit 5, the third on unit 6, and repeats the process until all the sequences have been written.

3. Sorts random data on unit 3 and writes the first sequence on unit 4, the second on unit 5, the third on unit 6, and repeats the process until all the sequences have been written.

Phase 2 — 1st Merge Pass

Unit 1: Output 18 Seq.
Unit 2: Output 17 Seq.
Unit 3: Output 17 Seq.
Phase 2 1st Merge Pass
Unit 4: Input 31 Seq.
Unit 5: Input 31 Seq.
Unit 6: Input 30 Seq.
52 Sequences

1. Merges sequences from units 4, 5, and 6 and writes the resulting sequence on unit 1.

2. Merges sequences from units 4, 5, and 6 and writes the resulting sequence on unit 2.

3. Merges sequences from units 4, 5, and 6 and writes the resulting sequence on unit 3.

4. Repeats steps 1, 2, and 3 until all the sequences on units 4, 5, and 6 have been merged and written on units 1, 2, and 3.

Phase 2 — 2nd Merge Pass

Unit 1: Input 18 Seq.
Unit 2: Input 17 Seq.
Unit 3: Input 17 Seq.
Phase 2 2nd Merge Pass
Unit 4: Output 11 Seq.
Unit 5: Output 11 Seq.
Unit 6: Output 11 Seq.
33 Sequences

1. Merges sequences from units 1, 2, and 3 and writes the resulting sequence on unit 4.

2. Merges sequences from units 1, 2, and 3 and writes the resulting sequence on unit 5.

3. Merges sequences from units 1, 2, and 3 and writes the resulting sequence on unit 6.

4. Repeats steps 1, 2, and 3 until all the sequences on units 1, 2, and 3 have been written on units 4, 5, and 6.

Figure 1. Three-Way Merge

N+3c₁	N	a₁	b₁	c₁
6	3	1	1	1
11	5	1	2	2
21	9	2	3	4
38	17	4	6	7
70	31	7	11	13
129	57	13	20	24
237	105	24	37	44
436	193	44	68	81
802	355	81	125	149
1475	653	149	230	274
2713	1201	274	423	504
4990	2209	504	778	927
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.

Figure 2. Multiphase Table

sum of a_1 and c_1 in the level immediately preceding; and c_1 is equal to the sum of the b_1 and c_1 in the level immediately preceding.

The values generated for $N + 3c_1$, at each table level are successively compared with S (the total number of sequences developed during phase 1) until a table level is reached where $N + 3c_1 \geqq S$. Then generation of succeeding levels ceases. The values a_1, b_1, and c_1 at this table level are the number of sequences that appear on three of the four available tape units when the adjustment phase is complete. If S is six or less, special values are assigned by the program.

Calculation of the factors required for redistribution of the sequences is performed using the values at the table level where $N + 3c_1 \geqq S$. The redistribution factors are calculated using the following formulas:

$$Y = \frac{S - N}{3} \text{ (rounded to the next lower integer)}$$
$$X = S - N - 2Y$$
$$P_1 = c_1 - Y$$
$$P_2 = A - X - c_1$$
$$P_3 = A + k - X - Y - a_1$$

To explain these formulas, it is assumed that during phase 1 the initial input file was read from tape unit 1; that 55 sequences of sorted records were developed; that 28 of the 55 sequences were written on tape unit 3; and that the other 27 sequences were written on tape-unit 4.

Explanation of Symbols:

P_1 = The number of sequences to be passed from tape-unit 4 to tape-unit 2.

P_2 = The number of sequences to be passed from tape-unit 4 to tape-unit 1.

P_3 = The number of sequences to be passed from tape-unit 3 to tape-unit 1.

Y = The number of sequences from tape units 1, 3, and 4 that are to be three-way merged and written on tape-unit 2.

X = The number of sequences from tape-units 3 and 4 that are to be two-way merged and written on tape-unit 1.

A = The number of sequences on tape-unit 4 at the end of phase 1.

k = The difference between the number of sequences on tape-unit 3 and the number of sequences on tape-unit 4 at the end of phase 1. This value is always either 0 or 1.

The values for N, a_1, b_1 and c_1 from the table are, respectively, 31, 7, 11 and 13. For this example, a_1 equals the number of sequences on tape-unit 3 after adjustment; b_1 equals the number of sequences that are on tape-unit 1 after adjustment; and c_1 equals the number of sequences on tape-unit 2 after adjustment.

The computed adjustment values for this example are: $P_1 = 5$; $P_2 = 6$; $P_3 = 5$; Y = 8; and X = 8.

The adjustment operations performed using these computed values are shown in Figure 3. The first operation performed is to pass P_1, or a total of 5, sequences from tape-unit 4 to tape-unit 2. Then P_2, or 6, sequences are passed from tape-unit 4 to tape-unit 1. Next P_3, or 5, sequences are passed from tape-unit 3 to tape-unit 1. The sequences are now distributed on three tapes but further adjustments are required before the multpihase merge can begin. The next operation is a two-way merge during which X, or 8, sequences are merged from tape-units 3 and 4 and then written on tape-unit 1. Then Y, or 8, sequences are three-way merged from tape-units 1, 3, and 4 and written on tape-unit 2.

Thus, the required distribution of seven sequences on tape-unit 3, eleven sequences on tape-unit 1, and thirteen sequences on tape-unit 2 is achieved, and the multiphase merge can begin.

Merge

Figure 4 is a diagram of the multiphase-merge operations for the example in the preceding section. During each phase of the merge, sequences are three-way
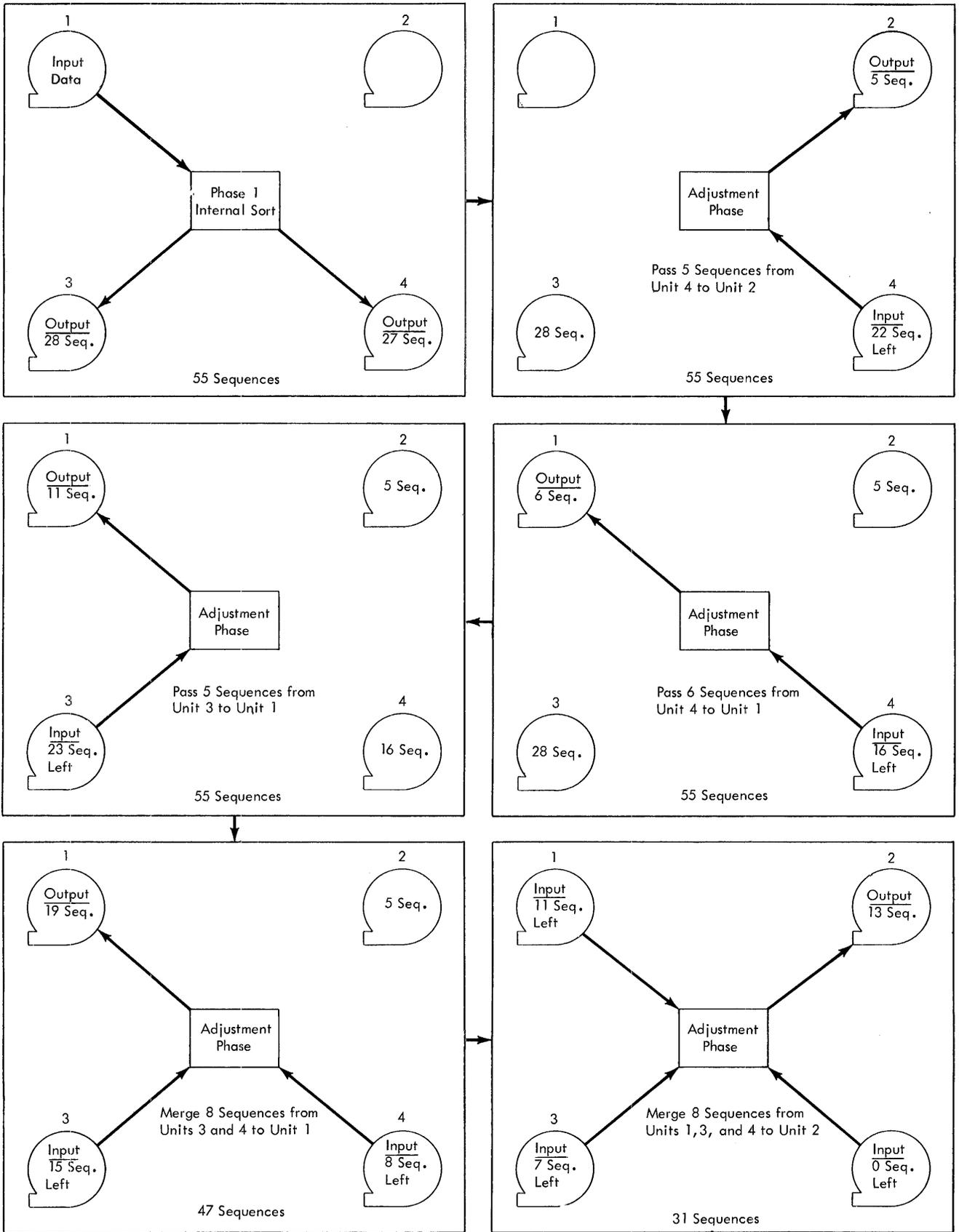
Panel 1 (top-left):

1 Input Data
2 (empty)
Phase 1 Internal Sort
3 Output 28̄ Seq.
4 Output 27̄ Seq.
55 Sequences

Panel 2 (top-right):

1 (empty)
2 Output 5̄ Seq.
Adjustment Phase
Pass 5 Sequences from Unit 4 to Unit 2
3 28 Seq.
4 Input 22̄ Seq. Left
55 Sequences

Panel 3 (middle-left):

1 Output 11̄ Seq.
2 5 Seq.
Adjustment Phase
Pass 5 Sequences from Unit 3 to Unit 1
3 Input 23̄ Seq. Left
4 16 Seq.
55 Sequences

Panel 4 (middle-right):

1 Output 6̄ Seq.
2 5 Seq.
Adjustment Phase
Pass 6 Sequences from Unit 4 to Unit 1
3 28 Seq.
4 Input 16̄ Seq. Left
55 Sequences

Panel 5 (bottom-left):

1 Output 19̄ Seq.
2 5 Seq.
Adjustment Phase
Merge 8 Sequences from Units 3 and 4 to Unit 1
3 Input 15̄ Seq. Left
4 Input 8̄ Seq. Left
47 Sequences

Panel 6 (bottom-right):

1 Input 11̄ Seq. Left
2 Output 13̄ Seq.
Adjustment Phase
Merge 8 Sequences from Units 1,3, and 4 to Unit 2
3 Input 7̄ Seq. Left
4 Input 0̄ Seq. Left
31 Sequences

Figure 3. Adjustment Phase

Multiphase Merge Program

Box 1 (top-left):

1 11 Seq

2 13 Seq.

Redistribution Completed
During Adjustment Phase

3 7 Seq.

4 0 Seq.

31 Sequences

Box 2 (top-right):

C Input 4 Seq. Left

2 Input 6 Seq. Left

Phase 2

3 Input 0 Seq. Left

Merge 7 Sequences from
Units 1, 2, and 3 to Unit 4

4 Output 7 Seq.

17 Sequences

Box 3 (middle-left):

1 Output 2 Seq.

2 Input 0 Seq. Left

Phase 2

3 Input 2 Seq. Left

Merge 2 Sequences from
Units 2, 3, and 4 to Unit 1

4 Input 1 Seq. Left

5 Sequences

Box 4 (middle-right):

1 Input 0 Seq. Left

2 Input 2 Seq. Left

Phase 2

3 Ouput 4 Seq.

Merge 4 Sequences from
Units 1, 2, and 4 to Unit 3

4 Input 3 Seq. Left

9 Sequences

Box 5 (bottom-left):

1 Input 1 Seq. Left

2 Output 1 Seq.

Phase 2

3 Input 1 Seq. Left

Merge 1 Sequence from
Units 1, 3, and 4 to Unit 2

4 Input 0 Seq. Left

3 Sequences

Box 6 (bottom-right):

1 Input 0 Seq. Left

2 Input 0 Seq. Left

Phase 2
(Final Merge)

3 Input 0 Seq. Left

Merge 1 Sequence from
Units 1, 2, and 3 to Unit 4

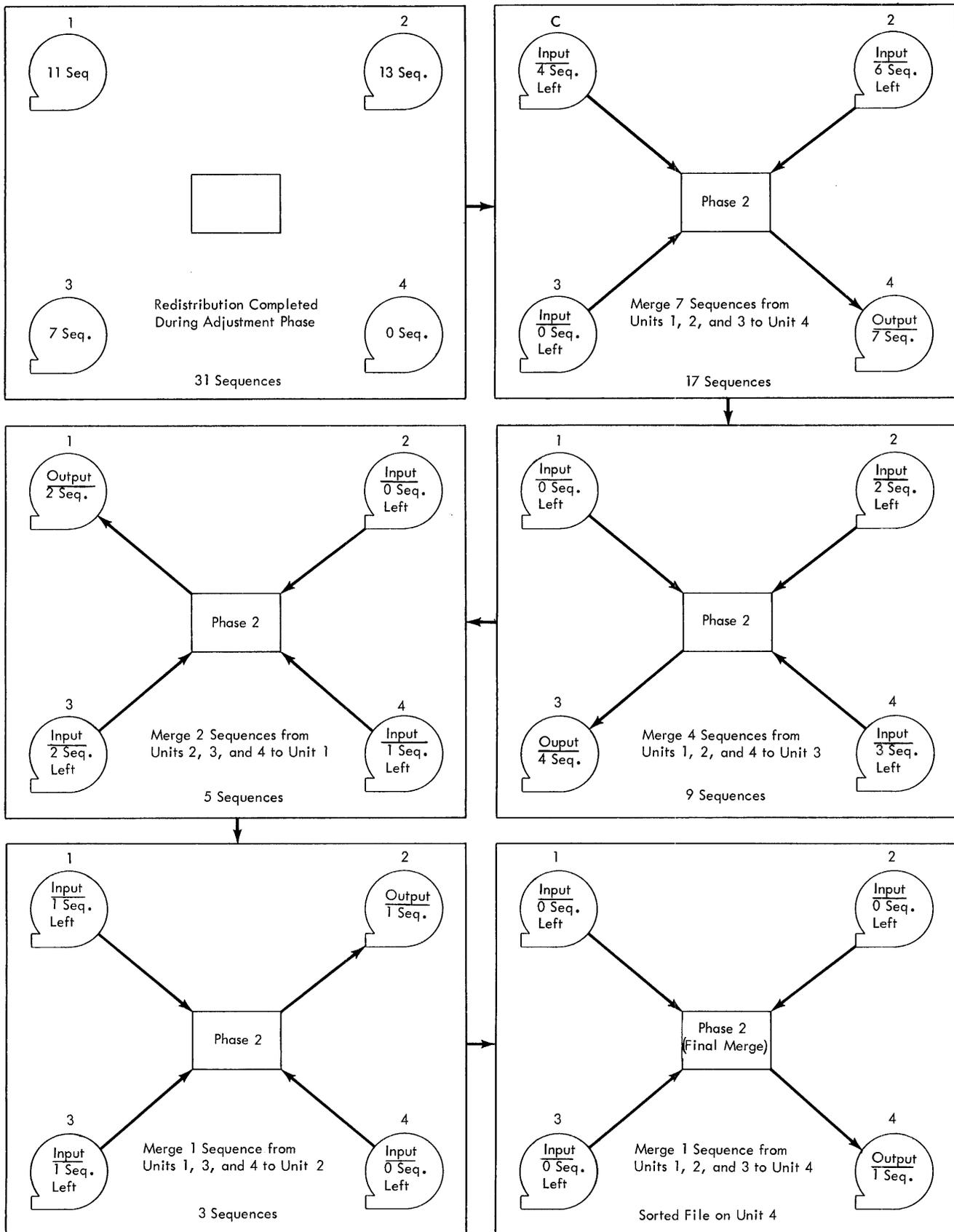4 Output 1 Seq.

Sorted File on Unit 4

Figure 4. Multiphase Merge

merged from three of the tape units and written on the fourth unit. The merging continues until all of the sequences on one of the input tapes have been read and merged. This tape is then rewound and becomes the output tape during the next merge phase. The output tape is also rewound and becomes an input tape during the next phase. This three-way merging process continues until the entire file has been merged and written on one tape, which, for this example, is on unit 4.

The specifications entered into the control card(s) are the same whether a balanced or a multiphase method of merging is employed during phase 2. All of the options available when a balanced merge is used are available during a multiphase merge including INTERRUPT and RESTART. When the program is interrupted during the multiphase-merge operations, the merge phase in process is completed, after which two of the four tapes are rewound automatically. Before the program can be restarted, each tape must be remounted on a tape unit with the same number as the one from which it was removed. Restart by pressing the tape-load key.

Tape Loadable Feature

To transfer the Sort 7 program to tape, use the optional program supplied with Sort 7. This program first inserts patch routines that make Sort 7 tape operable and then writes the modified Sort 7 on tape. At object time, patch routines occupy the uppermost 120 positions of core storage. Thus, these positions are not available for user routines.

Three tape units are required for the tape-build job. After Sort 7 has been transferred to tape, the user can perform a tape-update job to modify the tape by inserting or deleting routines. The update job can also copy the Sort 7 tape. Two tape units are required for the tape update job.

Five tape units are required when Sort 7 is loaded from tape. The Sort 7 tape must be mounted on tape unit 1. A number other than 1 must be selected as the unit number for each of the four remaining tape units. Since four tape units are used for the sort either a two-way balanced merge or a multiphase merge can be performed.

User Programming Feature

Exits are provided at key points within the main line and the input/output portions of the program so the user can set aside areas in phase 1 and/or phase 2 for his exclusive use during the program run. To reserve these areas, the user must specify the beginning address of each area in the control cards.

User routines must be written in the 1401-1460 tape Autocoder language, assembled, and punched into cards. If the Sort 7 program resides on tape, the routines must be transferred to the Sort 7 tape. The routines will increase the sorting time because they decrease the number of core storage positions available for use by the Sort 7 program.

Checkpoint and Restart Feature

Conditions may arise which make it necessary to interrupt the Sort-7 program before the sorting job being performed is complete. To allow for this possibility, a feature that permits the user to stop processing at certain stages of the sort and later to resume processing at this same point is incorporated into the program.

If processing is stopped during phase 1, all sorting performed up to that point is lost. To restart, it is necessary to reload the program deck. During phase 2, a checkpoint record is written before each merge pass begins. Thus, if processing is stopped during phase 2, only the merge pass that is interrupted is lost.

The output of the preceding pass remains intact. When the program is interrupted, the user must save the output reels from the last pass and the reel containing the checkpoint.

