

Reference Manual

IBM 650 Tape Sorting Program    Sort III

**IBM Reference Manual**

**IBM 650 Tape Sorting Program    Sort III**

# CONTENTS

	Page
INTRODUCTION . . . . .	1
A SHORT GLOSSARY OF TAPE SORTING TERMS . . . . .	3
GENERAL INFORMATION ON SORT III . . . . .	4
Input Format . . . . .	4
Control Data . . . . .	4
Sorting Technique . . . . .	4
Volume of Records Handled . . . . .	5
Control Card . . . . .	6
Sorting Times . . . . .	7
A Sample Multifunction Application . . . . .	7
DESCRIPTION OF SORT III FUNCTIONS . . . . .	9
Sorting . . . . .	9
Merging . . . . .	11
Transcribing . . . . .	11
Function Codes . . . . .	12
ARRANGING AND RESTORING OF CONTROL DATA . . . . .	14
Generation of Arranger and Restore Routines . . . . .	14
Specification of Control Data Fields . . . . .	15
Negative Control Data . . . . .	15
PADDING OF GROUPED RECORDS . . . . .	17
ESTIMATING SORTING AND MERGING TIMES . . . . .	18
Timing Formulas . . . . .	18
Use or Omission of Phase I . . . . .	20
TAPE LABELING PROVISIONS . . . . .	21
CONTROL CARD PREPARATION . . . . .	24
SORT III OPERATOR'S INSTRUCTIONS . . . . .	27
Console Procedure . . . . .	27
Program Deck . . . . .	28
Output Reel Removal . . . . .	28
Interrupt and Restart . . . . .	28
Programmed Halts . . . . .	29

## IBM 650 TAPE SORTING PROGRAM SORT III

### INTRODUCTION

Sort III is a tape sorting program designed to satisfy most of the sorting requirements of an IBM 650 Data Processing System installation with tapes. Four IBM 727 Magnetic Tape Units are required. The program is, of course, a generalized sorting program - i. e. , it is capable of modifying itself according to information punched in a control card by the user, and thus can perform a variety of sorting applications. Sort III also has a merging feature and a provision for duplicating a file without changing the order of the records, but with the option of changing the record format.

Sort III is an improved version of Sort II offering greater flexibility with respect to input and output records, both in the volume of records that can be sorted and in the configuration of control data used for sequencing the file. The sorting speeds of Sort II and Sort III are approximately the same. Those installations which are presently using Sort II and find it suitable should continue to use it. However, anyone contemplating the use of a generalized sorting program should consider Sort III because the manual for Sort II will not be reprinted.

The Sort III program will:

1. Sort ungrouped, fixed length records of up to 60 words.
2. Sort grouped, fixed length records if the 650 System is equipped with indexing registers. The program ungroups the records before sorting and can regroup them, if desired, after the sorting and/or merging operation is completed.
3. Sort numerical or alphanumeric records.
4. Sort on control data consisting of from one to fifty digits positioned in up to ten fields of the record.
5. Merge two files which are in sequence.
6. Duplicate an existing file with or without changing the format of the control data.
7. Automatically label all output tapes in accordance with instructions in a control card.
8. Permit automatic interrupt and restart.

9. Sort in one continuous operation as many ungrouped records as will fit on one reel of tape (2400 feet).

Program decks for Sort III are available in a condensed (five-per-card) format on a basis of one copy per 650 tape installation. Requests for decks should be addressed to:

IBM 650 Program Librarian  
International Business Machines Corporation  
590 Madison Avenue  
New York 22, New York

Flow diagrams and symbolic program listings are also available in reproducible (Ozalid master) form on a basis of one copy per 650 tape system from the above address.

## A SHORT GLOSSARY OF TAPE SORTING TERMS

Listed below are definitions of several computer terms used in tape sorting which are not explicitly defined in the text of this manual.

Control Data - That portion of a record which constitutes the controlling information for a particular process.

Control Data Field - A designated field in the record (consisting of control data) used to determine where a given record should be positioned in relation to other records in the file.

Grouping - The incorporation of several tape records into one long record in order to permit more efficient system utilization - e. g. , economy of tape space and tape acceleration time.

Hash Total - A total taken on an arbitrary field of the records for control purposes only. The hash total taken during one pass may be compared with that taken during a previous pass to aid in detecting any mishandling of records.

Pass - One complete cycle of reading and writing an entire file.

Record Count - A count of the number of records processed during one pass; used for control purposes.

Sequence - Any number of records in the desired sorting order.

Stepdown - The condition which occurs during a sort when the record being processed is exceeded by the record processed previously, indicating a break in sequence.

Tape Label - A record, usually located at the beginning of a file, which contains information related to identification, operation, and control of the file as opposed to a record which is a part of the file itself.

## GENERAL INFORMATION ON SORT III

### INPUT FORMAT

Sort III will accept as input ungrouped, fixed length numerical or alphanumeric records whose length does not exceed sixty words. In addition, if the program is used on a 650 tape system equipped with indexing registers, Sort III can process grouped fixed length records, arranged in any grouping provided the group length does not exceed sixty words. However, Sort III does not process grouped records in that form, but ungroups the records during the first pass.

### CONTROL DATA

Sort III permits the specification of as many as ten control fields to be used by the program in its various functions. Each control field may be located anywhere within a record and may be of any length provided the total number of digits in all control fields does not exceed fifty. On the basis of the control field specifications, Sort III generates a subroutine called the "Arranger routine" which will extract from each record all specified control fields, arrange them in a form appropriate for sorting, and reinsert them, in their new form, into the records. At a later point in the program another subroutine called the "Restore routine" is generated, if specified, to restore the processed records to their original format. Because these features are included in the program, it is necessary to refer to the records as being in "arranged" form, and "original" or "restored" form. (Note that the original and restored forms are exactly the same.)

### SORTING TECHNIQUE

The sorting technique employed in the Sort III program consists of reading a number of ungrouped records from the input file, arranging them in sorted sequences of from 21 to 96 records, and writing them out on alternate tapes. Subsequent passes merge these short sequences into longer sequences. By repeating this merging process, Sort III produces one long sequence called a sorted file. Once two separate files have been sorted on the same control data, they can be merged to form one longer sequenced file.

Sort III accomplishes the sorting operation in two steps called Phase I and Phase II. In the following list of functions for each phase an asterisk next to a function indicates that the program must be directed to perform it by means of the control card.

Phase I will:

1. arrange the control data for sorting \*
2. ungroup the records (if the system is equipped with indexing registers) \*
3. put records in sequences of 21 to 96 records

Phase II will:

1. merge the sequences written by Phase I
2. regroup the records \*
3. restore control data to the original format \*

#### VOLUME OF RECORDS HANDLED

Sort III can process only a fixed number of records in one continuous operation. The number of records depends upon the lengths of the tapes used and the ordering of the initial input file. If the input file is in random order with respect to the control data used for sorting, and few, if any, records have identical control data, the number of records which can be sorted is that number which can be written in ungrouped form on a length of tape one-and-one-half times the length of the shortest tape used. If these two conditions are not met, the only estimate which can be made of the maximum number of records which can be processed is that number of records which can be written in ungrouped form on the shortest tape used. From these considerations it can be seen that all tapes used in processing should be full length tapes to insure processing of the maximum number of records. Table I below shows the approximate number of ungrouped records which can be written on one full length reel of tape.

