HARVEST CONTROL PROGRAM

Problem Program Channel Assignment

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III. Summary

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I. Purpose and Scope

The function of the Problem Program Channel Assignment program is to make Tractor tape cartridge and transport assignments for Input, Output, and Work files which are on, or will be contained on, Tractor tapes required by problem programs during the production cycle. It makes these assignments in such a manner that time-consuming fetching and storing of Tractor tape cartridges is held to an absolute minimum during a production cycle.

In order to fulfill this function, the Channel Assigner must insure that certain conditions relative to both the physical locations of files requested within the Tractor filing system and the current status of availability of Tractor transports are met. These conditions are discussed in detail below.

II. Operations of the Channel Assigner

A. Definition and Explanation of "Level of File Usage"

The basic point of departure in all analysis carried out by the Channel Assigner is the "level of file usage". This term is defined as any point in time during the actual running of a problem program at which usage of a given file or files by the program is required. Several files required <u>simultaneously</u> during a production program are by definition on the <u>same</u> level of file usage.

For example, production program 1 requires a total of three files: files A, B, and C. If all three files are required simultaneously by the program, and at no other time and in no other combinations, there is <u>one</u> level of file usage within the program.

All files are on the same level of file usage: level 1 for program 1.

On Level 1

File A
File B
File C

Or, to illustrate on the basis of the files involved:

File	On Level
A	1
B	1
C	1

If program 2 requires initially files D, F, and G, then files E, G, and H, and finally files D and H, in that sequence, there will be three levels of file usage within program 2, as follows:

On Level 1	On Level 2	On Level 3
File D	File E	File D
File F	File G	File H
File G	File H	

Or again, on the basis of the files involved:

File	On Level
D	1, 3
E	2
F	1
G	1, 2
H	2, 3

A problem program is limited to 15 levels of file usage and an entire production cycle of n problem programs is limited to 1ØØØ such levels.

There are four refinements of the definition of "level of file usage" as used by the Channel Assigner. These are:

1. "Within-Step" Level: The level(s) on which a file is used within a problem program, i.e., from 1 to 15.

2. "Within-Cycle" Level: The relative level(s) on which a file is used within a production cycle, i.e., from 1 to 1ØØØ.

If program 1 is the first program in the production cycle and program 2 the second, the "within-step" and "within-cycle" levels for the files are as follows:

File	Within-Step Level	Program	Within-Cycle Level
A	1	1	1
B	1	1	1
C	1	1	1
D	1, 3	2	2, 4
E	2	2	3
F	1	2	2
G	1, 2	2	2, 3
H	2, 3	2	3, 4

Note that there cannot be two within-step levels of the same number within a program, nor two within-cycle levels of the same number within the problem program portion of a production cycle.

3. "Wait" Level: A level on which a file is not actually used, but the file has been required on a prior level and is required on a later level. Within-cycle level 3 of program 2 is a "wait" level for file D.

4. "Nil" Level: A level on which a file is not required, and use of the file is not required until a later level. Within-cycle level 2 is a "nil" level for file E in program 2.

Levels of file usage for any file used within a problem program are indicated by the programmer in the I/O Definition (IOD) pseudo-op statement. This indication is made in the file sequence indicators specified and these result in a 15-bit field

in the Symbol File Table entry formed by HAP II from the IOD statement. This 15-bit field is taken from the Symbol File Table entry by the Problem Program File Generator and placed in the appropriate file request entry in the File Control Table. These fields would appear as follows for the files in program 2:

File	Sequence Indicators
D	101000000000000
E	010000000000000
F	100000000000000
G	110000000000000
H	011000000000000