File Requirements

This section discusses the general characteristics of files that can be processed by Sort 7. The maximum file size depends on the record length, the sort blocking factor (number of records per block), and the density of the tape. See *User Calculations*.

Allowable Record Configurations

Sort 7 processes either fixed-length or variable-length records. The minimum record length is 13 characters for unblocked records and 10 characters for blocked records. The maximum record length per blocked or unblocked records is 3999 characters. When sorting variable length records with more than one control field and/or in descending order, the maximum record length or block length that can be handled is 3400 characters. There are four different record formats that the program can handle. A record mark following the last character of each record is optional.

The following terms are used in the description of the acceptable formats:

Block Character-Count Field: A four-character block character-count field at the beginning of each block contains a count of the total number of characters in the block including the four-character block character-

count field itself. The count, which must contain AB zone bits over the units position of the field, is used for checking for wrong-length record conditions.

Record Character-Count Field: A record character-count field of 3 or 4 characters in each data record contains a count of the number of characters in that record, including itself. This field must be in the same relative position in each data record, and must be the same length in each data record of a given file.

Form-1 Records

Form-1 records (Figure 5) are fixed-length and are written on tape unblocked.

$$L_1 = L_2 = L_3$$
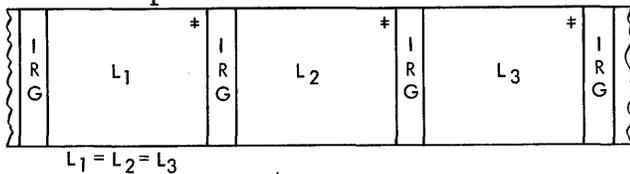
Figure 5. Form-1 Records

Form-2 Records

Form-2 records (Figure 6) are fixed-length and are written on tape in blocks. Padding records must be added to short-length blocks.
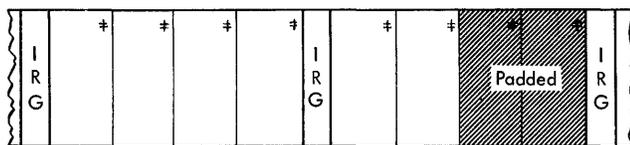

Figure 6. Form-2 Records

Form-3 Records

Form-3 records (Figures 7 and 8) are variable-length and written on tape unblocked. Each record can have a Record Character Count (RCC) field.
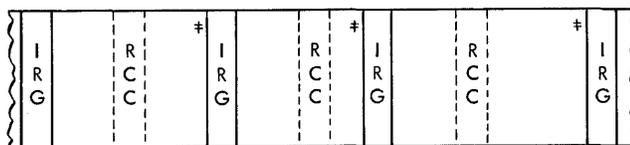

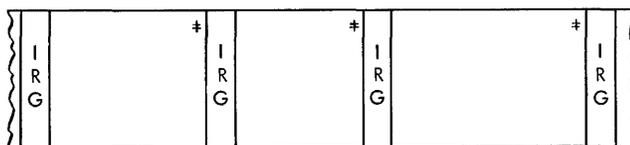Figure 7. Form-3 Record with a Record-Character Count Field

Figure 8. Form-3 Records without a Record-Character Count Field

If Form-3 records without record character count fields are specified for input, a record character count field is added at the beginning of each record (first four characters) by Sort 7 for internal processing. If the specified output record format in this case is equivalent to the input record format (that is unblocked), the added record character count field is normally deleted, and the records are restored to their original lengths. If, however, blocked output is specified, the record character count field added by Sort 7 is always retained.

Form-4 Records

Form-4 records (Figure 9) are variable-length, and written on tape in blocks. Each record contains a record character count field and each block contains a Block Character Count (BCC) field.
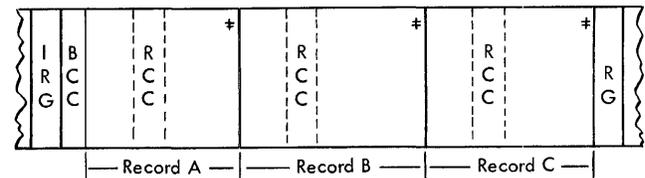

Figure 9. Form-4 Records

Restrictions

Records may contain any alphameric characters or special symbols except:

1. Tape mark as the first character of a record.

2. Record mark within a record. A record mark as the last character of each record is permissible but not mandatory.

3. A group mark.

4. A word separator. It is possible to have a word-separator character on tape if the tape is to be read in load mode. In this case the word separator reads into storage as a word mark over the character it precedes on tape. A word mark must occur in either the high-order position of a control data field, in the first position of the record, or, in the case of variable-length records, in the high-order position of the record character count field. Care must be taken to make certain that all control positions and the record length are specified correctly in this case.

Control Data Fields

From one to ten fields of each input record can be specified to control the sequence of records. These fields can be anywhere within the record, provided they are

in the same place in each record. The total length of all control-data fields may be as large as 999 characters.

The location of each control-data field must be specified by the user in the control cards. If more than one field is used, the user must specify which field is to be compared first (major), which second (intermediate or minor), and so forth.

Padding

The term *padding* refers to records added to a file to be sorted when the number of records in the file is not a multiple of the input blocking factor. These additional records are generated internally by the Sort-7 program. Padding does not occur in the case of variable-length records.

Sort 7 automatically adds padding records to an input file if, after reading into storage the last block of records during phase 1, it finds that there are insufficient records to fill the processing area. Enough padding records are generated to fill the remainder of the processing area. Padding records generated by Sort 7 are sorted and merged in the same manner as data input records. They must, therefore, be composed either entirely of nines or entirely of blanks. The user's choice must be punched in one of the control cards. If they contain nines, they will be the last records (ascending sequence) or first records (descending sequence) of a sorted file. If they contain blanks, the opposite results will be obtained.

The Sort program checks only the control data fields to determine padding records in the actual sorting or merging phases. A record mark may be the last character of each padding record generated, if the user so specifies.

Tape Density

The Sort-7 program processes input reels written in either high- or low-density mode. The final output reel or reels may be written in either density, although high density is recommended. The user need only set the density switch of the output tape unit to the density desired.

Note: If processing is performed in the high-density mode and the final output is in low density, the final output may require more than one full reel of magnetic tape for a two-way merge, or more than two full reels for a three-way merge. In this situation, the program halts when an end-of-reel is encountered during final output. The user may then mount a new tape and continue.

Input/Output Mode

Unless otherwise specified by the user in the control cards, the input tape(s) are assumed to be written in move mode. Tapes written in load mode can be processed by Sort 7 only if any word marks for the input data are in the high-order position of any control data field, in the beginning of a record, or in the high-order position of the record character count field. Records with word marks in any other position, and written on tape in the load mode, cannot be processed.

Sort 7 writes the phase-2 sorted output on tape in either move or load mode, depending upon the needs of the user. An output file written in load mode contains word marks over the high-order position of all control fields and over the first character of each record.

Sort Program Control Totals

In balanced sorting, all records in the file are read and written during each phase-2 merge pass. For this reason, a record count may be maintained during each pass and compared against the count from the previous pass to make certain records have not been dropped or added. If the counts differ, a halt will occur. The user, at this point, may restart the pass or continue with the sort.

In multiphase sorting, the number of records read and written during each phase-2 merge pass will vary. It is only during the last merge pass that all the records in the file will be handled. Therefore, it is impossible to provide an internal check from pass to pass. Instead, the phase 1 record count is compared to the record count taken during the final merge pass. If the counts differ, the end-of-sort message containing the record count will indicate that an error condition exists.

Unreadable Input Records

Tape records or blocks are considered unreadable when they contain one or more characters that cause redundancy indications after one hundred attempts have been made to read them. A wrong length record is not a redundant record and is not treated as such by the Sort-7 program.

Input tape blocks that are unreadable may be treated in a variety of ways, depending upon information specified by the user in the control cards. The Sort-7 program:

1. Writes the unreadable block on tape.

2. Punches it into cards, or

3. Prints the block on the printer.

If the user selects options 1 or 2, the program continues without halting and deletes the block as specified. If option 3 is chosen (printing the block), the program halts after printing is complete. The user then can attempt to correct the block, or he can accept the block as read.

Tape Labels

Sort 7 can process standard 120-character (Type A) and standard 80-character (Type B) header and trailer tape labels. See the tape IOCS specifications publication for a description of tape labels and label processing. Also, see Figure 19: *Schematics of Type A and Type B Labels.* The user can specify the kind of processing desired by means of the control cards.

Nonstandard header and trailer labels (not exceeding 120 characters in length) on the input tapes can be bypassed by Sort 7, or the labels can be processed by user routines. Exits are provided at convenient points to permit the inclusion of the user routines.

Input Header Labels

The Sort-7 program, depending upon control-card information, either bypasses or checks standard header labels on the input tapes. The user can specify that full label-checking or checking of just the file name be performed on each input header label. The file serial number, reel-sequence number, file name, and creation date are checked when full label-checking is specified.

When the input tapes contain nonstandard header labels, the user must specify in the control cards that the input tapes contain header labels and that label checking is not to be performed. Then, if the user does not insert a routine to process the nonstandard labels, the Sort-7 program bypasses the header labels.

If the user specifies in the control cards that the input tapes contain header labels, then all input tapes must contain a header label. The header labels on all tapes must conform to the user specifications on the control cards.

Work-Tape Header Labels

The work tapes for phase 2 of the Sort-7 program can contain standard header labels, or temporary header labels, or no header labels.

If the work tapes contain standard header labels, the user is permitted to specify that the sort check the retention cycle of the tapes. This safeguards master tape(s) that may still remain on the input tape unit(s) at the beginning of phase 2.

The work tapes can have temporary 80-character header labels that have the following format:

Positions	Contents
1-4	1HDR
5	Blank
6-10	Tape serial number
11-80	Blanks

The work tapes can have temporary 120-character header labels that have the following format:

Positions	Contents
1-4	1HDR
5	Blank
6-30	Blanks
31-35	Tape serial number
36-120	Blanks

If the user specifies that the work tapes do not contain labels, Sort 7 writes a temporary header label on each work tape.

Output Header Labels

The user can specify that standard header labels be written on the output tapes. The user can further specify, in the control cards, that these header labels contain either the information from the header label on the first input tape or information supplied by the user in a control card.

The information in positions 1-40 of the header label on the first input tape, with the exception of the creation date, can be duplicated in the header label written on each output tape. The current date, which must be punched in a control card, is written in the creation-date field of the output header labels.

If an entirely new standard header label is to be written on the output tapes, the user must punch the header-label information, with the exception of the tape serial number, into a control card. If the new label is to be a standard 80-character label, the user has the option of either punching a tape serial number into the control card or having the program place the tape serial number from the output tape into the new header label. This option is not available for standard 120-character labels.

Input Trailer Labels

Standard trailer labels on input tapes can be either bypassed or processed by Sort 7. If the user specifies that either 80-character or 120-character trailer labels are to be processed, the label is read, the label information is printed, and the block count maintained by the program is compared with the block count from the trailer label. If 80-character trailer labels are specified, the record count maintained by the program is also compared with the record count from the trailer label.

Nonstandard trailer labels can either be bypassed, or as each label is read either the first 80 or 120 characters can be printed as specified. The latter option must be used if user processing is desired. The process-

ing of nonstandard labels must be done by a user routine.

Trailer labels are not maintained on the Sort 7 work tapes.

Output Trailer Labels

Sort 7 and Merge 7 generate standard trailer labels and write them on the output tapes, if the user so specifies. Each generated output trailer label contains an end-of-reel or an end-of-file indication and a block count that is maintained by the program. The eighty character label also contains the record count that is accumulated by the program. Any further output trailer-label processing must be done by user-inserted routines.

Label Error Procedures

The Sort 7 program prints each input tape label the first time it is read. If an error is found when the program is checking either an input header label or an output header label, a message is printed and the program halts. The user can then either mount the correct tape and cause the program to check the header label on this tape or continue the operation with the incorrectly labeled tape. In the latter case, the program continues as if the tape were labeled correctly.

Sort 7 halts if the program-generated block count does not equal the block count contained in the input trailer label being checked. The user can then either accept the program block count as valid and continue the operation or check the input tape by editing it or making a rerun.

A similar halt occurs if a discrepancy is found when the record count maintained by the program is compared to the record count located on 80-character trailer label. There is no record count field on the 120-character label.

User Calculations

The Sort 7 program calculates and prints out the values of the following constants:

1. For fixed-length record applications:

   B is the sort blocking factor used by Sort 7.

   BL is the length of the sort block.

   MFS is the maximum file size.

   G is the number of records sorted internally at one time.

2. For variable-length records:

   BL_{max} which is the maximum length of a sort block.

   MFS is the maximum file size.

The user can calculate the values of these constants by using the formulas given in this section.

Fixed-Length Records

This section contains the formulas that can be used to determine the sort blocking factor (B), the sort block length (BL), the number of records sorted internally at one time (G), and the maximum file size (MFS).

Sort Blocking Factor

For a given application, the Sort 7 program calculates the sort blocking factor (B_{actual}). The user can determine B_{actual} if the maximum allowable blocking factor (B_{max}) and the users' input blocking factor (BI) are known. Calculate B_{max} as follows:

$$B_{max} = \left\lfloor \frac{ST - PS2 - UA2 - 12}{(M+1)\,L} \right\rfloor$$

where $\lfloor\ \rfloor$ means rounded low.

ST = Core storage capacity of the 1401 or 1460 system.

PS2 = Number of core storage positions required by phase 2 of the Sort 7 program.

This value is:

3925 for a balanced merge with standard label processing.

3225 for a balanced merge without standard label processing.

3215 for a multiphase merge with standard label processing.

2815 for a multiphase merge without standard label processing.

UA2 = Number of core storage positions required for user programming in phase 2. If a user area is not required, and

1. The program is on cards, UA2 = 0.

2. The program is on tape, UA2 = 120.

M = Type of phase 2 merge. This value is:

2 for a four-tape balanced merge.

3 for a multiphase merge (four-tape sort only).

3 for a six-tape balanced merge.

L = Record length.

After B_{max} has been calculated, B_{actual} can be determined using the following formula:

$$B_{actual} = \left\lfloor \frac{B_{max}}{BI} \right\rfloor (BI)$$

Where BI = the user's input blocking factor. BI should be equal to or a factor of B_{max}.

The value of the output blocking factor (BO) *must* be equal to or a factor of B_{max}; it must not exceed B_{max}.

Optimum Input Blocking Factor

The Sort-7 optimum input blocking factor (BI) is the actual sort-blocking factor (B) used in phase 2 of the program. The optimum input blocking factors shown in Figures 10 and 11 are based on the assumptions that fixed-length records are being sorted, and that a user-written routine has not been inserted in phase 2.

Number of Records Sorted Internally

The number of fixed-length records that can be sorted internally at one time (G_{actual}) can be determined if the sort block length (BL) is known. Calculate BL as follows:

$$BL = (B_{actual})(L)$$

where B_{actual} = Blocking factor determined by Sort 7

L = Record length

BL should be calculated for each sort application. The minimum BL is 400 characters; the maximum BL is 3999 characters.

The calculation of G_{actual} is an iterative process that uses the formula:

$$G_n = \left\lfloor \frac{ST - PS1_n - BL - UA1 - 2}{L + 3} \right\rfloor$$

2-WAY MERGE

Core-Storage Size	Record Length							
	10	20	40	80	100	200	500	1,000
8,000	135	67	33	16	13	6	2	1
12,000	268	134	67	33	26	13	5	2
16,000	399	199	99	49	39	19	7	3

3-WAY MERGE

Core-Storage Size	Record Length							
	10	20	40	80	100	200	500	1,000
8,000	101	50	25	12	10	5	2	1
12,000	201	100	50	25	20	10	4	2
16,000	301	150	75	37	30	15	6	3

MULTIPHASE MERGE

Core-Storage Size	Record Length							
	10	20	40	80	100	200	500	1,000
8,000	119	59	29	14	11	5	2	1
12,000	219	109	54	27	21	10	4	2
16,000	319	159	79	39	31	15	6	3

Figure 10. Optimum Input Blocking Factors when Tape Label Processing Is Specified

2-WAY MERGE

Core-Storage Size	Record Length							
	10	20	40	80	100	200	500	1,000
8,000	158	79	39	19	15	7	3	1
12,000	292	146	73	36	29	14	5	2
16,000	399	199	99	49	39	19	7	3

3-WAY MERGE

Core-Storage Size	Record Length							
	10	20	40	80	100	200	500	1,000
8,000	119	59	29	14	11	5	2	1
12,000	219	109	54	27	21	10	4	2
16,000	319	159	79	39	31	15	6	3

MULTIPHASE MERGE

Core-Storage Size	Record Length							
	10	20	40	80	100	200	500	1,000
8,000	129	64	32	16	12	6	2	1
12,000	229	114	57	28	22	11	4	2
16,000	329	164	82	41	32	16	6	3

Figure 11. Optimum Input Blocking Factors when Tape Label Processing Is Not Specified

where $\lfloor\ \rfloor$ means rounded low.

UA1 = Number of core storage positions required for user programming in phase 1. If a user area is not required and

1. The program is on cards, UA1 = 0.

2. The program is on tape, UA1 = 120.

Note: G is never greater than 2B when multiphase merging is used.

During each iteration, a value is calculated for G_n based on a $PS1_n$ value that is obtained from the chart in Figure 12. The iterations cease when two successive calculated G_n values fall within a particular range of G_n values shown in Figure 11. The last calculated G_n value is then used in the following formula to calculate G_{actual}.

$$G_{actual} = \left\lfloor \frac{G_n}{B_{actual}} \right\rfloor (B_{actual})$$

The method of calculating B_{actual} and G_{actual} is shown in the following example. Assume that fixed-length records are being sorted, a balanced merge with label processing is being used, and that:

$$ST = 16000$$

G_n	$PS1_n$
1	3215
2	3250
4	3320
8	3463
16	3504
32	3586
64	3750
128	3833
256	3999
512	4331

Figure 12. Values of G and Their Associated Phase-1 Program Sizes

$$L = 100$$
$$B_1 = 3$$
$$M = 2$$
$$UA1 = 0$$
$$UA2 = 0$$

Then:

$$B_{max} = \left\lfloor \frac{16000 - 3925 - 0 - 6}{3(100)} \right\rfloor = \left\lfloor \frac{12069}{300} \right\rfloor = 40$$

$$B_{actual} = \left\lfloor \frac{40}{3} \right\rfloor (3) = (13)(3) = 39$$

$$BL = (39)(100) = 3900$$

Then, using the first value of $PS1_n$ shown in the chart:

$$G_1 = \left\lfloor \frac{16000 - 3215 - 3900 - 0 - 2}{103} \right\rfloor = \left\lfloor \frac{8883}{103} \right\rfloor = 86$$

For the next iteration, use the $PS1_n$ value that is shown opposite the upper limit of the range in which G_1 falls. Thus, $PS1_n$ for the next iteration is 3833 because $2^6 < G_1 < 2^7$.