The input file may be physically contained on up to nine reels of tape, provided the total number of records does not exceed the maximum allowable number. If the maximum is exceeded a programmed halt (Halt 0273) will occur to indicate that the program cannot continue. This halt, however, will not occur until Phase II is near completion and a great deal of time has been wasted. By a combination of sorting and merging operations any number of records which can be contained on not more than eighteen reels of tape can be arranged into one sequenced file.



Tape Characters per record	Records per reel	Tape Characters per record	Records per reel	Tape Characters per record	Records per reel
10	36,000	210	16,000	410	10,285
20	33,882	220	15,567	420	10,105
30	32,000	230	15,157	430	9,931
40	30,315	240	14,769	440	9,762
50	28,800	250	14,400	450	9,600
60	27,428	260	14,048	460	9,442
70	26,181	270	13,714	470	9,290
80	25,043	280	13,395	480	9,142
90	24,000	290	13,090	490	9,000
100	23,040	300	12,800	500	8,861
110	22,153	310	12,521	510	8,727
120	21,333	320	12,255	520	8,597
130	20,571	330	12,000	530	8,470
140	19,862	340	11,755	540	8,347
150	19,200	350	11,520	550	8,228
160	18,580	360	11,294	560	8,112
170	18,000	370	11,076	570	8,000
180	17,454	380	10,867	580	7,890
190	16,941	390	10,666	590	7,783
200	16,457	400	10,472	600	7,680

Table I

### CONTROL CARD

The functioning of Sort III is determined by a control card prepared by the user of the program. The information which must be punched in the control card falls into two general categories: first, control information such as the size and grouping of input records, tape label handling, etc.; and second, information describing the position and length of control data fields, the mode in which records are represented on tape, and the number of digits in all control fields. (For further details see Control Card Preparation, page 24.) Control card information falling into the first category must be changed to some extent from one application to another, according to the function which Sort III is presently to perform and previous processing of the file by Sort III. However, information falling into the second category must be the same for all applications of Sort III to a given file which involves the same control data, regardless of previous processing of the file by Sort III.

## SORTING TIMES

The formulas for estimating sorting time appear in another section of this manual and include all the factors to be considered. Table II is designed as a quick reference and gives general approximations of the time it takes to sort records with ten digits (one word) of control data and twenty digits (two words) of control data. For records that exceed twenty digits of control data it is recommended that the formula be used to determine the approximate time.

## A SAMPLE MULTIFUNCTION APPLICATION

In order to illustrate the relationship between the functions which can be performed by Sort III, a sample application is presented below. The application is a comparatively simple case and does not indicate all the capabilities of Sort III.

Assume that a master file consisting of grouped records is contained on one full length reel of tape and that the control data is in the restored format. Assume also that five reels of additions to the file, which when taken together require less than one full length tape, have been prepared by card-to-tape operation. From the master file and the five reels of additions a new master file is to be created.

By treating the five reels of additions as one file and sorting these additions, one ordered file consisting of one reel of tape is created. Only one sorting operation is required since the total number of records is less than the maximum allowable number. When these records are sorted, the records should be left in arranged format and ungrouped. Next, the old master file is duplicated with ungrouping of records and arranging of control data. The two files of sorted records are now merged to create a new master file. The merging operation should include restoration of record format and regrouping. The new master file will then consist of two reels of tape and will be in proper form for further processing.

1 WORD OF CONTROL DATA RECORD LENGTH: 5 TO 60 WORDS							
RECORD VOLUME (in thousands)	5 Words	10 Words	20 Words	30 Words	40 Words	50 Words	60 Words
	MINIMUM Hr.—Min.	MINIMUM Hr.—Min.	MINIMUM Hr.—Min.	MINIMUM Hr.—Min.	MINIMUM Hr.—Min.	MINIMUM Hr.—Min.	MINIMUM Hr.—Min.
2	17	18	24	27	30	37	44
4	33	35	47	54	1—00	1—13	1—25
6	46	50	1—05	1—25	1—36	1—47	2—04
8	1—06	1—13	1—36	1—51	2—04	2—33	3—00
10	1—21	1—29	1—58	2—31	2—51		
15	2—10	2—24	3—20	3—39			
20	2—51	3—09	4—13				
25	3—32	3—53					
30	4—39						

2 WORDS OF CONTROL DATA RECORD LENGTH: 5 TO 60 WORDS														
RECORD VOLUME (in thousands)	5 Words		10 Words		20 Words		30 Words		40 Words		50 Words		60 Words	
	MIN. Hr.—Min.	MAX. Hr.—Min.	MIN. Hr.—Min.	MAX. Hr.—Min.	MIN. Hr.—Min.	MAX. Hr.—Min.	MIN. Hr.—Min.	MAX. Hr.—Min.	MIN. Hr.—Min.	MAX. Hr.—Min.	MIN. Hr.—Min.	MAX. Hr.—Min.	MIN. Hr.—Min.	MAX. Hr.—Min.
2	18	31	19	33	26	38	29	41	32	46	39	49	44	57
4	36	55	38	59	51	1—10	59	1—18	1—05	1—28	1—18	1—36	1—30	1—51
6	51	1—23	55	1—29	1—10	1—48	1—32	2—01	1—43	2—16	1—54	2—29	2—11	2—55
8	1—14	1—46	1—21	1—54	1—45	2—19	2—01	2—39	2—14	2—57	2—43	3—14	3—10	3—59
10	1—31	2—21	1—39	2—31	2—09	3—05	2—44	3—28	3—04	3—56				
15	2—27	3—23	2—41	3—39	3—39	4—29	3—58	5—04						
20	3—13	4—46	3—31	5—08	4—38	6—21								
25	4—04	5—53	4—25	6—21										
30	5—17	7—00												

Table II

## DESCRIPTION OF SORT III FUNCTIONS

In order to make Sort III as flexible and as widely applicable as possible, the program incorporates a merging feature and a provision for transcribing a tape file, i. e. , duplicating a file with or without changes in the record format. These functions, as well as the primary function of sorting, are described in some detail in the following sections.

### SORTING

Sort III uses a two-phase sorting procedure to order input files. The first phase initially orders the file into a number of separate sequences, and the second phase then reduces the number of individual sequences, during each of several machine passes, until a completely ordered file is obtained. The final output is in algebraic sequence (e. g. , -2, -1, 0, 1, 2) with alphabetic and special characters ordered according to their respective 650 double-digit codes.

During each pass, a count is taken of the records processed, and a hash total is taken on the first word of arranged control data. At the end of the pass, the record count and hash total are compared with the corresponding record count and hash total from the previous pass; error stops are provided in case a discrepancy is found.

The Sort III program permits, at the option of the user, the omission of Phase I when desirable, (see page 20 for details) and selection of the format (either restored or arranged) and grouping of output records.

#### Phase I

Phase I makes use of an "internal" sorting procedure. Specifically, a number of records are read from the input tape and stored on the drum; ungrouping and arranging are performed if necessary. The records are then sorted and written in ascending sequence on one of the output tapes in ungrouped form. The records in the sequence will be in arranged form if arrangement of control data was necessary.

The sorting procedure used is based on two tables; these tables are built up as records are read from tape and stored on the drum in sequential order. One table contains entries of the first ten digits of control data from each record read from tape. These entries are sorted in reverse order by a complements method. The second table contains the same data; however, this data is stored in sequential locations as each record is read, thus reflecting the drum locations in which the records have been stored. When enough records have been read to fill the allotted drum space, the low entry in the table of sorted control data

is used in a table lookup of the table of unsorted control data. The corresponding record is then written on the output tape and the TLU is repeated for the next entry in the table of sorted control data. When all records of the sequence have been written on the output tape, another group of records is read in and internally sorted. This process is repeated until all records have been read from the input file.