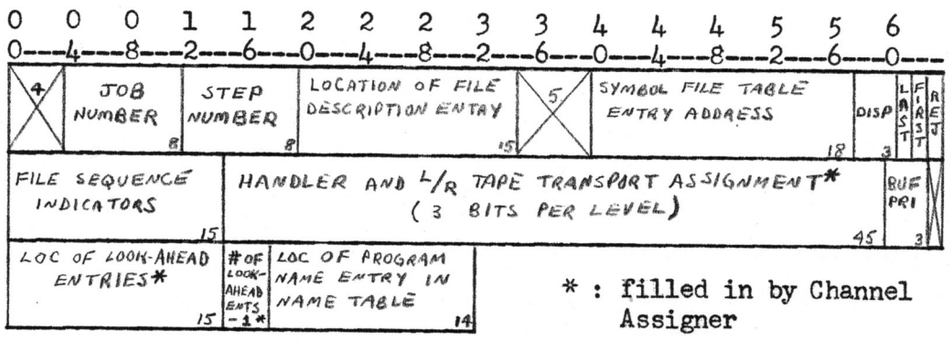
B. Generation of Table of "Within-Cycle" Levels (COUNTR)

The Channel Assigner must analyze and determine Tractor tape requirements for each level within the problem programs of the production cycle in order to optimize Tractor cartridge and transport assignments. Its first step is to construct a table of within-cycle levels, COUNTR. Information for the generation of this table is taken from entries in the HCP File Control Table.

The HCP File Control Table is available in memory at channel assignment time. It is generated by the Job Request Analyzer with certain information needed by the Channel Assigner being added by the Problem Program File Generator. It contains file request, description, and location entries for each problem program file requested for use in the production cycle. Entries in this table are shown below.

There is one and only one file request entry for each usage of a file in a problem program. If the same file is used in 5Ø programs in the production cycle, there will be 5Ø file request entries for it.

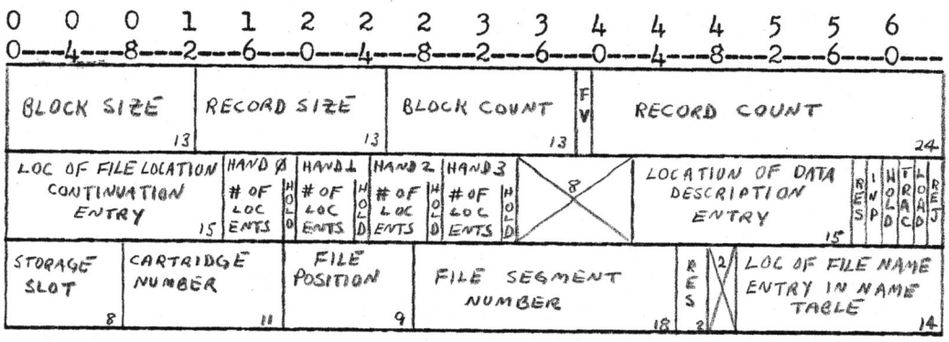
File Request Entry (2½ words)



* : filled in by Channel Assigner

There is one and only one file description entry for <u>all</u> appearances of a file within a job in the production cycle. If a file is used in 1Ø jobs, there will be 1Ø file description entries for it.

File Description Entry (3 words)



The location and identification of the first segment of a file is contained in word three of each file description entry. When a file is contained in more than one segment or is located on more than one Tractor handler, a file location continuation entry is required; each word of this entry has the same format as the file location word in the file description entry except that bits 50-63 (entry location in Name Table of file name) are unused.

Each file request entry in the File Control Table is analyzed by the Channel Assigner. The following information is obtained for each file, on a file-by-file basis:

1. The disposition of the file: Input, Output, or Work. If the file is an Input file and is now in Tractor storage, the handler on which it is stored is noted.
2. The within-step levels on which the file appears are noted according to the 15-bit file sequence indicator field in the file request entry.