Then:

$$G_2 = \left\lfloor \frac{16000 - 3833 - 3900 - 2}{103} \right\rfloor = \left\lfloor \frac{8265}{103} \right\rfloor = 80$$

Because G_1 and G_2 are within the same range in the chart ($2^6 < G_2 < G_1 < 2^7$), the iterations cease. G_{actual} is calculated using the last calculated G_n value (80).

$$G_{actual} = \left\lfloor \frac{80}{39} \right\rfloor (39) = (2)(39) = 78.$$

Maximum File Size

The input file to be processed by Sort 7 must be no longer than the number of records that can be contained on one reel (if phase 2 is a two-way merge or a multiphase merge), or on two reels (if phase 2 is a three-way merge). This number depends on record length, the sort blocking-factor, and whether processing is performed in the low- or high-density magnetic-tape mode. It can be determined as follows:

$$R = \frac{K \times B (N - 1)}{(B \times L) + IRG}$$

Explanation of Symbols:

R = Maximum number of input records.

K = Number of usable character positions per tape reel (assume 2,300 feet).
High-density tape: 22,080,000. (800 characters per inch).
High-density tape: 15,350,000. (556 characters per inch).
Low-density tape: 5,520,000. (200 characters per inch).

B = Sort blocking-factor.

L = Record length (if fixed) or maximum record length (if variable).

IRG = Number of character locations per interrecord gap (.75").
High-density tape: 417.
Low-density tape: 150.

N = Type of phase 2 merge. This value is:

2 for a four-tape balanced merge (2-way merge).

2 for a multiphase merge (four-tape sort only).

3 for a six-tape balanced merge (3-way merge).

Variable-Length Records

This section contains the formulas that can be used to determine the maximum sort block length (BL_{max}), the maximum number of core storage positions used for internal sorting (GL_{max}), and the maximum file size (MFS).

Maximum Sort Block Length

For a given application, the Sort 7 program calculates the maximum sort block length (BL_{max}). An actual blocking factor cannot be calculated since it will vary depending on the record length.

Calculate BL_{max} using the following formula:

$$BL_{max} = \left\lfloor \frac{ST - PS2 - UA2 - 12}{(M + 1)} \right\rfloor$$

See *Fixed Length Records: Sort Blocking Factor* for an explanation of the symbols used in the formula.

BL_{max} must not be greater than 3,999 characters or less than 400 characters.

Core Storage Used for Internal Sorting

The user should determine the maximum number of core storage positions used for internal sorting (GL_{max}) if he plans to use his own routines with Sort 7.

First calculate the value of G. Use the following formula for G_n and perform the necessary iterations until two successive calculated G_n values fall within a particular range of G_n values shown in Figure 12.

$$G_n = \left\lfloor \frac{ST - PS1_n - BL_{max} - UA1 - 2}{L_{min} + 3} \right\rfloor$$

Multiply the last calculated G_n value by L_{min} to determine GL_{max}.

See *Fixed Length Records: Number of Records Sorted Internally* for explanations of the iterative process and the symbols used in the formula.

For example, assume that a 3-way balanced merge with label processing is being used and that:

$$ST = 12000$$
$$L_{max} = 150$$
$$L_{min} = 15$$
$$UA1 = 3000$$
$$UA2 = 2000$$
$$B_1L_{max} = 900$$

Then:

$$BL_{max} = \left\lfloor \frac{12000 - 3925 - 2000 - 8}{3 + 1} \right\rfloor$$
$$= \left\lfloor \frac{6067}{4} \right\rfloor = 1516$$

For the first iteration, use $PS1_n = 3215$:

$$G_1 = \left\lfloor \frac{12000 - 3215 - 1516 - 3000 - 2}{15 + 3} \right\rfloor$$
$$= \left\lfloor \frac{4267}{18} \right\rfloor = 237$$

Thus, $PS1_n = 3999$ for the next iteration:

$$G_2 = \left\lfloor \frac{12000 - 3999 - 1516 - 3000 - 2}{15 + 3} \right\rfloor$$
$$= \left\lfloor \frac{3483}{18} \right\rfloor = 193$$

Because $2^7 < G_2 < G_1 < 2^8$ GL_{max} is calculated using the value of G_2:

$$GL_{max} = (193)(15) = 2895$$

Maximum File Size

The formula for estimating the maximum file size is the same as for fixed-length records.

User Programming

The user can write his own routines and incorporate them in the Sort 7 program. Exits, in the form of four-character no-op instructions, are provided at various points in the program. These no-op instructions can be easily changed to unconditional branches so that, during the running of the program, user-written routines can be executed.

A user's program in phase 1 tends to decrease the number of records that can be internally sorted (G). One included in phase 2 decreases the sort block length (BL). Therefore, these programs should be kept to a minimum so as not to affect sorting time to any great extent.

If the multiphase merge option is elected, user programming routines can be incorporated in phase 1 as usual. However, a routine incorporated in phase 2 must be associated with the final merge phase only.

A user routine should be written in IBM 1401-1460 tape Autocoder language and be assembled by the tape Autocoder processor.

If Sort 7 is to be loaded from tape, column 78 must not be used. The last instruction of each routine must be a branch back to the next sequential instruction in the Sort-7 program. After the routine has been assembled and a condensed object deck has been punched, the first three cards and the last card of the object deck should be removed. These are the clear-storage cards 1 and 2, the bootstrap card, and the clear-and-branch card.

To use any exit, the user punches a patch card that contains a branch instruction which overlays the no-op instruction. The format of the patch card is:

Columns	Contain	Explanation
1-4	BIII	This is the branch instruction that will replace the no-op. Punch the address (actual machine language) of the first instruction of the user-written routine into the positions indicated by III.
5-39	Blanks	

| 40-46 | L004XXX | This instruction loads the branch instruction from columns 1-4 of this card into core storage. The positions indicated by XXX contain the address (actual machine language) of the rightmost position of the no-op instruction. |

47-67	N000000N000000N000000
68-71	1040
72-80	Blanks

If index registers 1, 2, or 3 are to be used during the execution of the user routine, the contents of the register(s) must be saved. After the user routine has been executed and before the branch back to the next sequential instruction of the Sort-7 program, the contents of the index register(s) must be restored.

If Sort 7 is to be loaded from cards, the patch card followed by the user's object deck must be inserted in the Sort 7 program deck.

If Sort 7 is on tape, an ALTER card is also required for each user routine, or group of routines that is to be inserted between the same EX (execute) statement, that is to be transferred to the Sort 7 tape. The format of this card is:

Columns	Contain	Explanation
16-20	ALTER	
21-24	Object card sequence number	This is the card sequence number of the next EX (execute) statement after the no-op instruction on the program listing. The card sequence number must be four digits.
25-26	Blank	

The ALTER statement, the patch, and the user routine must be transferred to the Sort 7 tape by means of an update job.

Two programmed exits facilitate the addition of user programs to the program tape.

1. *Label—USERE1, location—0413, sequence number —150.*

This exit is available during the tape-build and tape-update operations. It can be used to add programs or routines to the program tape. When it occurs, tape unit 3 has been rewound and group marks have been placed in core-storage positions 81 and 181, as well as in the uppermost core position in the system.

The core-storage area between positions 3500 and 7500 is available for the program to be added. Insert the branch card and the routine between card number 0080 and card number 0081.

2. *Label—USERE2, location—2374, sequence number —525.*

This exit follows the halt that results when the tape-load key is pressed after halt 005 (see Figure 13). It enables the user to add programs or routines to the program tape. To get to the branch operation, the user must press the start-reset key and then the start key.

The core-storage area between positions 3500 and 7500 is available for the program to be added. Insert the branch card and the routine between card number 0080 and card number 0081.

If the user routines are assembled before Sort 7 is transferred to tape, the user can insert the routines in the Sort 7 deck and transfer both to tape by means of a build job. In this case, no ALTER cards are required.

The starting address of the phase 1 and/or phase 2 user programming area(s) must be specified in the control card. The user should subtract the number of positions required for his routines from the upper core storage limit (7999 for 8K, 11999 for 12K, 15999 for 16K). If Sort 7 is to be loaded from tape, the uppermost 120 positions are used by Sort 7. In this case, add 120 to the number of positions required for the user routine(s) before determining the starting address of the phase 1 and/or phase 2 user programming area(s).

Because Sort 7 uses the print area in core storage for label processing, the user is responsible for saving any data that may be in that area at the time his routine is initiated. This data must be restored in the print area before completion of the user's routine.

This section describes the exits available during the assignment phase, phase 1, and phase 2. The program-listing sequence number and the core-storage address of the leftmost position of the no-op instruction are shown for each exit. The branch instruction punched in the patch card is loaded into core storage in the locations that contain the no-op instruction for the exit.

If the routines are to become part of the Sort 7 program deck, they must be inserted between the appropriate cards. The sequence numbers of the cards are given for each exit or group of exits.

If Sort 7 is to be loaded from cards, the uppermost two positions in phase 1 and the uppermost 16 positions in phase 2 (multiphase) and the uppermost 22 positions in phase 2 (balanced) are used by the Sort program and are not available for user routines. These positions should be taken into consideration when the starting addresses of the user areas are determined.

Assignment Phase

1. *Label—EXITAP, location—982, sequence number —1360.*

This exit is available in the assignment phase after the dump tape (specified in column 19 of control card 1) has been rewound. This exit can be used to process a label on the dump tape if desired.

Insert the patch card and the assembled user routine for this exit between cards 0272 and 0273. Core storage usable for this routine is available between positions 1570 and 3975.

Sort 7 generates a work-tape header label on the dump tape if the dump-tape option is specified.

Phase-1 Exits

The lowest core-storage position that can be reserved for user programming in phase 1 when fixed-length records are being sorted can be determined using the formula:

$$\frac{\text{Lowest core-storage}}{\text{position available}} = PS1 + BL + GL + 6$$

Where:

PS1 = The $PS1_n$ value in Figure 1 that is shown opposite the upper limit of the range within which G_{actual} is contained. This value is 3833 for the example in *Fixed-Length Records*.

When variable-length records are being sorted, substitute BL_{max} for BL and GL_{max} for GL in the preceding formula. PS1 for variable-length records is the $PS1_n$ shown opposite the upper limit of the range within which G_2 is contained.

Use exits 1-4 for processing standard 80-character labels or nonstandard labels with 80 characters or less. Insert the patch card(s) and the assembled user routine(s) between card 0398 and card 0399.

1. *Label — EXIT7, location — 2481, sequence number — 1795.*

    This exit is available in the label-handling routine after an input header label has been read and checking, if specified, has been performed. This exit may be used to:

    a. Perform additional checking of the header label.

    b. Process a nonstandard header label, or,

    c. Read any additional header labels on the input tape.

    The low-order position of the header label that has just been read is 201, the high-order position is 280. The first 40 positions of the first header label are stored in positions 422-461, if a *1* is punched in column 22 of control card 1.

    The contents of positions 201-280 are printed during the label-handling routine.

The user should punch a *1* in column 21 of control card 1 if this exit is to be used to work on nonstandard header labels.

Note: The lowest core-storage position available for reading the first header label is 6500. The formula for calculating the lowest core-storage position is inapplicable because the EXIT7 instruction is executed before the complete initialization of phase 1. However, the formula *is* applicable for reading header labels after the first.

2. *Label — EXIT0, location — 4334, sequence number — 2078.*

    This exit is available before any work-tape labels are created or read, if labels are specified.

    Work-tape labels will be written on the output tapes if they are specified in column 4 of control card 3 or if columns 21-25 of control card 1 are not left blank.

    The low-order position of the label is 4175 (WLAREA − 29). The high-order position is 4254 (WLAREA + 50). After this exit, the labels will be read and checking, if specified, will be performed.

    If positions 4175-4254 do not contain a label, a temporary label will be constructed in these positions. Thus, this exit can be used to create labels before label checking.

3. *Label — EXIT5, location — 4658, sequence number — 2144.*

    This exit is available in the label-handling routine just before the writing of an output header label. If work-tape labels are specified:

    a. The label has been read, and

    b. Retention-cycle checking has been performed, if specified.

    If work-tape labels are not specified, a temporary work label has been set up in the label area ready to be written as an output header label.

    Any modification or checking of the work-tape header label can be performed at this time.

    This exit can also be used to produce the output header label on the work tapes. The label is written from WLAREA − 29 (4175). The user has 80 positions (4175-4254) for a nonstandard header label. A group mark can be found at WLGM (4256).

4. *Label — EXIT9, location — 4707, sequence number — 2154.*

    This exit is available after the phase-1 work-tape labels have been written.

    Use exits 5-8 for processing standard 120-character labels or nonstandard labels with 120 characters

or less. Insert the patch card(s) and the assembled user routine(s) between card 0442 and card 0443.

5. *Label — USEXT7, location — 2481, sequence number — 2264.*

   This exit is available in the label-handling routine after an input header label has been read and checking, if specified, has been performed. This exit may be used to:

   a. Perform additional checking of the header label.

   b. Process a nonstandard header label, or

   c. Read any additional header labels on the input tape.

   The low-order position of the header label that has just been read is 201, the high-order position is 320. The first 40 positions of the first header label are stored in positions 422-461, if a *3* is punched in column 22 of control card 1.

   The contents of positions 201-320 are printed during the label-handling routine.

   The user should punch a *3* in column 21 of control card 1 if this exit is to be used to work on nonstandard header labels.

   Note: The lowest core-storage position available for reading the first header label is 6500. The formula for calculating the lowest core-storage position is inapplicable because the USEXT7 instruction is executed before the complete initialization of phase 1. However, the formula *is* applicable for reading header labels after the first.

6. *Label — USEXT0, location — 4381, sequence number — 2339.*

   This exit is available before any work-tape labels are created or read, if labels are specified.

   Work-tape labels will be written on the output tapes if they are specified in column 4 of control card 3, or if columns 21-25 of control card 1 are not left blank.

   The low-order position of the label is 4175 (WLAREA − 29); the high-order position is 4294 (WLAREA + 90). After this exit, the labels will be read and checking, if specified, will be performed.

   If positions 4175-4294 do not contain a label, a temporary label will be constructed in these positions. Thus, this exit can be used to create labels before label checking.

7. *Label — USEXT5, location — 4659, sequence number — 2398.*

   This exit is available in the label-handling routine just before the writing of an output header label. If work-tape labels are specified:

a. The label has been read, and

b. Retention-cycle checking has been performed, if specified.

   If work-tape labels are not specified, a temporary work label has been set up in the label area ready to be written as an output header label.

   Any modification or checking of the work-tape header label can be performed at this time.

   This exit can also be used to produce the output header label on the work tapes. The label is written from WLAREA − 29 (4175). The user has 120 positions (4175-4294) for a nonstandard header label. A group mark can be found at MAGMWL (4296).

8. *Label — USEXT9, location — 4708, sequence number — 2407.*

   This exit is available after the phase-1 work-tape labels have been written.

9. *Label — USEXT6, location — 2658, sequence number — 2305.*

   This exit is available just after the standard 120-character input trailer label is read and checked, if specified. Any additional checking can be performed at this time.

   This exit also can be used to read or process any additional trailer labels that have 120 characters or less. Core storage positions 201-320 contain the trailer label.

   Note: Column 24 of control card 1 should contain a *3* if the user wants to process nonstandard trailer labels with 120 characters or less.

   Insert the patch card(s) and the assembled user routine(s) for exits 10-13 between card 0632 and card 0633.

10. *Label — PUTEXT, location — 1405, sequence number — 1571.*

    This exit occurs before records are moved from the input area to the output area. Index-register 1 contains the core-storage address of the beginning of the input record.

11. *Label — RITEXT, location — 1657, sequence number — 1628.*

    This exit is available immediately before writing a block of records on one of the output tapes. Core storage positions 1665-1667 contain the starting address of the output area.

12. *Label — GETEXT, location — 1920, sequence number — 1681.*

This exit is available after a tape record has been read and the associated error-checking is complete except for the wrong-length record check. Index-register 3 contains the core-storage address of the beginning of the input block. Index-register 1 contains the core-storage address of the group mark that was placed one position to the right of the last character of the block.

The exit can be used to perform:

a. *Record modification or editing.* Do not change the length of fixed-length records. If variable-length records are modified in length, be certain that both the record character count and block character count (if either is present) reflect the change. Also, modify the contents of index-register 1 accordingly, and relocate the group mark.

b. *Deletion.* The entire block can be deleted by branching the program to the instruction labeled NOISRT, location 2043, sequence-number 1710, in the tape read routine. If only selected records within the block are to be deleted, additional programming is required.

The user should insert blanks or nines in the control data field(s) of the record(s). The record can be deleted during the final output phase if an entire block of such records exits.

c. *Record-length check.* The user can insert a routine to check the length of variable-length records. Sort 7 does not check the lengths of variable length records.

13. *Label — EXIT6, location — 2680, sequence number — 1836.*

This exit is available just after the standard 80-character input trailer label is read and checked, if specified. Any additional checking can be performed at this time.

This exit also can be used to read or process any additional trailer labels that have 80 characters or less. Core storage positions 201-280 contain the trailer label.

Note: Column 24 of control card 1 should contain a *1* if the user wants to process nonstandard trailer labels with 80 characters or less.

Phase-2 Exits

This section describes the exits that are available for user-written routines during phase 2.

Phase-2 user-written routines should be placed into core storage above position 7000 for balanced merging and above 6000 for multiphase merging. This is necessary because the checkpoint record routine in this phase requires core-storage positions below this location.

Exits 1, 2, and 3 are available in the routine that processes standard 80-character labels on the work tapes (phase 2 prephase). These exits can be used regardless of which merging technique is employed in phase 2. Insert the patch card(s) and assembled user routine(s) for exits 1, 2, and 3 between card 0690 and card 0691.

1. *Label—EXDTAP, location—831, sequence number—3566.*

    This exit is available just before phase 2 is loaded into core storage. It can be used to process the header label on the dump tape.

2. *Label—PREIPX, location—1090, sequence number—3612.*

    This exit is available after the input header label has been read. Any checking of the label can be performed at this time. The low-order position of the label that has just been read is 700 (SWKLBA). The high-order position is 779. Position 780 contains a group mark.

3. *Label—PREOTX, location—1308, sequence number—3661.*

    This exit is available after the output header label (on the work tape) has been read and before it is written. The label can be modified, if desired, at this time. The low-order position of the label is 700 (SWKLBA); the high-order position is 779. Position 780 contains a group mark.