The output from Phase I is, therefore, a number of sorted sequences of records. Normally, two successive sequences formed by Phase I are written on different tapes, two units being used for output; however, two successive sequences will be written on the same output tape if, by doing so, a longer sequence of ordered records is created. The length of the sorted sequences formed and written on the output tapes by Phase I depends primarily upon the length of the input records. The following table shows the number of records in each sequence formed by Phase I:

<u>Record Length</u>	<u>Number of Records per Sequence</u>
1-10 words	96
11-25	48
26-50	26
51-60	21

If the input file consists of grouped records, the number of records per sequence may be slightly fewer than shown above, since a group is not read if the number of records in the group would cause the above indicated number of records per sequence to be exceeded. For example, if a file consists of twelve-word records grouped in five-record groups, output sequences will contain forty-five records (i. e. , nine groups) rather than fifty records (ten groups).

## Phase II

Phase II processing consists of a merge-type operation using two input and two output tapes. This phase also restores the record format and regroups the records, if so directed by the control card.

The "merge" operation performed by this phase consists of reading one sequence of records from each tape and merging those sequences, record by record, to form a new and longer sequence. This sequence is then written on one of the output tapes. Another sequence is then read from each input tape, merged, and written on the other output tape. The merge process is continued until all sequences from both input tapes have been processed and written as output. The two output tapes then become input tapes and sequences from the new input tapes are merged and written on the tapes used as input for the previous pass. Eventually no more

than two sequences will remain on the output tapes. Sort III then enters its last pass, which differs from previous passes in that restoration and/or regrouping are performed prior to the writing of the records, if such action was indicated in the control card.

In the event that Phase I is omitted, Phase II adjusts itself to read from only one input during the first pass, and to arrange control data fields, if required. However, if Phase I is omitted, input records must be ungrouped, since Phase II cannot perform the ungrouping.

## MERGING

Sort III may be used to merge two ordered files consisting of up to nine reels of tape each. When this function is indicated in the control card for Sort III, Phase I is automatically bypassed and only Phase II is used. The operation of the program when used for merging is similar to that of the last pass of Phase II. The main difference is that a programmed halt will occur during merging if an out-of-sequence condition is detected and the out-of-sequence record(s) are not zero padding records.

Input for merging must be ungrouped and in arranged format. The merged output may be in either arranged or restored format and may be grouped or ungrouped, at the option of the user.

Sort III is efficient and is recommended when only two files are to be merged, but should not be used to merge more than two files. Rather, a companion program, Merge II, should be used, since that program can merge up to five files in one pass. Merge II has the additional advantage of being able to process files consisting of up to 99 reels of tape. Input records to Merge II must be ungrouped, and the control data of the records must be in a form which does not require arrangement; that is, control data must normally be in the required form, or must have been arranged by some function of Sort III, and not restored to the original format. Any file acceptable to Sort III can be processed by Merge II, since the file either will be in the proper format or can be transcribed and arranged by Sort III to meet input requirements of Merge II. For more detailed information concerning the Merge II program, see the manual IBM 650 Tape Merging Program Merge II (form C28-4004).

## TRANSCRIBING

The term "transcribing" is used in this manual to describe the duplication of a tape file, possibly with changes in the format and/or in the grouping of the records which make up the file. This function permits, at the option of the user, nearly complete control of the grouping and format (either arranged or restored) of both input and output files. One use of this function of Sort III is the arrangement of control data and ungrouping of a file to be processed by Merge II.

Selection of the transcribing function causes Phase I to be automatically bypassed. The input and output procedures of Phase II are used, but the transcribing is accomplished by one block of the program which is modified according to the input and output format and grouping. Neither a record count nor a hash total is accumulated and the input file is not sequence checked.

The input to a transcribing pass may be either grouped or ungrouped records, and the grouping may be altered to the extent that grouped records may be ungrouped and ungrouped records grouped. However, if the input is in grouped form, the output must be either ungrouped or grouped in the same form. It should be noted that the grouping factor of a grouped file may be changed by two passes; the first to ungroup the records and the second to regroup them with the new factor.

### FUNCTION CODES

Sort III presents nine options with regard to program functioning and control data arrangement of input and output. Below is a brief description of the various options available. The number shown under Function Code indicates the digit which must be punched in column 1 of the control card in order to cause the program to execute the described function.

<u>Function Code</u>	<u>Function</u>
1	Sort a file, using Phase I. Restore output records to their original format.
2	Sort a file, using Phase I. Leave the output records in arranged form.
3	Sort a file, omitting Phase I. Restore the output records to their original format.
4	Sort a file, omitting Phase I. Leave the output records in arranged form.
5	Merge two files. Restore the output records to their original format.
6	Merge two files. Leave the output records in arranged form.
7	Transcribe a file into an output file with records in arranged format.

Function Code

Function

8	Transcribe a file, the control fields of which are in arranged format, into an output file with records in restored format.
9	Transcribe a file, do not change record format.

Notes

1. The Arranger routine is automatically generated and executed, if required, when sorting.
2. Because Phase II can process ungrouped records only, Phase I must be used if input records are grouped.
3. If the output of a sort is to be used as input to a merge (using either Sort III or Merge II), records should be left ungrouped and in arranged format. If a long output file is to be produced by means of a number of sorts and intermediate merges, only the last merge run should use function 5 and call for grouped output.
4. If input to and output from a sorting operation are grouped, the grouping factors need not be the same. However, transcribing operations require that the grouping factors of grouped input and grouped output be the same.



## ARRANGING AND RESTORING OF CONTROL DATA

The two subroutines which generate the Arranger and Restore routines for Sort III are described below. Since these generation routines are very complex, little detail is given; only material pertaining to their general nature and proper use is included.

It should be understood that the Arranger and Restore routines are necessary only in order to meet the control data requirements implicit in sorting fixed word length records. These requirements, generally speaking, are:

1. Control data fields, or portions thereof, must be in consecutive (i. e. , most-major through most-minor) order within a given word
2. Words containing control data can contain no non-control data, except that
  - (a) if constant non-control data is contiguous to a control field, the boundary of the control field may be extended so as to include such data
  - (b) the low-order positions of the word containing the most-minor control data may be any non-control data

If a given file meets the above conditions, arranging, and hence restoring, of control data format is not necessary. It can be seen that files of records whose format was designed for Sort II processing are always acceptable as input to Sort III without arrangement of control data. In this case the control fields are specified as one or more control fields, each beginning in the high-order digit of a word, and 10, 20, 30, 40, or 50 digits long. It is important that all consecutive and contiguous control data, if represented on tape in the same mode, be specified as one field. If, for example, the first (major) control data field occupies the first five digits of a word, and the second control data field the next five digits of the same word, failure to specify them as a single ten-digit field would cause generation of needless arranging and restoring instructions and a consequent loss of time.

### GENERATION OF ARRANGER AND RESTORE ROUTINES

The Arranger and Restore routines are generated step by step according to the control data descriptions punched in the Sort III control card. Two hundred drum locations are available for generated instructions and constants and for temporary storage. IAS locations unused by other sections of the Sort III program are also used for temporary storage. The generated instructions are optimized.

Two hundred locations are sufficient to contain generated instructions for arranging and restoring any configuration of six control fields, however complex. These

locations have also been found by experiment to be sufficient for all but very complex cases of seven to ten control fields.