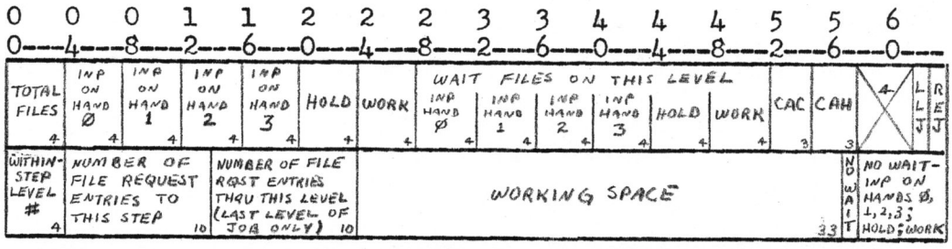
Using program 2 as an example, say the files used are as follows:

File	Disposition	On Handler	Sequence Indicators	Within-Step Levels
D	Input	Ø	101000000000000	1, 3 (+1)
E	Input	1	010000000000000	2 (+1)
F	Work	-	100000000000000	1 (+1)
G	Work	-	110000000000000	1, 2 (+1)
H	Output	-	011000000000000	2, 3 (+1)

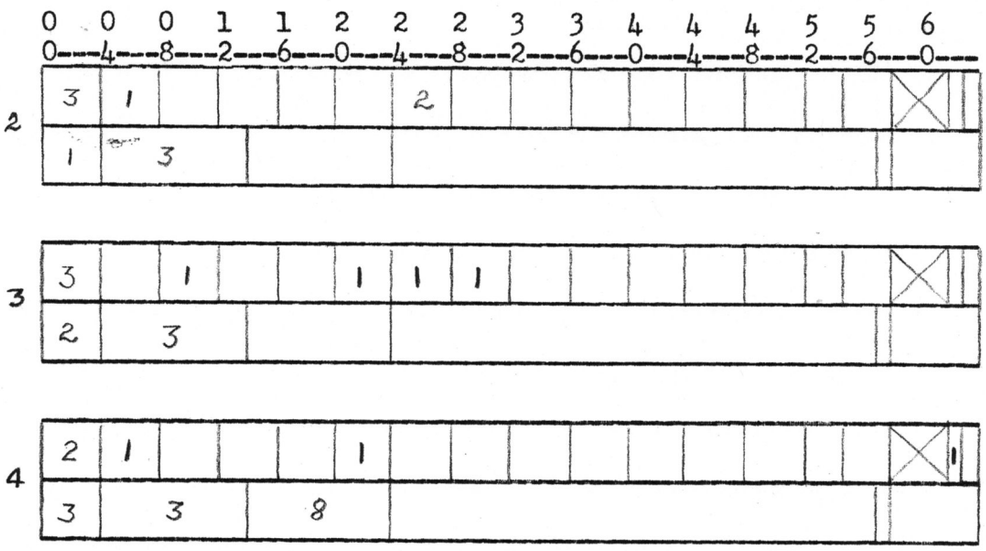
Since program 1 will already have been analyzed, there is an entry for within-cycle level 1 in COUNTR, and the within-step levels for files used in program 2 are increased by 1 to obtain the proper within-cycle level numbers in COUNTR. Similarly, the within-step levels required for files in program (step) 3 will be increased by 4 to obtain within-cycle level numbers for files used in this program.

Each within-cycle entry in the COUNTR table is two words in length. The length of the table is limited to 2ØØØ words. When analysis for program 2 is completed, there is an entry for each within-cycle level in that program (plus entries for all within-cycle levels in the preceding programs) in COUNTR which shows the total number of files required on the level, the number of existing

Input files now located in storage, and the number of Hold and Work files required, as well as the number of files of each category which will "wait" on the level. The format for each COUNTR Table entry is as follows:



After the above analysis, the COUNTR table entries for program 2 will be as follows:



When all entries have been made in COUNTR through file H, the Channel Assigner notes that this is the last file used in job 1. The following steps are taken:

1. The number of file request entries analyzed through the last level in this job is stored in the third field of word 2 of within-cycle level 4 entry in COUNTR.