    Exits 4, 5, and 6 are available in the routine that processes standard 120-character labels on the work tapes (phase 2 prephase). These exits can be used regardless of which merging technique is employed in phase 2. Insert the patch card(s) and assembled user routine(s) for exits 4, 5, and 6 between card 0726 and card 0727.

4. *Label—EXETAP, location—852, sequence number—3775.*

    This exit is available just before phase 2 is loaded into core storage. It can be used to process the header label on the dump tape.

5. *Label—PRAIPX, location—1104, sequence number—3820.*

    This exit is available after the input header label has been read. Any checking of the label can be performed at this time. The low-order position of the label that has just been read is 700 (SWKLBA). The high-order position is 819. Position 820 contains a group mark.

6. *Label—PRAOTX, location—1319, sequence number—3866.*

This exit is available after the output header label (on the work tape) has been read and before it is written. The label can be modified, if desired, at this time. The low-order position of the label is 700 (SWKLBA). The high-order position is 819. Position 820 contains a group mark.

Exits 7-26 are available when a *balanced* merge is used in phase 2.

Insert the patch card(s) and assembled user routine(s) for exits 7-14 between card 1056 and card 1057.

7. *Label — EXIT1, location — 1171, sequence number — 4059.*

This exit can be used to make any desired modification to the output block before it is written. Core storage positions 1186-1188 contain the starting address of the output area.

8. *Label — EXIT2, location — 1310, sequence number — 4083.*

This exit is available after the first input area has been filled. All error-checking has been done at this time. Core storage positions 1273-1275 contain the starting address of the first input area.

9. *Label — EXIT3, location — 1420, sequence number — 4104.*

This exit is available after the second input area has been filled. All error-checking has been done at this time. Core storage positions 1383-1385 contain the starting address of the second input area.

10. *Label — EXIT4, location — 1530, sequence number — 4125.*

This exit is available after the third input area has been filled. All error-checking has been done at this time. This exit is not available when a two-way merge is employed in phase 2. Core storage positions 1493-1495 contain the starting address of the third input area.

11. *Label—HTEXRT, location—3290, sequence number—4448.*

This exit is available after the 80-character header label on an input work tape has been read. The label can be checked at this time.

The reading of the label is part of the prepass routine that is performed just before each phase 2 pass.

The low-order position of the label is 101. The high-order position is 180.

12. *Label—HTEXWT, location—3226, sequence number—4455.*

This exit is available after the 80-character header label on an output work tape has been read and before it is written. The label can be modified at this time.

The low-order position of the label is 101. The high-order position is 180.

13. *Label—EXTLMP, location—4939, sequence number—5293.*

This exit is available before the last merge pass. Any desired modification for the final pass can be made at this time. Also, if deletion of records is desired, exits 1-3 (80-character labels) or exits 4-6 (120-character labels) should be initialized.

14. *Label—EXTCKP, location—5692, sequence number—5409.*

This exit is available before the checkpoint record for the next pass is written. Any special routines that have been added to the program can be updated at this time. The updated routines will be executed during the next pass of phase 2.

Insert the patch card(s) and the assembled routines for exits 15 and 16 between card 0890 and card 0891.

15. *Label—HTAXRT, location—3298, sequence number—4760.*

This exit is available after the 120-character header label on an input work tape has been read. The label can be checked at this time.

The reading of the label is part of the prepass routine that is performed just before each phase 2 pass.

The low-order position of the label is 201. The high-order position is 320.

16. *Label—HTAXWT, location—3334, sequence number—4766.*

This exit is available after the 120-character header label on an output work tape has been read and before it is written. The label can be modified at this time.

The low-order position of the label is 201. The high-order position is 320.

Use exits 17-21 for processing standard 80-character labels or nonstandard labels with 80 charac-

ters or less. Insert the patch card(s) and the assembled user routine(s) between card 1499 and card 1500.

17. *Label—LPHDX1, location—3280, sequence number—7947.*

This exit is available during the last merge pass after the header label on the output tape has been read but before any label-checking has been done.

The header label on the output tape has been read into positions 100-179.

After this exit, Sort 7 performs a series of moves from RTCYCL + 1 (461) into the header-label area. The information in the label area will be used to build the new output label if one is desired.

18. *Label—LPHDX2, location—3353, sequence number—7962.*

This exit is available during the last merge pass just before the output header label is written. Modifications to the output header label can be made at this time.

The label has been built in standard 80-character format in positions 100-179.

19. *Label—LPHDX3, location—3375, sequence number—7966.*

This exit is available during the last merge pass after the output header label has been written. The tape mark following the header label has not been written.

20. *Label—LPTRX1, location—3791, sequence number—8059.*

This exit is available during the last merge pass before the output trailer label is written. Modifications to the trailer label can be made at this time.

The trailer label will be written from positions 100-179. The block count has been moved into position 109. The address of the record count has been stored in ACTNR. The record count is kept in the last fourteen positions in core storage.

21. *Label—LPTRX2, location—3822, sequence number—8064.*

This exit is available during the last merge pass after the output trailer label has been written. Additional trailer labels can be written at this time.

The tape mark has not been written after the trailer label. The block count is returned to zero as each successive output trailer label is written.

Use exits 22-26 for processing standard 120-character labels or nonstandard labels with 120 characters or less. Insert the patch card(s) and the assembled user routine(s) between card 1530 and card 1531.

22. *Label—LPHEX1, location—3269, sequence number—8151.*

This exit is available during the last merge pass after the header label on the output tape has been read but before any label-checking has been done.

The header label on the output tape has been read into positions 200-319.

After this exit, Sort 7 performs a series of moves from RTCYCL + 1 into the header-label area. The information in the label area will be used to build the new output label if one is desired.

23. *Label—LPHEX2, location—3322, sequence number—8160.*

This exit is available during the last merge pass just before the output header label is written. Modifications to the output header label can be made at this time.

The label has been built in standard 120-character format in positions 200-319.

24. *Label—LPHEX3, location—3348, sequence number—8165.*

This exit is available during the last merge pass after the output header label has been written. The tape mark following the header label has not been written.

25. *Label—LPTSX1, location—3759, sequence number—8257.*

This exit is available during the last merge pass before the output trailer label is written. Modifications to the trailer label can be made at this time.

The trailer label will be written from positions 200-319. The block count has been moved into position 209.

26. *Label—LPTSX2, location—3790, sequence number—8262.*

This exit is available during the last merge pass after the output trailer label has been written. Additional trailer labels can be written at this time.

The tape mark has not been written after the trailer label. The block count is returned to zero as each successive output trailer label is written.

Exits 27-46 are available when a *multiphase* merge is used in phase 2.

Insert the patch card(s) and assembled user routine(s), for exits 27-34, between card 1436 and card 1437.

27. *Label — WTEX, location — 895, sequence number — 5843.*

This exit is available before an output block is written. Core storage positions 953-955 contain the starting address of the output area.

28. *Label — RD1EX, location — 1091, sequence number — 5877.*

This exit is available after the first input area has been filled. All error-checking has been done at this time. Core-storage positions 1055-1057 contain the starting address of the first input area.

29. *Label — RD2EX, location — 1224, sequence number — 5899.*

This exit is available after the second input area has been filled. All error-checking has been done at this time. Core storage positions 1188-1190 contain the starting address of the second input area.

30. *Label — RD3EX, location — 1357, sequence number — 5921.*

This exit is available after the third input area has been filled. All error-checking has been done at this time. Core storage positions 1321-1323 contain the starting address of the third input area.

31. *Label—MULEX1, location—2826, sequence number—6110.*

This exit is available after the 80-character header label on a work tape has been read. The label can be checked at this time. The header label has been read into positions 101-180.

32. *Label—MULEX2, location—2912, sequence number—6123.*

This exit is available after the 80-character output header label on a work tape has been read and before it is written. The label can be modified at this time. The header label will be written from position 101-180.

33. *Label — CPEX, location — 4841, sequence number — 7442.*

This exit is available before the checkpoint record for the next pass is written. Any special routines

that have been added to the program can be updated at this time. The updated routines will be executed during the next merge pass.

34. *Label — LPEX, location — 4925, sequence number — 7457.*

This exit is available before the last merge pass. Any desired modification for the final pass can be made at this time.

Insert the patch card(s) and the assembled routine(s) for exits 35 and 36 between card 1225 and card 1226.

35. *Label—MULAX1, location—2827, sequence number—6581.*

This exit is available after the 120-character header label on a work tape has been read. The label can be checked at this time. The header label has been read into positions 201-320.

36. *Label—MULAX2, location—2913, sequence number—6594.*

This exit is available after the 120-character output header label on a work tape has been read and before it is written. The label can be modified at this time. The header label will be written from positions 201-320.

Use exits 37-41 for processing standard 80-character labels or nonstandard labels with 80 characters or less. Insert the patch card(s) and the assembled user routine(s) between card 1557 and card 1558.

37. *Label—FPHDX1, location—2490, sequence number—8325.*

This exit is available during the last merge pass after the header label on the output tape has been read but before any label-checking has been done. The header label has been read into positions 100-179. Error-checking has been performed.

38. *Label—FPHDX2, location—2568, sequence number—8340.*

This exit is available during the last merge pass before the output header label is written. Modifications to the output header label can be made at this time. The header label will be written from positions 100-179. The contents of RTCYCL + 1 have been moved into the header-label area (100-139).

39. *Label—FPHDX3, location—2585, sequence number—8343.*

This exit is available during the last merge pass after the header label has been written. The tape mark has not been written on the tape.

40. *Label—FTREX1, location—2994, sequence number—8434.*

This exit is available during the last merge pass before the output trailer label is written. Modificacations to the trailer label can be made at this time. The trailer label will be written from positions 100-179. The block count has been moved to position 109. The record count is stored in ACTNR. The record count is kept in the last fourteen positions in core storage.

41. *Label—FTREX2, location—3025, sequence number—8439.*

This exit is available during the last merge pass after the output trailer label has been written. Additional trailer labels can be written at this time. After this exit, positions 100-180 are cleared. The block count is returned to zero. A tape mark is written and the tape is unloaded.

Use exits 41-46 for processing standard 120-character labels or nonstandard labels with 120 characters or less. Insert the patch card(s) and the assembled user routine(s) between card 1587 and card 1588.

42. *Label—FPHEX1, location—2484, sequence number—8519.*

This exit is available during the last merge pass after the header label on the output tape has been read but before any label-checking has been done. The header label has been read into positions 200-319. Error-checking has been performed.

43. *Label—FPHEX2, location—2542, sequence number—8530.*

This exit is available during the last merge pass before the output header label is written. Modifications to the output header label can be made at this time. The header label will be written from positions 100-179. The contents of RTCYCL + 1 have been moved into the header-label area (200-239).

44. *Label—FPHEX3, location—2559, sequence number—8533.*

This exit is available during the last merge pass after the header label has been written. The tape mark has not been written on the tape.

45. *Label—FTRAX1, location—2967, sequence number—8621.*

This exit is available during the last merge pass before the output trailer label is written. Modifications to the trailer label can be made at this time. The trailer label will be written from positions 200-319. The block count has been moved to position 109.

46. *Label—FTRAX2, location—2998, sequence number—8626.*

This exit is available during the last merge pass after the output trailer label has been written. Additional trailer labels can be written at this time. After this exit, positions 200-320 are cleared. The block count is returned to zero. A tape mark is written and the tape is unloaded.

Control Cards

This section describes the five object-time control cards that supply the Sort 7 program with the parameters of the file to be sorted and the three control cards that are associated with the tape loadable Sort 7 program.

Object Time Control Cards

Control card 1 must always be used.

Control card 2 is required only if more than one control-data field is used in the sort.

Control card 3 is used to specify that special options are desired. If these options are not desired in the program, the card need not be present.

Control cards 4 and 5 are used if certain input and output header label options are specified. Control card 4 is used if the input tape files have standard header labels that are to be checked. If this option is desired, a column 21 of control card 1 *must* contain a 2 (80-character labels) or a 4 (120-character labels).

Control card 5 is used if a new standard output header label is to be generated on the output tapes. If this option is desired, column 22 of control card 1 *must* contain a 2 (80-character labels) or a 4 (120-character labels).

For the user's convenience, a Sort 7 control card coding sheet is available (Form X24-3245). This coding sheet also provides for documenting each sort application. See *Appendix:* Figure 22.

Control Card 1

This card must always be used. Columns 3 and 6 must be blank if Sort 7 is on tape.

Columns 21-25 contain label specifications. Temporary header labels will be written on the work tapes if columns 21-25 are not blank.

If the user has 80-character input labels and desires 120-character output labels or vice versa, he should specify that the input labels are the same length as the output labels and that the input labels are to be printed but not checked. Sort 7 can use only one kind of label routine (80-character or 120-character) per program run. Therefore, input label checking could not be performed correctly since Sort 7 would use the label routine associated with the output label to check the input label. Also, do not specify that the control portion (positions 1-40) of the input header label is to be used as the control portion of the output label because the formats of the 80-character and 120-character labels are not the same.

If a mixture of labels is specified, halt 1226 will occur and INVALID LABEL SPECIFICATION will be printed. The user must indicate, at that time, which kind of labels is to be processed. He should select the kind (80-character or 120-character) that is to be used for the output label. To avoid the halt, prepare the control card as described.

Column(s)	Indicate
1	*First sort-input tape-unit number.* This column must be punched.
2	*Second sort-input tape-unit number.* This column must be punched. *Note:* Tape unit 1 may not be used as an input-tape-unit if Sort 7 is on tape.
3	*Third sort-input tape-unit number.* This column must be punched if a three-way merge is desired. Do not punch for a two-way merge.
4	*First sort work tape-unit number.* This column must be punched.
5	*Second sort work tape-unit number.* This column must be punched. *Note:* Tape unit 1 may not be used as a work-tape unit if Sort 7 is on tape.
6	*Third sort work tape-unit number.* This column must be punched if a three-way merge is desired. Do not punch for a two-way merge. *Note:* Card columns 1, 2, 4, and 5 are used to specify the tape-unit numbers for the multiphase option in phase 2.
7-8	*Total number of input reels (01-99) in the input file.* Punch the total number of reels in the file to to sorted. This value takes precedence over the contents of a trailer label when the program is determining if the last reel of a file has been processed.

Column(s)	Indicate
9-12	*Input record length.* a. For fixed-length input records, punch the number of characters in the record. b. For variable-length input records, punch the number of characters in the *longest* record.
13-15	*Input blocking factor.* a. Leave blank for variable-length blocked input records. b. Punch *001* for fixed- or variable-length unblocked input records. c. Punch the number of records per block for fixed-length blocked input records.
16-18	*Output blocking factor.* a. Leave blank for variable-length blocked output records. b. Punch *001* for fixed- or variable-length unblocked output records. c. Punch the number of records per block for fixed-length blocked output records.
19	*Unreadable Block Option.* a. Punch the tape-unit number if tape-dump option is desired. (This option cannot be used if a three-way merge has been specified.) Also, do not specify any of the tape-unit numbers that have been indicated in columns 1, 2, 4, and 5. If Sort 7 is on tape, do not specify *1* as the number of the dump-tape unit. b. Punch a *P* if unreadable blocks are to be punched into cards. c. Punch a *C* if the correct or print-scan option is desired.
20	*The density of the tapes used during phase 2.* a. Punch a *0* if the intended density is 200 characters per inch. b. Punch a *1* if the intended density is 556 characters per inch. c. Punch a *2* if the intended density is 800 characters per inch. *Note:* The maximum file size is computed on the basis of the density specified in this column.
21	*Input-tape header-label indicator.* a. Leave blank if the input tapes do not have header labels. b. Punch a *1* if the input tapes contain standard 80-character header labels that are to be printed but not checked. c. Punch a *2* if the input tapes contain standard 80-character header labels that are to be checked. Control card 4 is required in this case.

Column(s)	Indicate

d. Punch a *3* if the input tapes contain standard 120-character labels that are to be printed but not checked.

e. Punch a *4* if the input tapes contain standard 120-character header labels that are to be checked. Control card 4 is required in this case.

f. If nonstandard header labels are to be processed by a user routine and printed, by Sort 7, punch a *1* (80 characters or less) or a *3* (120-characters or less).

22   *Output-tape header-label indicator.*

a. Leave blank if the output tapes are not to have header labels.

b. Punch a *1* if the control portion of the standard 80-character input header label (positions 1-40) is to be used as the control portion of the output header label. If this is desired, the date should be punched in control card 3.

c. Punch a *2* if a new standard 80-character header label is to be generated by the program. Control card 5 is required in this case.

d. Punch a *3* if the control portion of the standard 120-character header label (positions 1-40) is to be used as the control portion of the output header label. If this is desired, the date should be punched in control card 3.

e. Punch a *4* if a new standard 120-character header label is to be generated by the program. Control card 5 is required in this case.

f. If a new nonstandard header label is to be generated by a user routine, punch a *1* (80-characters or less) or a *3* (120-characters or less).

23   *Output tape-mark option.*

a. Leave blank if a tape mark is not desired after the output header label.

b. Punch a *1* if a tape mark is desired after the output header label.

24   *Input-tape trailer-label indicator.*

a. Leave blank if the input tapes do not have trailer labels or if trailer labels on the input tapes are not to be processed.

b. Punch a *1* if standard 80-character trailer labels on the input tapes are to be printed but not checked.

c. Punch a *2* if the input tapes contain standard 80-character trailer labels on which block-count and record count checking is desired.

d. Punch a *3* if standard 120-character trailer labels on the input tapes are to be printed but not checked.

e. Punch a *4* if the input tapes contain standard 120-character trailer labels on which block count checking is desired.

f. If nonstandard labels on the input tapes are to be processed by user routines and printed by Sort 7, punch a *1* (80-characters or less) or a *3* (120-characters or less).

25   *Output-tape trailer-label indicator.*

a. Leave blank if the output tapes are not to have trailer labels.

b. Punch a *1* or a *2* if a standard output trailer label is to be generated by the program or a nonstandard trailer label is to be generated by a user routine.

Note: The length of the trailer label depends on the specifications in columns 21, 22, and 24.

26   *Padding indicator for fixed-length records only.*

a. Leave blank for low-order padding. The padding records will consist of blanks.

b. Punch a *9* for high-order padding. The padding records will consist of nines.

Note: Reverse the *blank* and *9* if records are processed in descending sequence.

27   *System core-storage capacity.*

a. Punch a *4* for 8,000 positions of core storage.

b. Punch a *5* for 12,000 positions of core storage.

c. Punch a *6* for 16,000 positions of core storage.

Note: If Sort 7 is on tape, the specifications in this column must correspond to the core size for which the Sort 7 tape has been built.