#### SPECIFICATION OF CONTROL DATA FIELDS

Fifty columns of the control card are reserved for the punching of control data field descriptions. Each such field is defined by a five-digit description. This description is made as follows:

- Digits 1 and 2 - The number of the word in the record (as the record appears in IAS) which contains the high-order digit of the control data field. Words are numbered 01, 02, etc. In subsequent discussions of control data fields these digits are designated "WW. "
- Digit 3 - The position, within the word WW, which contains the high-order digit of the control data field. These positions are counted 0 through 9 from left to right. This digit is designated "P. "
- Digits 4 and 5 - The number of digits in the control data field. These digits are designated "LL. "

The descriptions of both numerical and alphanumeric control fields are made in the way indicated above and describe the position and length of the control data fields as they appear in IAS. Alphanumeric fields are, therefore, described in their 650 double-digit form. Sort III requires the following regarding control data fields:

1. Each field of control data must be either entirely numerical or entirely alphanumeric.
2. It is not permissible to specify all or a portion of an alphanumeric control word (locations 90X9) as a control field, and a programmed halt will occur when such a description is detected by Sort III.
3. The description of alphanumeric control fields may not begin with an odd-numbered digit or indicate a length which is odd. In this case also, a programmed halt will occur.

#### NEGATIVE CONTROL DATA

Since both negative and positive control data cannot be arranged and packed together without extending the length of the records containing the data, Sort III

normally translates negative fields into positive fields during the arrangement of control data. All negative control fields which are made positive appear as positive in the output file regardless of the format of the records. However, in many cases, words containing negative control fields do not require arranging and will remain negative. To determine whether negative control data will be made positive it is suggested that a few records be processed by Sort III and then printed out.

## PADDING OF GROUPED RECORDS

The term "padding" is used to describe records which are added to a grouped file when the number of records contained in a file is not a multiple of the number of records which constitutes one group. Usually the records which are added for padding consist of either all nines or all zeros. It will be noted that if padding records made up of nines are introduced into a file of ordered records, the file will remain ordered since the padding records will be the highest in the collating sequence and the last records in the file. On the other hand, if zero padding records are used, the sequence of the file will be broken at the end, where padding records are located. For this reason the use of nines for padding records is recommended for files to be processed at any time by a program which requires the file to be ordered but does not test for padding records, e. g. , Merge II.

Sort III automatically adds padding records to a grouped output file if, preparatory to writing out the last group of records, it finds that there are insufficient input records to complete the group. The type of padding to be added is controlled by a punch in column 10 of the control card. If the punch is a zero, padding records will consist of zeros; if a nine appears in that column, padding records will be all nines; no other type of padding is permitted. Sort III will never add to an output file a group composed entirely of padding. However, there exists the possibility that the padding records added, together with padding already in the file, may result in one or more groups which consist solely of padding records.

In all applications of Sort III, padding records contained in an input file are treated as normal records and are sorted, merged, and transcribed in the usual manner. Except for one condition, which may arise during merging, all padding in an input file will appear in the output file. If a zero punch appears in column 10 of the control card, Sort III will examine, during merging operations, all input records which are determined to be out of sequence, and records found to be zero padding records will be deleted from the file. A record is considered a zero padding record if all control data and all non-significant information appearing in the word in which the minor control field terminates (when records are in arranged format) are zero. During the merging operation a programmed halt (Halt 0274) will occur either if zero padding is indicated in the control card and a non-zero record is detected out of sequence, or if nines padding is indicated in the control card and any record is detected out of sequence.

## ESTIMATING SORTING AND MERGING TIMES

### TIMING FORMULAS

This section presents formulas by which the time requirements for the sorting and merging functions of Sort III may be estimated. These formulas were derived from experimental timing runs and, although some minor adjustments have been made in the interests of simplicity, are quite accurate. Time requirements for transcribing functions of Sort III are not given, inasmuch as these functions will normally be used infrequently and are extremely fast in comparison with sorting and merging. The following formulas give the total number of minutes required for the indicated function:

$$\text{Sorting, using Phase I:} \quad \frac{N(P + 1)(A + 0.003C) + 0.6N + 1.2P}{1000}$$

$$\text{Sorting, omitting Phase I:} \quad \frac{NP(A + 0.003C) + 1.2P}{1000}$$

$$\text{Merging:} \quad \frac{N(A + 0.003C) + 1.2(R - 1)}{1000}$$

Explanation of symbols:

N = The number of records in the input file, or, if merging, in both input files.

C = The number of characters in each record as it appears on tape. For example, in a twenty-word numerical record, C = 200, and in a twenty-word alpha-numerical record of which seven words are numerical, C = 135.

A = A factor representing processing and tape acceleration time, which is derived from the total number of digits (as the record appears in IAS) of control data, as follows:

If the number of digits of control data is

ten or less, A = 0.67.

more than ten but less than thirty-one, A = 0.81.

more than thirty, A = 0.87.

R = The number of reels in both input files when merging.

P = The number of Phase II passes required for the completion of a sort. This factor depends wholly upon the actual number of sequences present in the file at the beginning of Phase II. If Phase I is omitted, divide the total number of records in the input file by 2, and, using the result, determine P from the table below. If Phase I is used, compute the number of sequences by dividing the total number of records in the input file by the length of the sequences formed by Phase I. Using the result, determine P from the table below; the indicated number of Phase II passes represents the minimum, which will be attained if Phase I is completely effective. However, if Phase I is used but is not completely effective, the actual number of passes will lie between this minimal figure and a figure computed on the basis of omitting Phase I. It is suggested that the mean of these two figures be used until one or two production runs have been made and the actual number of Phase II passes counted.

Several other factors, not conveniently or precisely expressible by formulas, will cause actual Sort III running times to differ somewhat from the times as computed from the formulas:

A. The ungrouping of grouped input files and the grouping of output files require additional processing time. The former will seldom add more than 10% to the total Phase I time, and the latter will cause a very slight time increase in the last Phase II pass.

B. The arranging and restoring of control data fields, if performed, will similarly increase the processing time. As a rough estimate, the additional time required for each operation is  $0.08NF$ , where F equals the number of fields which must be moved about by the Arranger and Restore routines -- i. e. , control data fields and also the fields composed of successive non-control digits in the words in which control data fields, or portions thereof, appear.

Table of Phase II Passes			
Number of Sequences	P	Number of Sequences	P
2	1	257 - 512	9
3 - 4	2	513 - 1024	10
5 - 8	3	1025 - 2048	11
9 - 16	4	2049 - 4096	12
17 - 32	5	4097 - 8192	13
33 - 64	6	8193 - 16384	14
65 - 128	7	16385 - 32768	15
129 - 256	8		

## USE OR OMISSION OF PHASE I

As previously mentioned, it is permissible to omit the use of Phase I when sorting a file of records. The purpose in either using or omitting Phase I is to reduce the total sorting time. Since the effect of both phases is to reduce the number of separate sequences present in a file, and since they differ in method only, the omission of Phase I should be considered. A saving in sorting time will be effected by using Phase I if its use causes a greater reduction in the number of sequences in a file than would be caused by Phase II in the same length of time. Since the factors required to determine the effectiveness of Phase I are seldom readily obtainable, the best method for determining its effectiveness on a given file is by two trial runs: one using Phase I and the second omitting it. Both runs should be made with approximately the same number of records, and the method which results in the shortest running time should be selected for future use.