28-29   *Total number of control-data fields.* Punch the number of control-data fields to be sorted (01-10).

30-32   *Total number of characters of control data.* Punch the number of characters in all control-data fields (001-999).

33-36   *Control-data field-1 location.* Punch the high-order position of control-data field 1.

37-39   *Control-data field-1 length.* Punch the total number of characters contained in control-data field 1.

40-46   *Expected file size.* If the file size is known or can be approximated, punch the number of records in the input file. This number is used for checking the maximum possible file size. If this number exceeds the maximum possible file size for the sort, a halt with an indicative message will occur.

Note: The specification of this number is optional.

47-51   *Starting address of the phase-1 user area.* User-written routines that are to be executed during phase 1 must be loaded into upper core storage. The address specified in these columns is the lowest core-storage address of the user programming area. Core-storage positions below this address are utilized

Column(s)	Indicate
	by the Sort-7 program. The last two positions of core storage, for example, positions 7998 and 7999 in an 8,000-position 1401 or 1460, are also used by the Sort-7 program and are not available for user-written routines.
	If Sort 7 on tape is used, a dummy user area is established in both phase 1 and phase 2. This area, reserved for Sort 7 routines, extends from 7880 to the end of core in the case of an 8K system. It is adjusted in the case of 12K and 16K so that it occupies the last 120 position of core storage. Therefore, these positions are not available for user programming.
52-56	*Starting address of the phase-2 user area.* User-written routines that are to be executed during phase 2 must be loaded into upper core storage. The address specified in these columns is the lowest core-storage address of the user programming area. Core-storage positions below this address are utilized by the Sort-7 program. For a balanced merge, the last twenty-two positions of core storage for example, positions 7978-7999 in an 8,000 position 1401 or 1460, are also used by the Sort-7 program and are not available for user-written routines. For a multiphase merge, the last sixteen positions of core storage are not available for user-written routines.
57	*Record-format indicator.*
	a. Leave blank for fixed-length records.
	b. Punch a *1* for variable-length records.
58-61	*Low-order (units) position of the record character count field.* This field must be specified if variable-length blocked records are being processed. If variable-length records are being processed in load mode and a word mark occurs in the high-order position of the record character count field, these columns must be specified. If this field is not specified for variable-length unblocked records, the sort program generates a record character count for each record.
	Note: Columns 58-73 are not punched if the input consists of fixed-length records.
62-65	*The length in characters of the smallest variable-length record.*
66-69	*The length in characters of the largest input block of variable-length records.* (See the note in columns 70-73.)
70-73	*The length in character of the longest output block of variable-length records.* The specification of this field is optional. If the field is not specified and blocked variable-length records are being processed, the length of the largest output block will equal the maximum sort-block length.
	Note: If the input and/or output consists of unblocked records, columns 66-73 can be left blank. In this case, the program uses the value specified in columns 9-12 of control card 1 as the maximum input and/or output block length.

Column(s)	Indicate
74	*Record-mark padding indicator for fixed-length records only.*
	a. Leave blank if a record mark is not desired in padding records.
	b. Punch a *1* if a record mark is desired as the last character of each padding record.
75	*File order.*
	a. Leave blank is the input file is to be sorted into ascending sequence.
	b. Punch a *1* if the input file is to be sorted into descending sequence.
76-80	*These columns are not used by Sort 7.*

Control Card 2

This card is used to specify that the input records contain more than one control-data field.

Column(s)	Indicate
1-4	*Control-data field 2 location.* Punch the high-order position of the control-data field.
5-7	*Control-data field 2 length.* Punch the total number of characters in the control-data field.
8-11	*Control-data field 3 location.* Punch the high-order position of the control-data field.
12-14	*Control-data field 3 length.* Punch the total number of characters in the control-data field.
15-18	*Control-data field 4 location.* Punch the high-order position of the control-data field.
19-21	*Control-data field 4 length.* Punch the total number of characters in the control-data field.
22-25	*Control-data field 5 location.* Punch the high-order position of the control-data field.
26-28	*Control-data field 5 length.* Punch the total number of characters in the control-data field.
29-32	*Control-data field 6 location.* Punch the high-order position of the control-data field.
33-35	*Control-data field 6 length.* Punch the total number of characters in the control-data field.
36-39	*Control-data field 7 location.* Punch the high-order position of the control-data field.
40-42	*Control-data field 7 length.* Punch the total number of characters in the control-data field.
43-46	*Control-data field 8 location.* Punch the high-order position of the control-data field.
47-49	*Control-data field 8 length.* Punch the total number of characters in the control-data field.
50-53	*Control-data field 9 location.* Punch the high-order position of the control-data field.
54-56	*Control-data field 9 length.* Punch the total number of characters in the control-data field.

Column(s)	Indicate
57-60	*Control-data field 10 location.* Punch the high-order position of the control-data field.
61-63	*Control-data field 10 length.* Punch the total number of characters in the control-data field.
64-80	*These columns are not used by Sort 7.*

Control Card 3

This card is used to specify to the program that various options are desired during the running of the Sort-7 program. Control card 3, if blank, may be omitted.

Column(s)	Indicate
1	*The number of characters (3 or 4) in the record character count field.* This field must be specified if variable-length records are to be read in the load mode. A word mark can occur only in the high-order position of a record character count field.
2	*Input-mode indicator.* a. Leave blank if records are to be read in move mode. b. Punch a *0* if records are to be read in load mode.
3	*Output-mode indicator.* a. Leave blank if the output records are to be written in move mode. b. Punch a *0* if the output records are to be written in load mode.
4	*Work-tape header-label indicator.* a. Leave blank if work tapes do not have header labels. b. Punch a *0* if work tapes have nonstandard header labels, or standard header labels and retention-cycle checking is not desired. c. Punch a *1* if work tapes have standard 80-character header labels and retention-cycle checking is desired. (Specify date in column 6-10.) d. Punch a *2* if work tapes have standard 120-character header labels and retention cycle checking is desired. (Specify date in columns 6-10.) *Note:* If a *1* or a *2* is punched in this column or if columns 21-25 of control card 1 are not left blank, a work-tape header label will be written on all sort work tapes.
5	*Work-tape header-label tape-mark option.* a. Leave blank if a tape mark does not follow each work-tape header label. b. Punch a *1* if a tape mark follows each work-tape header label.
6-10	*Run date.* The current date (year and day within the year YYXXX) can be specified if retention-cycle checking is desired on work tapes or output tapes. If the run date is punched, it takes precedence over the date specified in control card 5.

Column(s)	Indicate
11	*Rewind/unload option when IBM 7330 Tape Units are being used.* This option allows the user to specify that all IBM 7330 tape units being used are to rewind and unload (high-speed rewind) at the end of each pass. This option may be used for large files where the rewind time on IBM 7330 Magnetic Tape Units can be appreciably higher than the time required for the rewind/unload and the manual reloading operation. a. Leave blank for rewind. b. Punch a *1* for rewind/unload.
12	*Retain record character count option.* This option may be used if the input records are unblocked variable-length records without a record character count field and unblocked output is specified. a. Leave blank if record character count is not desired in the final output. b. Punch a *1* if the record character count added by the program is desired in the output.
13	*Input-header check-all option.* a. Leave blank if file name only is to be checked. b. Punch a *1* if file serial number, reel-sequence number, file name, and creation date are to be checked.
14	*Input-header reel-sequence increment option.* a. Leave blank if reel-sequence number is not to be increased. b. Punch a *1* if reel-sequence number is to be increased by 1 for each successive reel. *Note:* Column 21 of control card 1 must contain a 2 or a *4* if column 13 or 14 is punched.
15	*Output header-label checking option.* a. Leave blank if retention-cycle checking is not desired. b. Punch a *1* if retention-cycle checking is desired (date must be specified in control card 3 or in columns 41-45 of control card 5).
16	*Output header-label file serial option.* a. Leave blank if file serial number is to be as specified in columns 21-25 in control card 5. b. Punch a *1* if the tape serial number is to replace the file serial number.
17	*Output header-label reel-sequence increment option.* a. Leave blank if the output reel-sequence number is not to be increased. b. Punch a *1* if each successive output reel-sequence number is to be increased by 1.
18	*Output header-label tape serial-assignment option.* For standard 80-character labels: a. Leave blank if the tape serial number on the current output tape is to be retained. This number

Column(s)	Indicate
	will be the tape-unit number if the label is one that was generated by the program.
	b. Punch a *1* if the tape serial number punched in columns 19-23 of control card 3 is to be substituted for the tape serial number on tape. For standard 120-character labels: This column must be left blank.
	Note: Column 22 of control card 1 must contain a 2 or a *4* if column 15, 16, 17, or 18 is punched.
19-23	*New tape serial number (optional) for standard 80-character output header label.*
19-22	*Creating system (optional) for standard 120-character output header label. Punch 1401 or 1460.*
24-50	*These columns must be blank.*
51-80	*These columns are not used by Sort 7.*

Control Card 4

This card is required if header labels are to be checked on the input tape(s). If this card is used, column 21 of control card 1 must contain either a 2 (standard 80-character labels) or a 4 (standard 120-character labels).

Column(s)	Indicate
1-20	*These columns are not used by Sort 7.*
21-25	*Five-character file serial number (if it is to be checked).*
26	*Punch a minus sign if the input reel-sequence number is specified.*
27-29	*Three-character reel-sequence number (if it is to be checked).*
30	*Leave blank.*
31-40	*Ten-character file-identification name.*
41-45	*Five-character creation date (if it is to be checked).*
46	*Punch a minus sign if the input retention cycle is specified on a standard 80-character label.*
47-49	*Retention cycle. This entry is not checked by the program.*
50	*Leave blank.*
51-80	*These columns are not used by Sort 7.*

Control Card 5

This card is required if a new header label is to be written on the output tape(s). If this card is used, col-

umn 22 of control card 1 must contain either a 2 (standard 80-character labels) or a 4 (standard 120-character labels).

Column(s)	Indicate
1-20	*These columns are not used by Sort 7.*
21-25	*The file serial number that will be used in the output header label(s).*
26	*Punch a minus sign if the output reel-sequence number is specified.*
27-29	*Output header reel-sequence number.*
30	*Leave blank.*
31-40	*Ten-character output file-identification name. A significant character should be present in the first and last position of this field. There should not be more than one blank position between any two characters.*
41-45	*Five-character date. A date specified in columns 6-10 of control card 3 takes precedence over the date specified in these columns.*
46	*Punch a minus sign if the output retention cycle is specified.*
47-49	*Retention cycle of the output file.*
50	*Leave blank.*
51-80	*These columns are not used by Sort 7.*

Control Cards for Sort 7 on Tape

If Sort 7 is to be loaded from tape, a LAST card must follow the object-time control cards. The format is:

Columns	Contain
1-4	LAST

The user can copy the Sort 7 tape from tape unit 1 to tape unit 3 by using a COPY1 card for a tape-update job. The format is:

Columns	Contain
16-20	COPY1

The user can delete statements from the Sort 7 tape by using DELET cards for a tape-update job. The format is:

Columns	Contain
16-20	DELET
21-24	Sequence number of the statement. This must be four digits.

One DELET card is required for each statement to be deleted.

Operating Procedures

This section describes the procedures to be used for transferring the Sort 7 program to tape and for the actual running of the Sort 7 program. It includes: a description of the Sort 7 program deck; system preparation; checkpoint, interrupt, and restart procedures; halts and/or messages; and options available to the user during program operation.

Description of the Program Deck

The Sort-7 program deck consists of about 1605 cards punched in the Autocoder condensed load format. The format of the cards is as follows:

Columns	Contain
1-71	Sort 7 program instructions and the necessary loading instructions.
72-75	Sequential number of the card within the program deck. The cards are numbered from 001 to 1605.
76, 77	60. This is the Sort 7 program number.
78	Blank.
79	Column 79 is used for internal processing by Sort 7.
80	The version number of Sort 7.

The Sort 7 tape-build program deck, which precedes the Sort 7 deck, consists of about 210 cards. This deck contains Sort 7 modification cards that are punched in the Autocoder condensed loader format and ALTER cards.

Sort 7 Tape Build

To transfer Sort 7 from cards to tape:
1. Mount tapes on tape units 1, 2, and 3. Set all the density switches to the same density.

2. Sense switches:
   Turn sense switch A on.

   Turn sense switch E on to build a Sort 7 tape that is to be used on a 12K system. This tape can be built on a 12K or 16K system.

   Turn sense switch F on to build a Sort 7 tape that is to be used on a 16K system. This tape can be built on a 16K system.

   Note: An 8K Sort 7 tape can be built on an 8K, 12K or

16K system. Only sense switch A should be on when an 8K tape is being built.

3. Place the tape-build deck ahead of the Sort 7 deck in the read hopper of the 1402. User routines may be inserted in the Sort 7 deck and transferred to the Sort 7 tape during the tape-build job.

4. Press CHECK RESET, START RESET, and LOAD.

   The unmodified Sort 7 program is written on tape unit 1 and the ALTER and modification statements are written on tape unit 2. The tape-build program then reads alternately from units 1 and 2 to modify the Sort 7 program. The tape loadable Sort 7 is written on tape unit 3.

Figure 13 shows the halts that can occur during the tape-build job.

Sort 7 Tape Update

Perform a tape-update job to transfer user routines to the Sort 7 tape, to delete statements from the Sort 7, to copy the Sort 7 tape, and to update the tape to the newest modification level of Sort 7.

To update the tape to the newest modification level, the user is required to punch an ALTER (columns 16-20) card for each EXECUTE card involved. The EXECUTE card numbers for each modification level change card are punched in columns 35-38 of the change card. Punch this number in columns 21-24 of the ALTER card. Place each ALTER card in front of its associated modification level change card.

To update or copy the Sort 7 tape:
1. Mount the Sort 7 tape on tape unit 1. Mount tape on tape unit 3. The setting of the density switches must be the same as for the tape-build job.
2. Turn sense switches A and C on. When copying a 12K tape, turn A, C, and E on. When copying a 16K tape, turn A, C, and F on.
3. Place the appropriate cards in the read hopper of the 1402:
   To incorporate user routines. ALTER and assembled-routine cards. See User Programming.
   To delete statements: DELET cards.
   To copy the Sort 7 tape: COPY1 card.
   To update the Sort 7 tape to a new modification level: IBM-supplied change deck with the appropriate ALTER cards as described above.

Number	I-Address Register	Sequence Number	Message and/or Reason	Procedure
1.	0005	0522	A message is not associated with this halt. Reason: The Sort 7 tape has been read.	Either press the start key to perform a sort job, or press the restart and start keys to perform a tape-update job.
2.	0337	0119	A message is not associated with this halt. Reason: An invalid card has been detected.	Remove the invalid card and restart.
3.	0344	0123	A message is not associated with this halt. Reason: An end-of-file has been detected during the tape-build job.	Mount a new reel and restart.
4.	0348	0125	A message is not associated with this halt. Reason: A write-redundancy indication remains after 30 attempts to write tape.	Either press the start key to retry 30 more times in the same area, or press the start reset and start keys to skip forward and retry.
5.	0368	0130	A message is not associated with this halt. Reason: An ALTER card should be present and has not been detected.	Check the ALTER cards and restart.
6.	0372	0132	A message is not associated with this halt. Reason: An end-of-file on the old Sort 7 tape has been detected before all the cards in the read hopper have been processed.	Check the ALTER cards for proper sequence numbers and arrangement. Restart. (The cards must be in ascending sequence.)
7.	0376	0137	A message is not associated with this halt. Reason: A read-redundancy indication remains after 99 attempts to read tape.	Press the start key to retry 99 more times.
8.	0380	0139	A message is not associated with this halt. Reason: The last card in the Sort 7 program deck is invalid.	Check the card and restart.
9.	0384	0140	A message is not associated with this halt. Reason: A record on the alter tape (tape unit 2) is neither an ALTER card nor a load card.	Either press the start key to bypass the record, or press the start reset and start keys to reread the record.
10.	0551	0176	ERROR	Consult the Operating Procedures and restart the job.
11.	1253	0317	END OF UPDATE RUN MODIFIED OR COPIED TAPE ON UNIT 3	
12.	2290	0507	END OF SYSTEMS CONSTRUCTION. SYSTEMS TAPE ON TAPE UNIT 3 THIS TAPE IS BUILT FOR A XK SYSTEM	X can be 8, 12, or 16.
13.	7890(8K) 11890(12K) 15890(16K)	0547	A message is not associated with this halt. Reason: A read-redundancy indication remains after 90 attempts to read the Sort 7 tape during a sort job.	Press the start reset and start keys to retry 90 more times.

Figure 13. Sort 7 (on Tape) Halts and Messages

Turn sense switch E on if the Sort 7 tape was built for a 12K system. Turn sense switch F on if the Sort 7 tape was built for a 16K system.

4. Press START RESET, CHECK RESET, and TAPE LOAD. When halt 1 occurs, press START RESET and START. Figure 13 shows the halts that can occur during the tape-update job.

System Preparation

Paper or forms should be placed on the printer and an appropriately punched carriage tape should be installed.

Place blank cards in the punch feed of the card read-punch and turn the punch ON, if the punch option is specified.

Set the tape-select switch to the N position.

The input tapes and work tapes must be properly mounted on the tape units as specified in control card 1. Set the tape-density switch on the tape units to the correct density.

Inserting Control Cards and
Loading the Program

During the assignment phase, certain control card errors will cause a halt and an associated message will print. However, some errors, such as overlapping control fields, will not be detected. Because the program will accept these errors, the user must make certain that all control cards are properly specified and correctly punched.

Control card 1 must always be used. Control cards 2, 3, 4, and 5 are used only if the various options and functions they control are desired by the user. These control cards must be in ascending sequence.

For Sort 7 on cards:

1. Insert the control cards into the assignment phase portion of the program deck between card number 244 and card number 245 (columns 72-75).

2. Place the program deck, including the control cards, in the read hopper of the 1402.

3. Press CHECK RESET, START RESET, and LOAD.

4. When the system attempts to read the last card, press START.

For Sort 7 on tape:

1. If the tape-loadable option is to be used, make certain the Sort 7 tape is mounted on tape unit 1 and the density setting is the same as that for the tape-build job.

2. Place the control card(s), followed by the LAST card, in the read hopper of the 1402.

3. Press CHECK RESET, START RESET, and TAPE LOAD. When halt 1 (Figure 13) occurs, press START.

4. When the system attempts to read the LAST card, a reader stop will halt the program. Press START to continue.

Note: The core storage capacity indicated in column 27 of control card 1 must correspond to the core storage capacity for which the Sort 7 tape was built.

The program, whether loaded from cards or tape, will run without interruption to the end of the job, unless an error occurs or a halt has been planned by the user.

Checkpoint, Interrupt, and Restart

Checkpoint records containing the contents of core storage are written before each pass of phase 2. Thus, if processing is stopped during phase 2, only the merge pass that is interrupted need be lost. This feature allows the user to stop processing (if necessary) and later continue his program from the beginning of the pass where the interrupt occurred.

Checkpoint records are written on the first-specified output tape unit. (A checkpoint record is not written before the final pass of a multiphase merge.) Output will be written, in rotation, on one or two specified tape units, depending upon whether a two- or three-way merge is being performed.

Interrupt

If the user desires to interrupt the program during phase 2, sense switch E must be ON. With this switch ON, an indicative message is printed and the program halts. This message includes: the phase 2 pass number, the tape-unit number that contains the checkpoint record, the input and output tape-unit numbers, the word *interrupt*, and the tape density as specified in control card 1. If the user does not desire to stop processing, he can press the start key to continue.

If sense switch E is OFF, the same message, with the exception of the words *interrupt* and *density* prints at the completion of each merge pass.

Restart

If a sense-switch-E interrupt or other planned and unplanned interrupts occur and the user desires to restart, the following procedure should be used.

1. Check the message, if one is printed, to determine which tape units contains the last checkpoint record written. Rewind all tape units before restarting.

2. Set the tape-unit number on the tape unit containing the checkpoint record to 1. If any other tape unit on the system is set to 1, press the reset key on that tape unit. The tape unit that is changed must be set back to the original number later in the procedure, and the tape unit that was originally 1 must be readied. It is important that all tapes that were removed be remounted on tape units set to their original setting.

3. Set the tape-select switch to N. Press the check-reset key and then the start-reset key.

4. Before the checkpoint record can be read into storage, the tape must be positioned past any header labels and any tape marks following labels that appear on the tape. (The output header label will be checked when restarting the last merge pass of phase 2 if retention-cycle checking is specified. The pass information is available from the printed message.)

   To read past the label and the tape mark (if one or both exist), press the tape-load key. The tape is read past the label. The system stops with the process light and the check-reset light turned ON. Press the check-reset key and the start-reset key.

   If another read is required to read past the tape mark, perform the same operation.

5. After the tape has been properly positioned, press the tape-load key. The checkpoint record is read, a message is printed, and a halt occurs. When the halt occurs, set the tape-unit numbers to their original setting and make the work-tape units ready.

6. a. When the program is restarted using the tape loadable system, press the start key to continue processing.

   b. When the program is restarted using the program deck; the last portion of the program deck, beginning with the card listed in the message on the printer, must be in the card-read hopper. If the restart is made during any but the last pass, this portion of the deck was in the reader at the time the interruption occurred. If the restart is made during the last pass, or if the cards had been removed from the reader, these cards *must* be placed in the reader before performing the restart.

7. To restart during the last pass of a multiphase merge, sense switch F must be ON. The restart point will be at the next to the last pass.

Sense-Switch Options

This section describes the options that are available to the user through the use of sense switches during the running of the Sort 7 program. The sense switches utilized are B, C, D, E, F, and G.

Sense Switches Used

Sense switch B: when ON during phase 1 with multi-reel input specified, is used to cause a halt after each input tape has been processed. Sense switch B also is used to interrupt the last merge pass of phase 2. The switch performs this function for both the balanced merge and the multiphase merge.

The user can determine the number of the output tape unit for a balanced merge by considering the number of passes required. If an odd number of passes is required, the output will be on the tape unit specified in column 2 of control card 1. If an even number of passes is required, the output will be on the tape unit specified in column 5 of control card 1.

The phase-2 message, EST PH 2 PASSES XX, gives the estimated number of passes based on program calculations.

A message giving the number of the output tape unit for a multiphase merge is printed.

Sense switch C is used to specify the multiphase-merge option.

Sense switch D is used to rewind and unload the phase-1 input tape(s).

If sense switch D is ON during phase 2 (balanced merge or multiphase merge), a halt with an indicative message occurs before the checkpoint record is written on the first output tape. To continue the sort, press the start key. The sense-switch-D option is inoperable during phase 2 if labels are present.

Sense switch E is used to cause a halt at the end of a phase-2 merge pass after the checkpoint record for the next pass has been written. To continue the sort run, press the start key.

The user can interrupt the sort at this time. If an interrupt occurs, all sort-tapes must be retained. The program can be restarted later by using the restart procedures described under *Restart.*

Sense switch F is used to restart the program when an interrupt has occurred during the last pass of the multiphase merge. If the switch is ON, the program assumes that the last pass is the one to be restarted.

Sense switch G is used in the print-scan or correct option. See *Error Routines* for information on the use of this switch.

Error Routines

This section describes the options that are available to the user for handling input/output errors.

Input Error Routines

The Sort 7 program provides three options for tape-read redundancies.

The first is a *tape-dump* option. When this option is specified, the block containing the redundant character(s) will be written on the specified dump tape if the block has remained redundant after 100 read attempts.

The second is a *punch* option. The function of this routine is the same as the tape-dump option, except that the redundant block is punched in cards.

The third is a *correct* or *print-scan* option. This option permits the user to accept or correct the redundant block after it has been printed.

The correct or print-scan option is also used for wrong-length fixed-length records in phase 1.

Records that are deleted when any of these options are selected are not included in the totals printed at the end of the sort.

Print-Scan or Correct Option

The redundancy indicator in the 1401 or 1460 is turned on when a character is read from tape with an incorrect parity (bit count). The parity of this character is automatically corrected by the 1401 or 1460. However, the character in core storage that results from the parity adjustment may not be the same character that was read from tape.

If the tape-select switch on the 1401 console or the diagnostic switch on the 1460 console is set to the D-position, characters are read into core storage as they appear on tape. The print-scan option makes use of this feature of the 1401 or 1460.

Unreadable Tape Blocks

When the print-scan option is specified, unreadable tape blocks will be printed and the program will halt. In phase 1, to accept the unreadable block, press START RESET and START. In phase 2, to accept the unreadable block, press START. The sort will continue and the unreadable block or wrong-length record will be processed.

If an attempt to correct the record is to be made:
1. Turn the auxiliary-console check-stop switch off.

2. Turn sense switch G on.

3. Turn the tape-select switch to the D-position.

4. In phase 1: Press START RESET and START.
   In phase 2: Press START.

The tape block will be read into core storage exactly as it appears on the tape. If the block contains no redundant characters during this read operation, the program will continue processing. In this case, the user must:

1. Press STOP to stop processing.

2. Turn the auxiliary-console switch on.

3. Turn sense switch G off.

4. Set the tape-select switch to the N-position.

5. Press START to continue processing.

If the block still contains a redundant character(s) during the read operation, the block is printed and a programmed halt occurs with the error lights ON. The invalid characters in core storage now must be corrected manually from the console.

The correction procedure is as follows:

1. Press CHECK-RESET to reset the error indicators.

2. Turn the mode switch to the storage-scan position and then press START.

The 1401 or 1460 sequentially scans the character in each core-storage position. An error halt occurs when an invalid character is sensed. The storage position in error is shown in the storage-address display unit. The B-register displays the contents of the storage position in which the error was detected. A valid character can be entered manually into this position by setting the manual address switches to the address shown in the storage-address display unit and using the enter key on the auxiliary console with the mode switch still set to STORAGE SCAN. Repeat this process until all invalid characters are corrected.

After all invalid characters have been corrected:

1. Turn the tape-select switch to the N-position.

2. Turn sense switch G off.

3. Turn the auxiliary-console check-stop switch on.

4. Turn the mode switch to RUN.

5. Press START.

A knowledge of the record format and control-data field locations is necessary before making an attempt to correct a record containing a redundant character.

Wrong-Length Records

When the print-scan option is specified, wrong-length fixed-length records detected in phase 1 are printed and the program halts. The wrong-length record must be deleted. It cannot be accepted or corrected.

Press START to delete the record.

Header-Label Read Redundancy

If a read redundancy occurs while a header label is being read, the program makes 100 attempts to read the label correctly. Then, if the label has not been read correctly, a halt occurs. If the start key is pressed, the program accepts the label as read. If this label is to be used later in the sort, the fact that the label has been altered during the read operation must be considered before accepting it as read. If the start-reset key and the start key are pressed, the program makes 100 additional read attempts and then halts. If this is an output header label, a new tape can be mounted at this time.

Input Area Location

The user should know the record format and control-data field positions before attempting to correct a redundant block.

The beginning of the input area (after the redundant block has been read into core storage) can be found, during phase 1, in the contents of index-register 3 (core-storage locations 097-099). During phase 2 (balanced merge), the address of the high-order position of the input area can be found in one of the three index registers as determined by the contents of location 2709. If this location contains:

1. An A-zone bit, then index-register 1 (core-storage locations 087-089) contains the address of the input area.

2. A B-zone bit, then index-register 2 (core-storage locations 092-094) contains the address of the input area.

3. AB-zone bits, then index-register 3 (core-storage locations 097-099) contains the address of the input area.

The same method may be used to find the address of the input areas when multiphase merging is used during phase 2. In this case the contents of location 729 determine which index register contains the address of the input area.

Write Redundancy

If a write redundancy occurs, the tape is backspaced and the write tried again. If the error still exists, the backspace and the write are again tried. If there still is an error, the tape is backspaced and then the error record is erased before the write operation is retried. If a successful write operation cannot be performed, this routine is repeated ten times. After twenty retries, the program halts. At this time, the user has the option of pressing the start key and trying to write another twenty times, or he can mount a new tape. If a new tape is mounted during phase 1, the program deck must be reloaded. If a new tape is mounted during phase 2, the particular pass where the error occurred must be restarted.

Dump-Tape Handling

If the tape-dump option is specified, special considerations must be made in the case of label-handling or restart.

The Sort 7 program does not process labels on the dump tape. If label processing is desired, it must be accomplished by user-inserted routines. The assignment phase rewinds the specified dump tape and all specified work tapes. An exit (EXITAP) is available in the assignment phase after the tapes are rewound. If a header label is desired on the dump tape, this exit may be used for this purpose. The tape is not rewound during either phase 1 or phase 2. The program writes a tape mark on the dump tape at the end of phase 1. At the completion of the sort operation, the dump tape is tape-marked, rewound, and unloaded.

Note: If a rerun of the sort is made because of an interruption at a halt other than the sense-switch-E halt, any block redundant in the first run of the pass will probably remain redundant in the rerun and will then appear on the dump tape twice.

Halts and/or Messages

Messages Not Accompanied by a Halt

The following messages are printed during a sort run primarily to inform the machine operator of the current status of the program.

Assignment-Phase Messages

1. The information punched in each control card that is inserted in the program deck is printed exactly as it is punched in the card.

2. L XXX B XXX BI XXX BO XXX BL XXXX MFS XXXXXXX

   This message prints when fixed-length records are being processed. L is the input-record length, B is the sort-blocking factor, BI is the input-blocking factor, BO is the output-blocking factor, BL is the computed sort-block length, and MFS is the maximum file size.

3. L MAX XXXX BL MAX XXXX MFS XXXXXX

This message prints when variable-length records are being processed. L MAX is the maximum input-record length, BL MAX is the maximum sort-block length, and MFS is the maximum file size.

4. END OF ASSIGNMENT PHASE.

Phase-1 Messages

1. PHASE 1 INTERNAL SORT

2. CHECKPOINT ON TAPE UNIT #X

3. G XXX

This message prints if fixed-length records are being processed. XXX is the number of records that are sorted internally at one time.

4. END OF INTERNAL SORT.

Phase-2 Messages (Balanced Merge)

1. MAX PH 2 PASSES XX

XX is the maximum number of phase-2 passes.

2. EST PH 2 PASSES XX

XX is the estimated number of phase-2 passes based on program calculations.

3. XXXXXXX—RECORDS READ—PASS 00
XXXXXXX—PAD REC ADDED—PASS 00
XXXXXXX—REC PROCESSED—PASS 00

This message gives the record counts that describe the results of the phase-1 internal sort.

4. XXXXXX—REC PROCESSED—PASS XX
PASS XX—CKPT X-INP X, X, X

This message is printed after each phase-2 merge pass. The number of the pass just completed and the numbers of the input and checkpoint tapes are given.

5. OUTP X-END OF SORT

This message prints when the sort has been completed. The program halts after this message prints.

Phase-2 Messages (Multiphase Merge)

1. NUM OF MULTIPHASE PASSES XX

This message shows the number of passes that are required to merge the file.

2. XXXXXX—RECORDS READ—PASS 00
XXX—PAD REC ADDED—PASS 00
XXXXXX—REC PROCESSED—PASS 00

This message gives the record counts that describe the results of the phase-1 internal sort.

3. END OF MULTIPHASE ADJUSTMENT

This message is printed when the adjustment phase has been completed.

4. PASS XX—CKPT X-INP X, X, X OUT-X

This message is printed after each phase-2 merge pass. The number of the pass just completed and the numbers of the checkpoint, input, and output tapes are given.

5. XXXXXX TOTAL RECORDS PROCESSED
XXXXXX PADDED RECORDS REMOVED
XXXXXX RECORDS FINAL OUTPUT
OUTP X-END OF SORT

This message prints when the sort has been completed.
The program halts after this message prints.

Halts and Associated Messages

Figures 14, 15, 16, 17, and 18 are a listing, by phase, of the halts and associated messages that can occur during the running of the Sort 7 program. The information given for each halt consists of the:

1. I-address that is displayed on the 1401 or 1447 console when the halt occurs. This is the core-storage address of the next sequential instruction after the halt instruction;

2. Sort-7 program-listing sequence-number of the halt instruction;

3. Message associated with the halt and/or the reason for the halt; and

4. Procedure to be followed to continue processing.

Number	I-Address Register	Sequence Number	Message and/or Reason	Procedure
1.	1034	1371	RECORD LENGTH ERROR - MAXIMUM LESS THAN MINIMUM - RESTART Reason: The specified maximum record length is less than the specified minimum record length.	Correct the control card and restart the sort.
2.	1226	1402	INVALID LABEL SPECIFICATION Reason: The user has specified a combination of 80-character and 120-character labels in columns 21-25 of control card 1.	Either press the start key for 80-character labels, or press the start reset and start keys for 120-character labels.
3.	2542	591	CF LNGH ERROR - FOR COMPUTED TLCF, PRESS START Reason: The total control-data field length specified in columns 30-32 of control card 1 is not equal to the sum of the lengths of the individual control-data fields.	Either press the start key to accept the total control-data field length computed by the program or correct the control card and restart the sort.
4.	3636	771	MACHINE SIZE ERROR - FOR 8K, PRESS START Reason: The system core-storage capacity specified in column 27 of control card 1 is incorrect.	Either press the start key if the system capacity is 8,000 positions of core storage, or correct the control card and restart the sort.
5.	4210	835	OVERSIZE INPUT BLOCKING Reason: The input block length for variable length specified in columns 13-15 of control card 1 is greater than the maximum allowable block length.	Correct the control card and/or condition and restart the sort.
6.	4229	841	OVERSIZE RECORD LENGTH - RESTART Reason: The record length specified in columns 9-12 of control card 1 is greater than the maximum allowable record length.	Correct the control card and/or condition and restart the sort.
7.	4248	847	RECORD SIZE TOO SMALL - RESTART Reason: The input record length specified in columns 9-12 of control card 1 is less than the minimum allowable length (ten characters if blocked, thirteen characters if unblocked).	Correct the control card and/or condition and restart the sort.
8.	4412	876	OVERSIZE INPUT BLOCKING, GREATEST POSSIBLE B XXX - RESTART Reason: The input blocking factor specified in columns 13-15 of control card 1 is greater than the maximum possible sort blocking factor.	Correct the control card and/or condition and restart the sort.
9.	4431	882	BOL TOO LARGE - RESTART Reason: The specified output block length specified in columns 70-73 of control card 1 is greater than the sort block length.	Correct the control card and restart the sort.
10.	5111	992	BO NOT SUBMULTIPLE OF B, TO SET BO EQUAL TO XXX PRESS START Reason: The output blocking factor specified in columns 16-18 of control card 1 is not a submultiple of the program-calculated sort blocking factor. The program provides the user with the option to continue processing with the output blocking factor equal to the sort blocking factor. BO NOT SUBMULTIPLE OF B, TO SET BO EQUAL TO XXX PRESS START. TO MAKE B A MULTIPLE OF BO, PRESS START/RESET AND START Reason: The output blocking factor is not a submultiple of the sort blocking factor. The program, if the user so desires, will recalculate the sort blocking factor on the basis of the output blocking factor instead of on the basis of the input blocking factor.	Press the start key to continue processing with the output blocking factor equal to the sort blocking factor. Otherwise correct the control card and restart the sort. Press the start-reset key and then the start key if the program is to recalculate the sort blocking factor. Otherwise, press the start key to continue processing.
11.	5173	1005	BO GREATER THAN B, BO MAY EQUAL XXX OR ANY SUBMULTIPLE OF IT. PRESS START FOR BO EQUAL B Reason: The output blocking factor specified in columns 16-18 of control card 1 is greater than the program-calculated sort blocking factor. The program provides the user with the option of continuing with the output blocking factor equal to the sort blocking factor.	Press the start key to resume processing with the output blocking factor equal to the sort blocking factor. Otherwise correct the control card and restart the sort.