As an additional guide in the use or omission of Phase I in a sort, the following points concerning its effectiveness are presented:

- A. Phase I produces sequences of records sorted on the first ten digits of control data. Therefore, if a file is to be sorted on twenty or fewer digits, Phase I will, in general, be highly effective, since ten digits will suffice to order most records of such files. If more than twenty digits of control data are to be used for sorting, Phase I is less likely to be effective unless there exist few records in the file for which the first ten digits of control data are identical.
- B. If a file to be processed by Sort III is already ordered to a significant degree according to the control data used for sorting, Phase I may be incapable of producing fewer sequences than exist in the file, and should be omitted.

## TAPE LABELING PROVISIONS

Sort III provides facilities for duplicating, deleting, adding, replacing, and numbering of tape labels. Sort III assumes that tape labels are written as the first record of the file and are not followed by a tape mark. No facilities are included for the handling of beginning-of-reel labels followed by a tape mark or of end-of-reel labels.

Six columns of the control card are reserved to indicate the appropriate action to be taken on tape labels. The first, column 11, is punched with a function code digit which indicates the action to be taken. Below is a list of the permissible codes and the appropriate action which will be taken.

<u>Code</u>	<u>Action</u>
1	No tape labels will appear on the output reels.
2	A tape label will be read from a punched card and written as a numerical eight-word label on each output reel.
3	A tape label will be read from a punched card, expanded to ten words, and written as a ten-word alphanumerical label on each output reel.
4	A numerical tape label 1-50 words long will be read from the first input reel and written on each output reel.
5	An alphanumerical tape label 10, 20, 30, 40, or 50 words long will be read from the first input reel and written on each output reel.

When codes 2 and 3 are punched into column 11 of the control card, a label card must be prepared by the user of the program and placed between the control card and card 347 of the program deck.

The label card may constitute a numerical or an alphanumerical tape label, regardless of the mode of representation of the file processed. The card must be prepared as follows:



#### A. Numerical Label

Words 1-8 of the card must be completely punched with the desired label data; blank columns are not permitted. Any alphabetic characters must be expressed in double-digit representation (i. e. , A = 61, B = 62, etc. ).

Column 1 of the card must contain a 12-punch, and the units position of each word must be punched either plus (12-punch) or minus (11-punch) as desired.

When written on tape, the label will be eight words long, precisely as punched in the card.

#### B. Alphanumerical Label

Words 1-7 of the card to originate an alphanumerical label must be completely punched with the desired label data; blank columns are not permitted. These words must be punched in a form compatible with the WTA command - i. e. , each word must be entirely alphanumerical (double-digit representation) or numerical (single-digit representation).

Word 8 of the card must constitute a control word for the WTA command, and must be punched 088XXXXXXXX, where each X is either 8 or 0 according as the word it governs is alphanumerical or numerical.

Column 1 of the card must contain a 12-punch and the units position of each word must contain either a plus (12-punch) or minus (11-punch) as desired.

When placed in IAS preparatory to being written on tape, the label record will be expanded to ten words. Words 1-7 of the card become words 1-7 of the label and word 8 of the card becomes word 10 (alphanumerical control word) of the label. Words 8 and 9 of the label are filled in with zeros.

Columns 12 and 13 of the control card, the second and third columns of the six reserved to indicate the action to be taken on tape labels, are used to indicate the length of the labels present on input reels. If the input reels do not have labels, these columns are punched 00.

When 1, 2, or 3 is punched in column 11 of the control card and columns 12 and 13 are non-zero, the first record of each input reel is bypassed. If 4 or 5 appears in column 11, columns 12 and 13 must of course be non-zero, and the label which appears on the output reels is the one appearing on the first reel of the file mounted on tape unit 8010.

The remaining three columns (14-16) of those reserved for tape label action are used to indicate whether output reels are to be numbered sequentially and, if so,

what digit of the label record is to be used for numbering. If columns 14 and 15 are punched 00, all output reel labels will be exactly alike. If columns 14 and 15 are non-zero, the reel number in the position specified by the three columns is increased by 1 for each successive reel, columns 14 and 15 indicating the number of the word in the record (as the record appears in IAS) which is to contain the reel numbering digit, and column 16 indicating the number of the digit (counting 0 through 9 from left to right) which is to be updated for each reel. For example, 425167 in columns 11-16 of the control card would indicate the following:

<u>Card Columns</u>	<u>Contents</u>	<u>Meaning</u>
11	4	A numerical label is to be read from the first reel of the file mounted on unit 8010 and written on each output tape.
12-13	25	Input tape labels are twenty-five words long.
14-15	16	The sixteenth word of the tape label contains the numbering digit.
16	7	The digit to be updated for each reel is number seven counting from left to right.

If the sixteenth word in the label record of the first reel on unit 8010 were 6123973157 and there were three output reels, then the sixteenth word of the three output labels would be:

Output reel 1	6123973157
Output reel 2	6123973257
Output reel 3	6123973357

The remainder of the tape labels of each output reel would be identical with the remaining words of the duplicated input label.

## CONTROL CARD PREPARATION

The control card for Sort III should be punched as indicated below and inserted between cards 345 and 347 of the program deck. The card is, of course, prepared to conform to the requirements of the specific application.

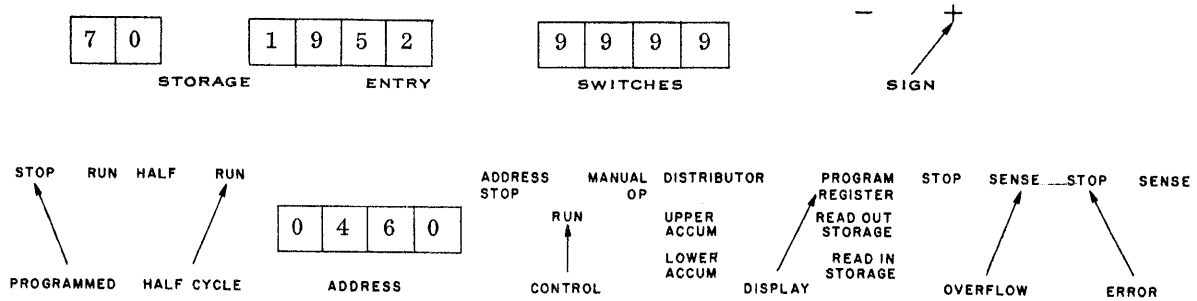
<u>Card Columns</u>	<u>Length of Field</u>	<u>Description (and references)</u>
1	01	<p><u>Master Function Code:</u></p> <p>1 = Sort, using Phase I; restore.            2 = Sort, using Phase I; do not restore.            3 = Sort, omitting Phase I; restore.            4 = Sort, omitting Phase I; do not restore.            5 = Merge; restore.            6 = Merge; do not restore.            7 = Transcribe; arrange.            8 = Transcribe; restore.            9 = Transcribe; do not alter control fields.</p>
2	01	<p><u>Number of reels</u> constituting the input file to be mounted on tape unit 8010. Must not be zero.</p>
3	01	<p><u>Number of reels</u> constituting the input file to be mounted on tape unit 8011. Must be zero except when merging.</p>
4-5	02	<p><u>Record Length:</u> The number of words in each input record. If records are grouped, length of one record of the group.</p>
6-7	02	<p><u>Input Grouping:</u> The number of records in each group of the input file; if records are ungrouped these columns must be punched with 01.</p>
8-9	02	<p><u>Output Grouping:</u> The number of records to make up each output file group; if</p>

<u>Card Columns</u>	<u>Length of Field</u>	<u>Description (and references)</u>
		an ungrouped output file is desired these columns must be punched 01.
10	01	<u>Padding Indicator:</u> Either "0" or "9" according as padding records present in and to be added to the file consist of zeros or nines. (See page 17 for further details.)
11	01	<u>Tape Label Function Code:</u> 1 = No output tape label. 2 = Read a numerical output tape label from a punched card. 3 = Read an alphanumerical output tape label from a punched card. 4 = Duplicate the numerical input tape label on the output reels. 5 = Duplicate the alphanumerical input tape label on the output reels.
12-13	02	<u>Input Tape Label Length:</u> The length in words of the input tape label; if there is no input tape label, these columns must be punched 00.
14-16	03	<u>Tape Label Updating Position:</u> The output tape label digit, in the form WWP, to be updated by 1 for each successive output reel. If there is no output tape label, or if updating is not desired, these columns must be punched 000.
17-18	02	<u>Phase II Pass Limit:</u> Phase II will be stopped automatically, if sorting, each time the number of passes punched here has been executed. If no pass-count stop is desired, these columns should be punched 99. If merging or transcribing, these columns have no significance.