Figure 14. Assignment Phase Halts and Messages (Part 1 of 2)

Number	I-Address Register	Sequence Number	Message and/or Reason	Procedure
12.	5884	1122	EFFECTIVE FILE SIZE GREATER THAN MAXIMUM FILE SIZE. PRESS START TO CONTINUE. Reason: The specified file size is greater than the program-calculated maximum allowable file size.	Either press the start key to continue processing using the program-calculated file size, or correct the control card and condition and restart the sort.
13.	5980	1131	TLCF GREATER THAN L Reason: The total control-data field length specified in columns 30-32 of control card 1 is greater than the specified input record length.	Correct the control card and restart the sort.
14.	6591	1200	One of the following five messages will be associated with this halt. (1) AN INVALID CONTROL CARD IS PRESENT OR OUT OF SEQUENCE. CHECK COLUMN XX-XX. (2) TAPE UNIT IS INVALIDLY SPECIFIED. (3) RCC IS NOT SPECIFIED FOR VARIABLE (4) NO. OF CONTROL FIELDS IS INVALIDLY SPECIFIED (5) NO. OF INPUT REELS IS INVALIDLY SPECIFIED Reason: The program has determined that incorrect data has been punched in the control card. The incorrect field is shown in each message. Message (3) is printed when columns 58-61 in control card 1 are blank and variable-length blocked records are specified.	Correct the control card(s) and restart the sort.
15.	6652	1206	USER AREA SPECIFIED ABOVE CORE SIZE RESTART Reason: The starting address of the Phase-2 user area specified in columns 52-56 of control card 1 is greater than the specified core-storage capacity.	Correct the control card and restart the sort.
16.	6814	1236	URPI IS INVALIDLY SPECIFIED, PRESS START FOR PUNCH OPTION Reason: The unreadable-record procedure is invalidly specified in column 19 of control card 1.	Press the start key to select the punch option. Otherwise, correct the control card and restart the sort.
17.	6862	1247	AN INVALID CONTROL CARD IS PRESENT Reason: The message explains the reason for this halt.	Check the control cards, insert the proper control cards in the proper sequence, and restart the sort.
18.	6884	1253	CONTROL CARD #4 AND/OR #5 ARE MISSING Reason: The user has selected options that require control card 4 and/or control card 5, and the card(s) are not present.	Check the control cards, insert the proper cards in the proper sequence, and restart the sort.
19.	6953	1262	TAPE UNIT NOT AVAILABLE - PRESS START FOR PUNCH OPTION Reason: The user has specified that any unreadable tape blocks are to be written on tape and Phase 2 is to be a three-way merge.	Either press the start key if unreadable tape blocks are to be punched into cards or correct the control card and restart the sort.
20.	7009	1274	THE LENGTH OF RCC IS NOT SPECIFIED FOR VARIABLE Reason: The user has specified that variable-length records are to be read in the load mode and that each record has a record-character-count field. However, column 1 of control card 3 does not contain a 3 or 4.	Correct the control card and restart the sort.

Figure 14. Assignment Phase Halts and Messages (Part 2 of 2)

Number	I-Address Register†	Sequence Number†	Message and/or Reason	Procedure
1.	782	3257	A message is not associated with this halt. Reason: A redundant input block or a wrong-length fixed-length record has been read and printed when the print-scan or correct option is specified.	For redundant input blocks, follow the procedure described under Print-Scan or Correct Option. For wrong-length records, press the start key to delete the record.
2.	803	3294	A message is not associated with this halt. Reason: End-of-reel has been reached on the tape on which any unreadable input tape blocks are being written.	Rewind and unload the tape. Mount a new tape and press the start key.
3.	1796	1654	A message is not associated with this halt. Reason: A write redundancy indication remains after twenty attempts to write a specific block on the output tape. The tape-select light of the unit on which the write redundancy occurred is ON.	Either press the start key to have the program try to write the block twenty more times or mount a new tape. (Refer to Write Redundancy)
4.	1807	1656	A message is not associated with this halt. Reason: The number of records in the input file is greater than the maximum allowable number.	Either press the start key if it is known that the output tape can contain the input file, or correct the condition and restart the sort.
5.	1848	3408	EOR ON 2 OUTPUT TAPES Reason: The input file cannot be written on the two output tape reels. This condition can result if the tapes are not full length.	Either decrease the file size or mount two full reels of tape and restart the sort.
6.	1933	1689	A message is not associated with this halt. Reason: Fixed-length records are being processed and the program has read a wrong-length record.	Press the start key to handle through the redundancy routine. The record will be written on tape, punched, or printed depending on the specification in column 19 of control card 1. If the record is printed, halt number 1 occurs.
7.	2235	1752	A message is not associated with this halt. Reason: End-of-file has been reached on an input tape and sense switch B is ON.	Load the next input tape if another tape is to be processed. Press the start key to continue processing.
8.	2565 (B) 2566 (A)	1816 (B) 2288 (A)	ERROR – SHOULD BE (80 character label) Reason: An error was detected in checking the input header label. The input header label is printed before this message prints. The label printed in this message contains the correct input header label information.	Press the start key if the label is acceptable as read. To recheck the label or, if a new tape has been mounted, press the start-reset key and then the start key to continue processing.
9.	2735 (B) 2713 (A)	1848 (B) 2317 (A)	ERROR – SHOULD BE (input block count kept by the Sort-7 Program) Reason: The input block count in the input trailer label being processed does not equal the block count kept by the program. The trailer label is printed before this message.	Either press the start key to continue processing if the block count kept by the program is correct, or correct the error condition and restart the sort.
10.	2739 (B) 2717 (A)	1849 (B) 2318 (A)	A message is not associated with this halt. Reason: A read-redundancy indication remains after one hundred attempts to read an input trailer label. The input error options are not available when the program encounters an unreadable trailer label.	Press the start key to have the program ignore the label and continue processing.
11.	4564 (B) 4562 (A)	2121 (B) 2375 (A)	RETAIN TAPE X FOR XXX DAYS Reason: The retention cycle of the tape on tape unit X indicates that this tape should be retained for XXX days.	Press the start key to continue processing if the tape can be used for output by Sort 7. If a new tape with a header label is mounted, press the start-reset key and then the start key to continue processing.

† (A) indicates that 120-character labels (Type A) are being processed.
  (B) indicates that 80-character labels (Type B) are being processed.

Figure 15. Phase 1 Halts and Messages (Part 1 of 2)

Number	I-Address Register	Sequence Number	Message and/or Reason	Procedure
12.	4600(B) 4598 (A)	2129 (B) 2383 (A)	A message is not associated with this halt. Reason: Retention-cycle checking routine has exceeded a 30-year period.	Press the start key to accept tape and continue processing. Press the start-reset key and start key to retry retention test.
13.	4869 (B) 4854 (A)	2192 (B) 2443 (A)	A message is not associated with this halt. Reason: A read-redundancy indication remains after one hundred attempts to read a header label on a work tape.	Either press the start-reset key and then the start key to have the program attempt to read the label one hundred more times, or press the start key to accept the label as read, or mount a new tape with a header label and press the start-reset key and then the start key to continue processing.
14.	4987 (B) 4972 (A)	2214 (B) 2465 (A)	A message is not associated with this halt. Reason: A write-redundancy indication remains after twenty attempts to write a header label on a work tape.	Either press the start key to have the program attempt to write the label twenty more times, or mount a new tape and restart the sort.
15.	5153	3181	A message is not associated with this halt. Reason: A write-redundancy indication remains after twenty attempts to write a checkpoint record.	Either press the start key to have the program attempt to write the record twenty more times, or mount a new tape and restart the sort.
16.	5157	3182	A message is not associated with this halt. Reason: End-of-reel has been reached while the program was attempting to write a checkpoint record.	Press the start key to continue processing. The program attempts to write the checkpoint record on the tape.
17.	5264	3204	PHASE 1 INP X X X OUT X X X Reason: A Phase-1 restart has been performed. The input tapes and the output tapes must be mounted on the specified tape units.	Press the start key to resume processing after the tapes have been properly mounted and assigned and the program deck starting with card 598 has been placed in the card reader.
18.	5275	2654	PATCH PROGRAM TOO LARGE PRESS START - IGNORE PATCH Reason: The area of core storage that is reserved for a user-written routine is too large and the Phase-1 internal processing cannot be performed. The user is given the option of restarting or of continuing the program with the user routine being deleted.	Either press the start key to continue processing without the user routine, or correct the condition and restart the sort.
19.	5688	2734	OVERSIZE INPUT BLOCKING - RESTART Reason: The specified input block length is greater than the maximum allowable length.	Correct the control card and/or condition and restart the sort.

Figure 15.   Phase 1 Halts and Messages (Part 2 of 2)

Number	I-Address Register	Sequence Number	Message and/or Reason	Procedure
1.	611	3519 (B) 3732 (A)	A message is not associated with this halt. Reason: A read-redundancy indication remains after one hundred attempts to read a header label on a Phase 2, pass 1, output tape.	Press the start key to accept the label as read and to bypass the retention cycle check, or press the start-reset key and then the start key to have the program attempt to reread the label 100 more times.
2.	619	3530 (B) 3742 (A)	A message is not associated with this halt. Reason: A write-redundancy indication remains after twenty attempts to write a header label on a Phase 2, pass 1, output tape.	Press the start key to have the program use this tape as a work tape, or mount a new tape and press the start-reset key and then the start key. Exercising the first option may cause a halt during the next Phase-2 pass.
3.	634	3540 (B) 3750 (A)	RETAIN TAPE X FOR XX DAYS Reason: The retention cycle in a header label written on a Phase 2, pass 1, output tape indicates that the tape should be saved.	Press the start key to have the program write a header label on this tape and continue processing. If a new tape is mounted, press the start-reset key and then the start key to continue processing.
4.	642	3549 (B) 3758 (A)	A message is not associated with this halt. Reason: A tape mark is not written after a header label when it is specified that a tape mark follows each header label.	Insure that either the control cards are correct or that all header labels have tape marks following them, and then restart the sort.
5.	646	3553 (B) 3762 (A)	A message is not associated with this halt. Reason: A Phase 2, pass 1, input tape contains an unreadable header label.	Either press the start key to bypass the label, or press the start-reset key and then the start key to have the program attempt to read the label 100 more times.
6.	863 (B) 884 (A)	3574 (B) 3783 (A)	INPUT TAPES MAY BE SAVED Reason: A sense-switch-D interrupt has occurred. The user can unload the Phase-1 input tapes and mount work tapes on the input tape units.	Mount the required work tapes and press the start key to continue processing.
7.	1267 (B) 1279 (A)	3651 (B) 3857 (A)	A message is not associated with this halt. Reason: Retention-cycle checking routine has exceeded a 30-year period.	Press the start key to accept tape and continue processing. Press the start-reset key and the start key to retry retention test.

Figure 16. Prephase Label Handling Routine Halts and Messages

Number	I-Address Register	Sequence Number†	Message and/or Reason	Procedure
1.	710	3970	A message is not associated with this halt. Reason: A read-redundancy occurred during the reading of a checkpoint at the end of a phase 2 merge pass.	Press the start key to continue processing using the checkpoint record as read. Press the start-reset key to have the program retry to read the checkpoint record.
2.	2549	4307	A message is not associated with this halt. Reason: End-of-file has been reached during the reading of the first input tape of the current merge pass.	Replace the tape on which the end-of-file indicator was detected and then restart the sort.
3.	2622	4325	A message is not associated with this halt. Reason: A write-redundancy has occurred on an output tape during the current merge pass. Twenty attempts to write the output block have been made. The tape-select light of the unit on which the write redundancy occurred is ON.	Press the start key to attempt to write the block twenty more times.
4.	3031	4895	A message is not associated with this halt. Reason: A redundant tape block has been read and printed when the print-scan or correct option is specified.	Follow the procedure described in Print-Scan or Correct Option.
5.	3038	4856	A message is not associated with this halt. Reason: End-of-reel has been reached on the tape upon which unreadable tape blocks are being written.	Rewind and unload the dump tape, mount a new tape, and press the start key.
6.	3091	4401 (B) 4716 (A)	A message is not associated with this halt. Reason: A read-redundancy indication remains after one hundred attempts to read a header label.	Press the start key to accept the label as read. Press the start-reset key and then the start key to have the program try to read the label 100 more times.
7.	3091	7898 (B) 8110 (A)	A message is not associated with this halt. Reason: A read-redundancy indication remains after one hundred attempts to read the header label on the final output tape.	Press the start key to accept the label as read. The retention cycle will not be checked. Press the start-reset key and then the start key to have the program attempt to read the label one hundred more times. The option of mounting a new tape is also provided. In this case, mount the tape, press the start-reset key and then the start key to continue processing.
8.	3096	4407 (B) 4721 (A)	A message is not associated with this halt. Reason: A write redundancy has occurred during the writing of a header label. Twenty attempts to write the record have been made.	Press the start key to have the program attempt to write the header label twenty more times.
9.	3099	7905 (B) 8115 (A)	A message is not associated with this halt. Reason: A write-redundancy indication remains after twenty attempts have been made to write the header label on the final output tape.	Press the start-reset key and then the start key to attempt to write the record twenty additional times. The option of mounting a new tape is also provided. In this case, mount the tape and then press the start key to continue processing.
10.	3111	4411 (B) 4724 (A)	A message is not associated with this halt. Reason: A read-redundancy indication remains after one hundred attempts to read a header label.	Press the start key to accept the label as read. Press the start-reset key and then the start key to have the program try to read the label 100 more times.

† Same as Figure 15, Part 1.

Figure 17. Phase 2 (Balanced Merge) Halts and Messages (Part 1 of 3)

Number	I-Address Register	Sequence Number †	Message and/or Reason	Procedure
11.	3114	7909 (B) 8118 (A)	RETAIN TAPE X FOR XXX DAYS Reason: The retention cycle of the tape on tape unit X indicates that the tape should be retained.	Press the start key if the tape is to be used. If a new tape is mounted, press the start-reset key and then the start key to continue processing.
12.	3122	7913 (B) 8121 (A)	A message is not associated with this halt. Reason: A write-redundancy indication remains after twenty attempts have been made to write the trailer label on the final output tape.	Press the start key to accept the label as written. Press the start-reset key and then the start key to attempt to write the label twenty additional times.
13.	3126	4416 (B) 4727 (A)	A message is not associated with this halt. Reason: A tape mark is not written after a header label when it is specified that a tape mark follows each header label.	Insure that either the control cards are correct or that all header labels have tape marks following them, and then restart the sort.
14.	3128	5610	A message is not associated with this halt. Reason: A three-way merge is being performed, tape labels are not being processed, two output tapes have become full during the final merge pass and additional output records remain to be written.	Mount new tapes on the last two output tape units and press the start key.
15.	3132	5611	A message is not associated with this halt. Reason: A two-way merge is being performed, tape labels are not being processed, the output tape has become full during the final merge pass, and additional output records remain to be written. The tape has been tape marked, rewound, and unloaded.	Mount a new tape on the tape unit on which the tape-select light is ON. Press the start key to continue processing.
16.	3137	7918 (B) 8124 (A)	(B) CHG TP X (A) CHANGE REEL ON UNIT X Reason: End-of-reel has been reached on the final output tape that is mounted on unit X.	Mount a new tape reel and press the start key to continue processing.
17.	4477	4954	A message is not associated with this halt. Reason: There is an error in the program calculation of the number of merge passes required in Phase 2.	Decrease the size of the input file and restart the sort.
18.	4801	5265	XXXXXX REC PROCESSED - PASS XX ERROR Reason: The record count kept by the program during the previous merge pass does not equal the record count kept by the program during the current merge pass.	Press the start key to continue processing, or restart the pass as described in Checkpoint, Interrupt, and Restart.
19.	4934	5291	LAST MERGE PASS INTERRUPT Reason: All Phase-2 merge passes except the final pass have been completed. This halt occurs before the initialization of the final pass.	Press the start key to continue processing.
20.	5674	5405	DENSITY MAY BE CHANGED Reason: Sense switch D is ON. The halt occurs before the checkpoint record is written on the first output tape.	Press the start key to continue processing.
21.	5936	5456	PASS XX - CKPT X - INP X, X, X, INTERRUPT (HIGH) (LOW) DENSITY Reason: Sense switch E is ON. This halt occurs after the checkpoint record for the next merge pass has been written. The message shows the number of the merge pass just completed, the tape on which the checkpoint record is written, and the tapes that contain the input for the next merge pass.	Press the start key to continue processing, or interrupt the program and restart processing at a later time. In the latter case, save the input tapes and the tape containing the checkpoint record.
22.	6040	5477	A message is not associated with this halt. Reason: A Phase-2 restart has been performed using the systems tape. The program is ready to position the systems tape.	Insure that all tapes are correctly mounted and addressed. Press the start key to continue processing.

† Same as Figure 15, Part 1.

Figure 17. Phase 2 (Balanced Merge) Halts and Messages (Part 2 of 3)

Number	I-Address Register	Sequence Number	Message and/or Reason	Procedure
23.	6102	5488	PLACE CARDS FROM 1468 IN READER PASS XX INP X, X, X, OUT X, X, X, (HIGH) (LOW) DENSITY, Reason: A Phase-2 restart has been performed after a sense-switch-E interrupt. The message shows how many merge passes have been completed, the numbers of the input and output tape units, and the density that was specified in control card 1.	Refer to Restart for the procedure to be followed.
24.	6274	5515	A message is not associated with this halt. Reason: End-of-file occurred while bypassing the old checkpoint record on restart.	Press the start key to accept the record as read and continue processing.
25.	6299	5520	A message is not associated with this halt. Reason: 99 attempts to read a checkpoint failed.	Press start to retry the read operation. If the read error persists, restart the entire program.
26.	6319	5524	A message is not associated with this halt. Reason: End-of-file occurred while attempting to read the checkpoint record.	Press the start key to continue processing. Press the start-reset key and then the start key to backspace the tape and reread the checkpoint record.
27.	6327	5526	OUTP X - END OF SORT Reason: The sort run is completed and the final output tape on unit X is rewound and unloaded.	
28.	6579	5567	A message is not associated with this halt. Reason: A write-redundancy has occurred while writing the checkpoint record. Twenty attempts to write the record have been made.	Press the start key to have the program attempt to write the record twenty more times.
29.	6583	5568	A message is not associated with this halt. Reason: End-of-reel has occurred while the program was attempting to write a checkpoint record.	Press the start key to accept the checkpoint record as written. Otherwise, restart the sort run.

Figure 17. Phase 2 (Balanced Merge) Halts and Messages (Part 3 of 3)

Number	I-Address Register	Sequence Number†	Message and/or Reason	Procedure
1.	1730	6002	A message is not associated with this halt. Reason: A write redundancy has occurred on the output tape. Twenty attempts to write the block have been made.	Press the start key to have the program attempt to write the record twenty more times.
2a.	2053	6061	OUTPUT EXCEEDS REEL LENGTH Reason: End-of-reel has been reached on the output tape in a merge pass other than the final pass.	Correct the condition causing the halt and then restart the sort. Conditions causing the halt could be one of the following: (1) use of short tape reels; (2) use of low density; or (3) exceeding the maximum file size.
2b.	2053	6061	CHANGE REEL ON UNIT X Reason: End-of-reel has been reached on the final output tape (with labels) that is mounted on tape unit X.	Mount a new tape reel and press the start key to continue processing.
3.	2206	6865	A message is not associated with this halt. Reason: End-of-reel has been reached on the dump tape.	Rewind and unload the dump tape, mount a new tape, and then press the start key to continue processing.
4.	2223	6837	A message is not associated with this halt. Reason: A redundant tape block has been read and printed when the print-scan or correct option is specified.	Follow the procedure described in Print-Scan or Correct Option.
5.	2306	7323	A message is not associated with this halt. Reason: A read redundancy has occurred while reading a checkpoint record.	Press the start key to accept the checkpoint record as read. Press the start-reset key and then the start key to attempt to reread the checkpoint record.
6.	2327	8283 (B) 8481 (A)	A message is not associated with this halt. Reason: A read-redundancy indication remains after one hundred attempts to read the header label on the final output tape.	Press the start key to accept the label as read. In this case the retention cycle is not checked. Press the start-reset key and then the start key to have the program attempt to read the label one hundred more times. The option of mounting a new tape is also provided. In this case, mount the tape, press the start-reset key and then the start key to continue processing.
7.	2335	8287 (B) 8484 (A)	A message is not associated with this halt. Reason: A write-redundancy indication remains after twenty attempts have been made to write the header label on the final output tape.	Press the start-reset key and then the start key to have the program attempt to write the label twenty more times. The option of mounting a new tape is also provided. In this case, mount the tape and then press the start key to continue processing.
8.	2350	8291 (B) 8487 (A)	RETAIN TAPE X FOR XXX DAYS Reason: The retention cycle of the tape on tape unit X indicates that the tape should be retained.	Press the start key if the tape is to be used. If a new tape is mounted, press the start-reset key and then the start key to continue processing.
9.	2358	8296 (B) 8491 (A)	A message is not associated with this halt. Reason: A write-redundancy indication remains after twenty attempts have been made to write the trailer label on the final output tape.	Press the start key to accept the label as written. Press the start-reset key and then the start key to have the program attempt to write the label twenty additional times.
10.	2366	8301 (B) 8494 (A)	CHANGE REEL ON UNIT X Reason: End-of-reel has been reached on the final output tape (with labels) that is mounted on tape unitX that is mounted on tape unit X.	Mount a new tape reel and press the start key to continue processing.