<u>Card Columns</u>	<u>Length of Field</u>	<u>Description (and references)</u>
19-20	02	<u>Total Number of Digits of Control Data:</u> The number of digits in all control fields; i. e. , the sum of all LL's in card columns 31-80 (see below). May not be greater than 50.
21-30	10	<u>Control Field Mode Indicators:</u> If the input file is numerical the punching in these columns should be 0000000000. If alphanumerical, the ten digits in these columns specify the mode of each control field in card columns 31-80 as follows:  Column 21 - "8" if the first control field is alphanumerical, "9" if numerical.  Column 22 - "8" if the second control field is alphanumerical, "9" if numerical. "0" if there is none.  Columns 23-30 - Mode indicators as above for control fields 3 through 10.
31-80	50	<u>Control Field Descriptions:</u> Specifications of the control fields, in the form WWPLL, as follows:  Columns 31-35 - First control field.  Columns 36-40 - Second control field; "00000" if none.  Columns 41-80 - Specifications, as above, for control fields 3 through 10.

All 80 columns of the control card must be filled. In addition, a plus (12-punch) must be punched in card columns 1, 10, 20, . . . , 70, 80.

## SORT III OPERATOR'S INSTRUCTIONS



Initial Console Setting as shown above.

- A. Normal Starting Procedure: Computer Reset; Program Start.
- B. Special Instructions: See page 28 for interrupt and restart procedure.

Card Input (533, 537, or 407)

### READ FEED

NO. OF CARDS	FILE DESCRIPTION
345	Phase I (includes zero drum and five per card loader).
1	Control Card.
1	Tape label card (if required).
375	Phase II (includes five per card loader).

### CONTROL PANELS

Wire column 1 of First Reading to Load hub

### TAPE UNITS

ADDRESS	INPUT, OUTPUT OR OTHER	FILE PROTECTION RING		LABEL CHARACTERISTICS	FILE DESCRIPTION
		IN	OUT		
8010	Input		X		Input file
8011	Varies				*
8012	Output	X			Work Tape
8013	Output	X			Work Tape
8014					
8015					

407 Output (Optional for error print-out)

- A. Card Input \_\_\_\_\_
- B. Paper Forms Required Optional
- C. Carriage Control Tape Optional
- D. Control Panel Required Any panel for printing 10 Storage Exit words;  
Jackplug PVC or select it off by MTC.

\* If sorting, mount a work tape; if merging, mount the second input file.  
If transcribing, tape unit 8011 is not used.

## PROGRAM DECK

The Sort III program deck is made up of 722 cards end-printed 1-345 and 347-723. Cards 1 through 345 are the program cards for Phase I. Card 346 is omitted since the control card and possibly a label card are to be inserted at this point. Cards 347-721 are the program cards for Phase II. Cards 722 and 723 are the restart cards to be used as described under Interrupt and Restart.

If one of the sorting functions which use Phase I is specified in the control card, cards 347-721 may be separated from the deck and not readied in the Read Feed hopper until Halt 0111 occurs. In all other cases the entire deck (except for the restart cards) must be loaded into the Read Feed hopper together.

## OUTPUT REEL REMOVAL

Program steps cause all final output reels and all exhausted input reels to be rewound with the Tape Indicate light on, thus furnishing effective file protection. This method of protective rewind is used in conjunction with an automatic alternation of output reels so that a filled reel may be unloaded while the program is writing on the other output tape.

When a reel is rewound with the Tape Indicate light of the unit on, remove the tape and mount a new work tape. If both output tapes are rewound with the Tape Indicate light on, the program will hang up with the Control Unit Checking light on and a RWD (55) instruction in the Program Register. To continue processing, mount new work tapes on the output units and the program will automatically continue. The Error Sense Reset key should be depressed to turn off the Control Unit light before the new work tapes are mounted.

## INTERRUPT AND RESTART

Sort III is designed to permit the interruption of a sort and its completion at a later time. The method used to permit interruption and restart of the program is the periodic writing on tape in self-loading form of the contents of the drum. The records thus written are referred to as "checkpoint" records.

Two interruption procedures are offered to the user of Sort III. They are:

- A. End-of-pass interruption, which can be used to interrupt the program shortly after the conclusion of Phase I (if used) and at the conclusion of any Phase II pass.
- B. Immediate interruption, which can be used at any time except during Phase I, or during the first pass of Phase II if Phase I is omitted, and during the concluding minutes of the last Phase II pass.

The immediate interruption procedure should not be used under normal circumstances since it wastes the uncompleted portion of the pass being executed at the time of interruption; instead, the end-of-pass procedure should be used in all normal instances.

## I. Interrupt Procedures

### A. End-of-pass interruption.

Set the Address switches to 0460, and then the Control switch to Address Stop at any time during execution of the program. Processing will cease when the pass currently being executed is finished.

### B. Immediate interruption.

Set the Address switches to 0440 and then the Control switch to Address Stop at any time during processing. The program will usually stop within a few seconds; if it does not, the end-of-pass method must be used.

When the address stop occurs, display and record the contents of the lower accumulator (which will be either 11 1111 1111 or 33 3333 3333). Rewind and remove the reels mounted on 8010, 8011, 8012, and 8013. Label each reel with the address of the tape unit from which it was removed. The 650 is then free to be used as desired.

## II. Restart Procedure

Remount all tape reels removed during interruption according to the tape unit addresses with which they are labeled. Then select the proper restart card according to the contents of the Lower Accumulator at the time of interruption;

if 11 1111 1111, use the card (#722) punched 11 1111 in the first six columns

if 33 3333 3333, use the card (#723) punched 33 3333 in the first six columns

Ready this restart card in the input device and follow the normal starting procedure.

## PROGRAMMED HALTS

Note: If input records are grouped, the Program Reset instead of the Computer Reset key should be used in effecting transfers, in order to avoid disturbing the contents of the indexing registers.