† Same as Figure 15, Part 1.

Figure 18. Phase 2 (Multiphase Merge) Halts and Messages (Part 1 of 3)

Number	I-Address Register	Sequence Number†	Message and/or Reason	Procedure
11.	2703	6077 (B) 6552 (A)	A message is not associated with this halt. Reason: A read-redundancy indication remains after the program has attempted to read an output work tape header label one hundred times.	Press the start key to accept the label as read. In this case the redundant record is written as the header label on the tape. Press the start-reset key and then the start key to have the program attempt to read the label 100 more times.
12.	2708	6083 (B) 6557 (A)	A message is not associated with this halt. Reason: A write redundancy occurred when the program attempted to write a header label on a work tape. Twenty attempts to write the label have been made.	Press the start key to have the program try to write the label up to twenty more times.
13.	2723	6087 (B) 6560 (A)	A message is not associated with this halt. Reason: A read-redundancy indication remains after one hundred attempts have been made to read the header label on an input work tape.	Press the start key to accept the label as read. Press the start-reset key and then the start key to have the program attempt to read the label up to 100 more times.
14.	2731	6092 (B) 6563 (A)	A message is not associated with this halt. Reason: A tape mark is not written after a header label when it is specified that a tape mark follows each header label.	Insure that either the control cards are correct or that all header labels have tape marks following them, and then restart the sort.
15.	3393	8675	OUTPUT X - END OF SORT. Reason: The sort is complete. The final output is on tape unit X.	
16.	3598	7198	A message is not associated with this halt. Reason: A Phase-2 restart has been performed using the systems tape. The program is ready to position the systems tape.	Insure that all tapes are correctly mounted and addressed. Press the start key to continue processing.
17.	3701	7220	PASS XX - CKPT X-INP X, X, X OUT - X RESTART (HIGH) (LOW) DENSITY. Reason: A restart has been performed after a sense-switch-E interrupt. The message shows the number of merge passes completed, the tape on which the checkpoint record is written, the input and output tape-unit numbers, and the density of the input tapes.	Refer to Restart for the procedure to be followed.
18.	4068	7287	PLACE CARDS FROM 1532 IN READER Reason: A restart has been performed after a sense-switch-E interrupt and sense switch F is ON, indicating that the last merge pass is the one to be restarted. The message that shows the number of merge passes completed, the tape on which the checkpoint record is written, the input and output tape-unit numbers, and the density of the input tapes does not print until the header labels on the input tapes, if any labels are present, have been processed.	Mount the tapes as specified in the previous message, if labels are present. Set the density switches, and then press the start key.
19.	4207	7329	A message is not associated with this halt. Reason: An end-of-file indication occurred while the program was attempting to read the checkpoint record.	Press the start key to continue processing, if the checkpoint record was read correctly. Press the start-reset key and then the start key to have the program backspace the tape and retry to read the checkpoint record.
20.	5603	7570	DENSITY MAY BE CHANGED Reason: Sense switch D has been turned ON. The halt occurs prior to the writing of the checkpoint record on the output tape.	Press the start key to continue processing.
21.	5637	7581	LAST MERGE PASS OUT-X INTERRUPT Reason: Sense switch B is ON. The halt occurs after all merge passes except the last have been completed and before the initialization of the last pass. X is the number of the tape unit that will contain the final output.	Press the start key to continue processing.

† Same as Figure 15, Part 1.

Figure 18. Phase 2 (Multiphase Merge) Halts and Messages (Part 2 of 3)

Number	I-Address Register	Sequence Number	Message and/or Reason	Procedure
22.	5779	7611	PASS XX - CKPT X-INP X, X, X OUT-X INTERRUPT Reason: Sense switch E is ON. The halt occurs after the checkpoint record for the next merge pass has been written and prior to any processing in the current pass.	Press the start key to continue processing.
23.	5838	7622	A message is not associated with this halt. Reason: A write redundancy has occurred while writing the checkpoint record. Twenty attempts to write the record have been made.	Press the start key to have the program attempt to write the record twenty more times.
24.	5842	7623	A message is not associated with this halt. Reason: End-of-reel has been reached while attempting to write a checkpoint record.	Press the start key to accept the checkpoint as written. Otherwise restart the sort.

Figure 18. Phase 2 (Multiphase Merge) Halts and Messages (Part 3 of 3)

Appendix

Standard Tape Labels

Figure 19 shows schematics of Type A (120-character) and Type B (80-character) header and trailer labels.

Arrangement of Input Tapes

The maximum number of merge passes (see *Phase-2 Messages*) is exceeded if the first input tape is full or nearly full, and contains a presequenced file. Mount the presequenced file on input tape unit 3 for a 3-way merge, on input tape unit 2 for a 2-way merge, and on input tape unit 2 for a multiphase merge to avoid additional merge passes.

Compare Figures 20 and 21 to see why additional merge passes are required when the presequenced file is the first input tape.

Figure 20 shows the results of the internal sort and two phase-2 merge passes when the presequenced file is on the first input tape in a 3-way merge. During the remaining merge passes, sequences from the third input unit (unit 3 or unit 6) are merged with the sequence from the first two input units (units 1 and 2 or units 5 and 6). Merge passes are performed until one sequential file is developed.

Figure 21 shows the results when the presequenced file is the third input tape in a 3-way merge. The merging process, described in Figure 21, is repeated until one sequential file is developed.

Coding Sheet

Figure 22 shows the coding sheet that can be used for preparing the Sort 7 object-time control cards.
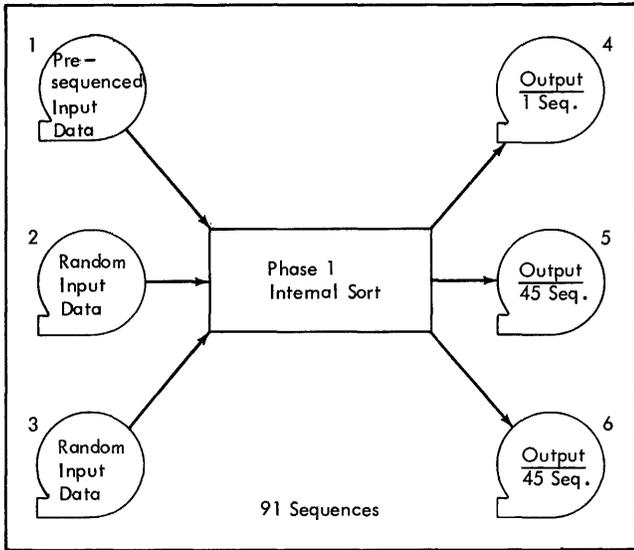
Type A (120-character) Labels

Type B (80-character) Labels

Figure 19. Schematics of Type A and Type B Labels
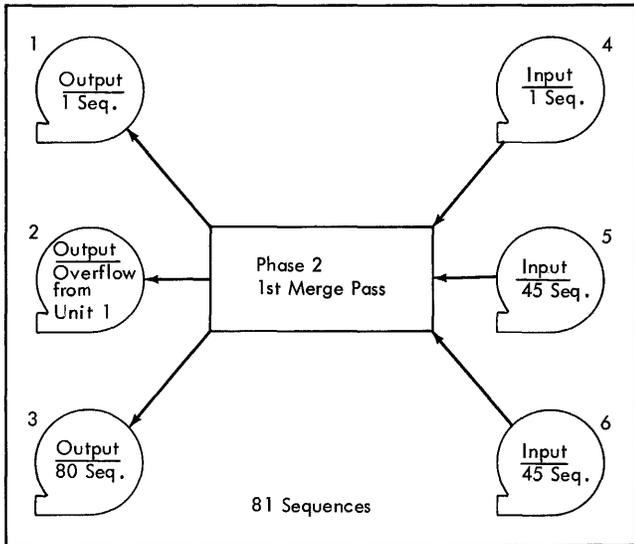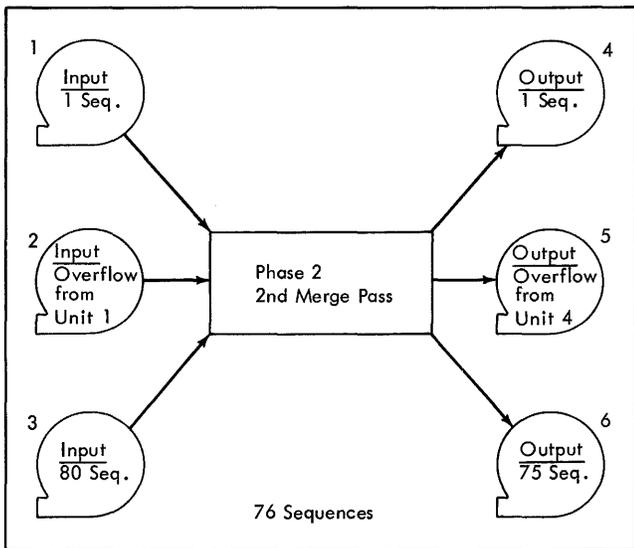
Figure 20. Three-Way Merge with a Presequenced File on Input Tape Unit 1
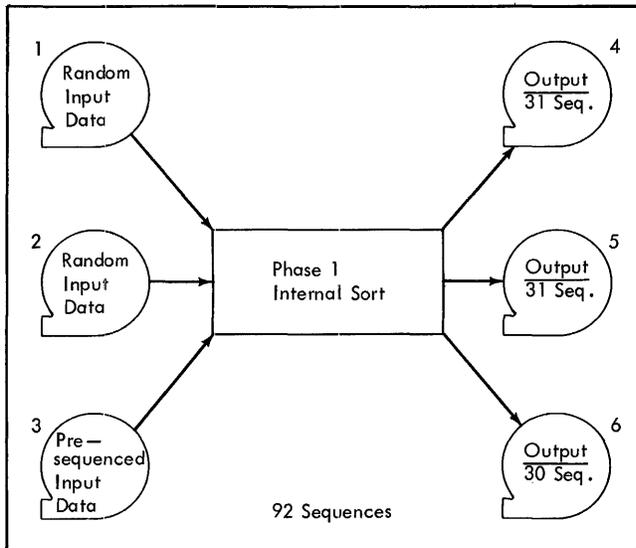
Phase 1 Internal Sort (diagram)

1 Random Input Data
2 Random Input Data
3 Pre—sequenced Input Data

Phase 1 Internal Sort

4 Output 31 Seq.
5 Output 31 Seq.
6 Output 30 Seq.

92 Sequences

1. Sorts random data on unit 1 and writes the first sequence on unit 4, the second on unit 5, the third on unit 6, and repeats the process until all the sequences have been written.

2. Sorts random data on unit 2 and writes the first sequence on unit 4, the second on unit 5, the third on unit 6, and repeats the.process until all the sequences have been written.

3. Passes part of the presequenced data to unit 4 and part to unit 5.

Phase 2 1st Merge Pass (diagram)

1 Output 18 Seq.
2 Output 17 Seq.
3 Output 17 Seq.

Phase 2 1st Merge Pass

4 Input 31 Seq.
5 Input 31 Seq.
6 Input 30 Seq.

52 Sequences

1. Merges sequences from units 4, 5, and 6 and writes the resulting sequence on unit 1.

2. Merges sequences from units 4, 5, and 6 and writes the resulting sequence on unit 2.

3. Merges sequences from units 4, 5, and 6 and writes the resulting sequence on unit 3.

4. Repeats steps 1, 2, and 3 until all the sequences on units 4, 5, and 6 have been merged and written on units 1, 2, and 3.

Phase 2 2nd Merge Pass (diagram)

1 Input 18 Seq.
2 Input 17 Seq.
3 Input 17 Seq.

Phase 2 2nd Merge Pass

4 Output 11 Seq.
5 Output 11 Seq.
6 Output 11 Seq.
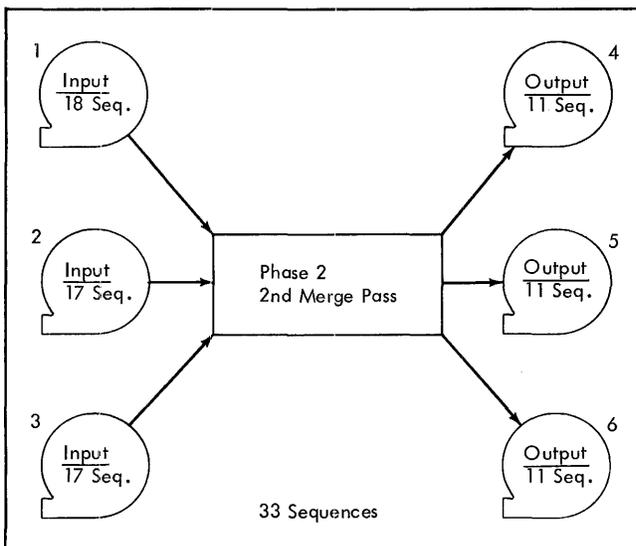
33 Sequences

1. Merges sequences from units 1, 2, and 3 and writes the resulting sequence on unit 4.

2. Merges sequences from units 1, 2, and 3 and writes the resulting sequence on unit 5.

3. Merges sequences from units 1, 2, and 3 and writes the resulting sequence on unit 6.

4. Repeats steps 1, 2, and 3 until all the sequences on units 1, 2, and 3 have been written on units 4, 5, and 6.

Figure 21. Three-Way Merge with a Presequenced File on Input Tape Unit 3

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INTERNATIONAL BUSINESS MACHINES CORPORATION

Control Card Formats for Sort 2, Merge 2, Sort 4, Sort 7, and Merge 7

IBM 1401-1460

Printed in U.S.A.
Form X24-3245

Program _____

Date _____

Col.	CONTROL CARD 1 — Indicates	CONTROL CARD 2 — Indicates	CONTROL CARD 3 # — Indicates	CONTROL CARD 4 # — Indicates	CONTROL CARD 5 # — Indicates
1	Input/output tape	Control-data	No. of characters in RCC *†	Blank or	Blank or
2	unit numbers	field-2	Input-mode indicator	comments	comments
3		location	Output-mode indicator		
4			Work-tape header-labels ✓		
5		Control-data	Work-tape header-label tape mark ✓		
6		field-2	Run date		
7	No. of input reels	length			
8		Control-data			
9	Input record length	field-3			
10		location			
11			Rewind/unload (7330) ✓		
12		Control-data	Retain RCC option * ✓		
13	Input blocking	field-3	In-header check option		
14	factor	length	In reel-sequence increment option		
15		Control-data	Out-header check option		
16	Output blocking	field-4	Out-header file serial option		
17	factor	location	Out reel-sequence increment option		
18			Out-tape serial number option		
19	Unreadable block option	Control-data	New tape serial		
20	Phase 2 tape density ✓	field-4	number for output		
21	In-tape header-labels	length	header-label	Five-character	File serial
22	Out-tape header-labels	Control-data		file serial	number for
23	Output tape-mark option	field-5		number (if	output header
24	In-tape trailer-labels	location	Must be blank for	checking)	labels
25	Out-tape trailer-labels		Sort 7		
26	Padding indicator	Control-data	Blank or comments	Minus **	Minus **
27	Core-storage size	field-5	for Sort 4 and	Reel-sequence	Output header
28	Total number of	length	Merge 7	number	reel-sequence
29	control-data fields	Control-data		(if checking)	number
30	Total number of	field-6		Blank	Blank
31	characters of	location		Ten-character	Ten-character
32	control-data			input file-	output-file
33	Control-data	Control-data		identification	identification
34	field-1 location	field-6		name	name
35		length			
36		Control-data			
37	Control-data	field-7			
38	field-1 length	location			
39					
40	Expected file size	Control-data			
41	Not checked by	field-7		Five-character	Five-character
42	Merge 2 or Merge 7	length		creation	date
43		Control-data		date (if	
44		field-8		checking)	
45		location			
46				Minus **	Minus **
47	Starting address	Control-data		Retention	Retention period
48	of the Phase-1	field-8		period of	of output file
49	user area	length		input file	
50	Not checked by	Control-data		Blank	Blank
51	Merge 2 or Merge 7	field-9	Blank or	Blank or	Blank or
52	Starting address	location	comments	comments	comments
53	of the Phase-2				
54	user area	Control-data			
55	Not checked by	field-9			
56	Merge 2 or Merge 7	length			
57	Record-format	Control-data			
58	Low-order position	field-10			
59	of the record	location			
60	character count				
61	field	Control-data			
62	Number of characters	field-10			
63	in the smallest	length			
64	variable-length	Blank or			
65	record	comments			
66	Number of characters				
67	in largest input				
68	block of variable-				
69	length records				
70	Number of characters				
71	in largest output				
72	block of variable-				
73	length records				
74	Record mark with padding‡				
75	File order				
76	Input tape unit usage				
77	for Merge 2, Merge 7				
78	Blank or comments				
79	for Sort 2, Sort 4,				
80	and Sort 7				

Control cards 3, 4, and 5 are not used by Sort 2 or Merge 2.

‡ Sequence check for Merge 7.

* RCC--Record character count field.
† Unreadable record option for Sort 4.
✓ Not checked by Merge 2 or Merge 7.

** Leave blank for Sort 4. Required for Sort 7 and Merge 7 if the next three columns are to be punched.

Figure 22. Control Card Coding Sheet

READER'S COMMENT FORM

Sort 7   Form C24-3317-1
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