## Phase I Assignment Routine

<u>Halt</u>	<u>Description and Action</u>
0000	The function code punched in column 1 of the control card is 0, and hence invalid. Correct the control card and reload the entire Sort III program deck.
0001	The number of reels specified in column 2 of the control card for the 8010 input file is zero. Correct the control card and reload the entire Sort III program deck.
0002	The individual record length specified in columns 4-5 of the control card is zero. Correct the control card and reload the entire Sort III program deck.
0003	Although the function code in column 1 of the control card is either 1, 2, 3, or 4, calling for a sort, a pass-count stop of 00 is punched in columns 17-18. Correct the control card and reload the entire Sort III program deck.
0004	The input file grouping specified in columns 6-7 of the control card is zero. Correct the control card and reload the entire Sort III program deck. (Note: Ungrouped input records must be designated by 01 in columns 6-7.)
0005	The input group length (record length times grouping factor) is greater than 60 words. Correct the control card and reload the entire Sort III program deck. This halt may also be caused by failure to insert the control card, in which case Sort III has assumed that the first card of the Phase II portion of the deck is the control card. If this condition exists, position the control card properly and reload the entire Sort III program deck.
0006	The output file grouping specified in columns 8-9 of the control card is zero. Correct the control card and reload the entire Sort III program deck. (Note: Ungrouped output records must be designated by 01 in columns 8-9.)
0007	The output group length (record length times grouping factor) is greater than 60 words. Correct the control card and reload the entire Sort III program deck.
0008	The control card indicates that input records are grouped. However, the function called for (sort, omitting Phase I; or

HaltDescription and Action

- merge) does not permit grouped input records. Correct the control card and reload the entire Sort III program deck if the input file grouping specified in columns 6-7 is incorrect; otherwise, transcribe the file for ungrouping before continuing with the desired function.
- 0009           The function called for (any other than merging) does not use an input file mounted on tape unit 8011. Correct the control card, and, if necessary, mount a work tape on tape unit 8011; then reload the entire Sort III program deck.
- 0010           The function called for (merging) requires that the second input file be mounted on tape unit 8011. Correct column 3 of the control card, and, if necessary, mount the first reel of the second input file on tape unit 8011; then reload the entire Sort III program deck.
- 0011           The total number of digits in the control fields, as punched in columns 19-20 of the control card, is greater than 50. Correct the control card and reload the entire Sort III program deck.
- 0012           Although the third word of the control card is non-zero, indicating that the input file is composed of alphanumerical records, the record length as punched in columns 4-5 is not a multiple of ten. Correct the control card and reload the entire Sort III program deck.
- 0013           One of the control fields designated in columns 31-80 of the control card extends past IAS location 9059. Correct the control card and reload the entire Sort III program deck.
- 0014           Either the initial digit (P) or the length (LL) of one of the control data field descriptions punched in columns 31-80 of the control card, and designated in word three as alphanumerical, is odd. Correct the control card and reload the entire Sort III program deck.
- 0015           Although the third word of the control card is non-zero, indicating that the input file is composed of alphanumerical records, one of the control fields punched in columns 31-80 extends into an alphanumerical tape record control word (IAS location 90X9). Correct the control card and reload the entire Sort III program deck.

HaltDescription and Action

- 0016           The total number of digits in the control data fields, as computed by Sort III from the control data field descriptions punched in columns 31-80 of the control card, does not agree with the corresponding number indicated in columns 19-20. Correct the control card and reload the entire Sort III program deck.
- 0017           The capacity of one of the internal tables built up by Sort III during generation of the Arranger routine has been exceeded. It will not be possible for Sort III to process this file.
- 0018           Two or more of the control data fields punched in columns 31-80 of the control card overlap each other within the record. Correct the control card and reload the entire Sort III program deck.
- 0019           The drum and IAS locations available for the generated Arranger routine are not sufficient. It will not be possible for Sort III to process the file. However, if the file is grouped, it is possible that by first transcribing it for ungrouping, enough locations may be made available to permit generation of the entire Arranger routine.
- 0020           The function called for (transcribing) may not be necessary, as the input grouping is identical to the output grouping, and as the control data fields are in a configuration which neither requires arranging nor, never having been arranged, requires restoring. However, this halt is merely precautionary, and if it is desired to transcribe the file for duplication and/or packing into a smaller number of reels and/or an alteration in the tape label, depress the Program Start key to continue processing.
- 0021           The function called for (transcribing) is not permissible, as both input and output are grouped, and their grouping factors are not identical. It is possible to process the file by first transcribing it for ungrouping and by then transcribing it for a new grouping.
- 0030           The input tape label length designated in columns 12-13 of the control card is greater than 50 words. Correct the control card and reload the entire Sort III program deck.
- 0031           The tape label function code punched in column 11 of the control card is either 0 or greater than 5, and hence invalid. Correct the control card and reload the entire Sort III program deck.

HaltDescription and Action

- 0032            Although the tape label function code punched in column 11 of the control card is either 4 or 5, calling for label duplication, the input tape label length designated in columns 12-13 is zero. Correct the control card and reload the entire Sort III program deck.
- 0033            An error has been detected while reading the input tape label from the tape on 8010. Probably an incorrect tape label length is punched in columns 12-13 of the control card, in which case the control card should be corrected and the entire Sort III program deck reloaded; or else an incorrect reel has been mounted on tape unit 8010 as the input file, in which case the correct reel should be mounted on the unit and then the Program Start key depressed. If neither of these events has occurred, four attempts to reread will be caused by depressing the Program Start key.
- 0034            An end of file condition has been detected while reading the input tape label from the tape on 8010. Probably an incorrect reel has been mounted as the input file on tape unit 8010, in which case, mount the correct reel and reload the entire Sort III program deck. If this is not the case, Sort III will not accept the input reel since the first record is a tape mark.
- 0035            An error has been detected while writing the tape label on the tape mounted on unit 8012. One attempt to rewrite the label will be caused by depressing the Program Start key.
- 0036            An end of file has been detected while writing the tape label on tape mounted on unit 8012. (Should not occur.) Check the tape for proper mounting.
- 0037            An error has been detected while writing program data on the tape mounted on unit 8013. One attempt to rewrite correctly will be caused by depressing the Program Start key.
- 0038            An end of file has been detected while writing program data on tape 8013. (Should not occur.) The tape on unit 8013 may be improperly mounted or may be too short.

## Phase I Running Program

<u>Halt</u>	<u>Description and Action</u>
0100	The input reel mounted on tape unit 8010 has been completely processed. When the tape has been rewound, remove it, mount the next reel of the input file on the tape unit, and depress the Program Start key.
0101	An error has been detected while reading a record from the input file mounted on unit 8010. Four attempts to reread the record correctly will be caused by depressing the Program Start key. If the error persists, IAS may be examined by console read-out, or, if a 407 is attached to Output Synchronizer 2, may be printed by transferring to location 0501. If the error can be corrected by manually altering the contents of IAS, do so. Then depress the Error Sense Reset key and transfer to location 0303 to re-enter the program.
0102	An error has been detected while writing a record on the output tape specified by the data address of the word in the Distributor. One attempt to rewrite the record correctly will be caused by depressing the Program Start key.
0103	An end of file has been detected while writing a record on the output tape specified by the data address of the word in the Distributor. This tape is too short. Replace it with a longer tape and start over at the beginning of the sort. If full length tapes are being used, the input file contains too many records and/or does not meet the conditions necessary for sorting.
0104	The IAS print-out is finished.
0105	An error has been detected while writing an end of file tape mark on the tape mounted on unit 8012. One attempt to rewrite the tape mark correctly will be caused by depressing the Program Start key.
0106	An error has been detected while writing an end of file tape mark on the tape mounted on unit 8013. One attempt to rewrite the tape mark correctly will be caused by depressing the Program Start key.

HaltDescription and Action

- 0107 An error has been detected while writing a tape mark, for identification purposes, on the tape mounted on unit 8013. One attempt to rewrite the tape mark correctly will be caused by depressing the Program Start key.
- 0109 The sort is complete; Phase II is not necessary. The output reel is mounted on tape unit 8012 and the last input reel on tape unit 8010. Both have been protectively rewound.
- 0111 Phase I has been completed. To begin Phase II, remove the last input reel (which has been protectively rewound) from tape unit 8010, and replace with a work tape. Check to insure that the remainder of the Sort III program deck is readied in the read hopper of the input device and that the Storage Entry switches are set to 70 1952 9999+ . Depress the Program Start key. Note: If it is desired to interrupt the sort immediately after Phase II has been loaded, perform the above action, but set the Address switches to 0460 and the Control switch to Address Stop before depressing the Program Start key.

Phase II Running ProgramHaltDescription and Action

- 0200 An error has been detected while reading the tape label from the tape on unit 8012. Four attempts to reread the record correctly will be caused by depressing the Program Start key.
- 0201 An end of file condition has been detected while reading the tape label from tape 8012. (Should not occur.)
- 0202 An error has been detected while writing the tape label on the tape specified by the data address of the word in the Lower Accumulator. One attempt to rewrite the record correctly will be caused by depressing the Program Start key.
- 0203 An end of file condition has been detected while writing the tape label on the tape specified by the data address of the word in the Lower Accumulator. (Should not occur.)

<u>Halt</u>	<u>Description and Action</u>
0204	An error has been detected while reading program data from the tape mounted on unit 8013. One attempt to reread the record correctly will be caused by depressing the Program Start key.
0205	An end of file condition has been detected while reading program data from the tape mounted on unit 8013. (Should not occur.)
0210	The drum and IAS locations available for the generated Restore routine are not sufficient. It will not be possible for Sort III to process, or to complete the processing, of this file. However, it is possible that if the function being performed is sorting or merging, and if grouped output is being called for, rerunning the program with ungrouped output may make enough locations available to permit generation of the entire Restore routine. The file could later be transcribed for grouping.
0220	An error has been detected while writing checkpoint records on the selected tape. One attempt to rewrite the record correctly will be caused by depressing the Program Start key.
0221	An end of file condition has been detected while writing checkpoint records on the selected tape. (Should not occur.) The selected tape may be too short.
0222	An error has been detected while reading checkpoint records from the selected tape during the restart process. Check to see that the correct restart card is being used; if not, ready the other restart card in the read hopper of the input device. Set the Storage Entry switches to 70 1952 9999, and depress the Computer Reset and Program Start keys. If the correct restart card is being used, one attempt to correctly reread the record will be caused by depressing the Program Start key. If the error persists, restart is not possible, and the job must be rerun from its beginning.
0223	This is a precautionary halt related to interrupt and restart. If a sort is now being restarted following interruption by the immediate method, disregard the stop and depress the Program Start key. If the end-of-pass method was used, the sort is now being restarted either at the beginning of Phase II, if Phase I was used, or at the end of the first pass of Phase II, if Phase I was omitted. Check to see that the last reel of the 8010 input

HaltDescription and Action

- file has been removed and that a work tape has been mounted on tape unit 8010. If so, depress the Program Start key. If not, perform this action now, and then depress the Program Start key.
- 0250 An end of file condition has been detected while reading the first record from the tape specified by the data address of the word in the Distributor. (Should not occur.)
- 0251 An end of file condition has been detected while reading the first or second record from the tape specified by the data address of the word in the Distributor. (Should not occur.)
- 0252 An error has been detected while writing an end of file tape mark on the tape specified by the data address of the word in the Distributor. One attempt to rewrite the tape mark correctly will be caused by depressing the Program Start key.
- 0253 An error has been detected while reading or writing a record. The type of error may be determined from the operation code of the word in the Lower Accumulator, and the tape unit involved from its data address. Depression of the Program Start key will cause either four attempts to reread or one attempt to rewrite the record correctly. If the error is a read error and persists, IAS may be examined by console read-out, or, if a 407 is attached to Synchronizer 2, may be printed by transferring to location 1350. If the error can be corrected by manually altering the contents of IAS, do so, and then depress Error Sense Reset key and transfer to location 1152 to re-enter the program.
- 0254 The IAS print-out is finished.
- 0260 The input reel mounted on unit 8010 has been completely processed. When it has finished rewinding, remove it, mount the next reel of the file on tape unit 8010, and depress the Program Start key. If a merge is being performed, be careful that the reel mounted is the next of the input file assigned to this unit.
- 0261 A merge is being performed, and the input reel mounted on unit 8011 has been completely processed. When it has finished rewinding, remove it, mount the next reel of the appropriate file on tape unit 8011, and depress the Program Start key.



HaltDescription and Action

- 0262 A sort is being performed, and the last reel of the input file mounted on unit 8010 has been processed. When it has finished rewinding, remove it, mount a work tape on unit 8010, and depress the Program Start key. Note: If it is desired to interrupt the sort at this point, perform the above action, but set the Address switches to 0460 and the Control switch to Address Stop before depressing the Program Start key.
- 0270 The record count accumulated during the current pass does not agree with that of the previous pass or (if on the first pass) with that of Phase I. The present record count is in the Distributor; the difference between the two record counts is in the Lower Accumulator. Depress the Program Start key to continue processing, using the present record count.
- 0271 The hash total accumulated during the current pass does not agree with that of the previous pass or (if on the first pass) with that of Phase I. The present hash total is in the Distributor; the difference between the two hash totals is in the Lower Accumulator. Depress the Program Start key to continue processing, using the present hash total.
- 0273 An end of file condition has been detected while writing a record. The tape specified by the data address of the word in the Distributor is too short. It will be necessary to replace it with a longer tape and to start the job over from the beginning. If full length output reels are being used, the input file contains too many records and/or does not meet the conditions necessary for sorting.
- 0274 If the function being performed is that of merging, the input file specified by the data address of the word in the Distributor is not truly sorted. The file should be sorted and the merge begun again.
- If the function being performed is that of sorting, a sequence break has been discovered during the last pass on the reel identified by the data address of the word in the Distributor. The halt suggests that some mishandling of tape reels has occurred after the next-to-last pass, particularly if the sort was interrupted at that time; otherwise, the halt should never occur. In any case, the sort should be begun again.

Halt

Description and Action

0275

Pass-count halt: the desired number of Phase II passes has been completed. The same number of additional passes will be performed if the Program Start key is depressed. If it is desired at this time to change the value of the pass count, set the new value in the Storage Entry switches, in the form 00000000XX, turn the Sign switch to minus (-), and then depress the Program Start key.

If it is desired to interrupt the sort at this point, set the Address switches to 0460 and the Control switch to Address Stop before depressing Program Start.

0276

Equivalent to Halt 0275; however, only one pass remains to complete the sort.

0280 }  
0281 }  
0282 }  
0283 }

The job is finished. Unless the function being performed was that of transcribing, the output record count (adjusted to include added and deleted padding records, if any) is in the Distributor. Any input reels which have not yet been removed are protectively rewound.

The table below shows, according to halt code, which tape unit contains the final output reel. In addition, the unit used for the next-to-last output reel is shown. The next-to-last reel is on the unit indicated only if the Tape Indicate light of the unit is on (otherwise the reel has previously been removed).

<u>Halt</u>	<u>Final reel on unit</u>	<u>Next-to-last reel on unit</u>
0280	8010	8011
0281	8011	8010
0282	8012	8013
0283	8013	8012

**IBM**

**International Business Machines Corporation**  
500 Madison Avenue, New York 22, N.Y.