2. The number of file request entries analyzed through the last level of the preceding step (program 1) is inserted in the second field of word 2 of each within-cycle level in this step (levels 2-4) in COUNTR.
3. Since within-cycle level 4 is the last level in this job, the "last level in job" indicator is set to 1 in bit 62 of word two of within-cycle level 4 entry in COUNTR.
4. The constant (1, in this case) used in computing the within-cycle level number from the within-step level number in this step (program 2) is stored as a 1Ø-bit number in bits Ø-9 of the vacant "location of look-ahead entries" field in word 3 of each file request entry for this step (program 2) in the File Control Table.

Steps (1) and (3) above are not carried out if file H is the last file in this step but not the last file in this job.

The entire procedure is repeated for each file request entry in the File Control Table until every file request entry has been analyzed and the COUNTR table is completed for the production cycle.

C. Checks Made on Requirements for Levels

1. Excessive File Requests

The number of Tractor tape transports now available is obtained and compared against the "total files" field of each within-cycle level in COUNTR. If the number of requested files for any level exceeds Tractor transport availability, the entire job in which that level appears is rejected and will not be processed further by the Channel Assigner. The

following steps are taken:

a. The first within-cycle level of this job is marked "rejected" in COUNTR. The reject indicator for this level (bit 63 of word 1) is set to 1.

b. All file request entries for this job are marked rejected in the File Control Table. Bit 63 of word 1 of the file request entry is set to 1.

c. A three-bit code, ØØ1, meaning "rejected for excessive file requests" is inserted in bits Ø-2 of word 3 of each rejected file request entry.

The check is then resumed at the first level of the next job in COUNTR and is repeated until every level in COUNTR has been checked.

2. Conflicting Cartridge Check

It is possible that a condition may occasionally arise in which two existing Input files required on the same level of file usage within a production program are physically located on the same Tractor cartridge. The programmer will not be aware of this condition.

The Channel Assigner, working from both the file request and file description-location entries in the File Control Table, checks for this condition by comparing the cartridge location(s) of each existing Input file in a step (program) against those of all other existing Input files in that step which will be used on the same level or levels. In case of a cartridge conflict between two files, an entry for each file is made in a 1ØØ word temporary table, CACTAB, which is

designed to make a cumulative count of the number of times files conflict with each other on this basis.

If files K, L, M, and N are required simultaneously, and also K and O on a later level, and all are on the same cartridge, CACTAB would appear as follows:

IDENT FILE K (15)	# OF CONFLICTS 4 (6)	FILE L	3
FILE M	3	FILE N	3
FILE O	1		

File K, the file with the greatest number of cartridge conflicts, will be copied on another and non-conflicting cartridge. All file request entries for file K within the job are flagged in bits 13 and 14 of word three with the two-bit code Ø1, "copy on another cartridge", and a 1 is added to the "CAC" field in word 1 of each within-cycle level entry in COUNTR on which file K appears within the job. Note that had all the number of cartridge conflicts been equal, or if, say, K, L, and M had been equal but higher than N and/or O, the last or rightmost file in either case would have been selected for copying.

CACTAB is now cleared and the identical check is repeated, starting with the next file request entry below the initial file K entry, except that this time all following file K entries for the job are ignored. This process is repeated until CACATB shows no cartridge conflicts remaining in the job. An advance

is then made to the first file request entry in the next job in the File Control Table and the process is again repeated.

3. Over-Assigned Handler Check

Since the programmer will not know in which Tractor handler existing Input files requested for a given level of file usage are stored, it is possible that the number of requested Input files will exceed the number of Tractor tape drives (two, at most) currently available for the particular Tractor handler.

In order to check on this condition, the Channel Assigner compares the number of required existing Input files for each level in COUNTR for each handler against the current availability of Tractor tape drives on each handler. If a file is requested which is now in storage in a Tractor handler that is "down" (no tape drives available), the entire job in which that file is requested is rejected. The same steps are taken as previously indicated in "rejected for excessive file requests", except that the three-bit code ØlØ is inserted in bits Ø-2 of word 3 of each affected file request entry.

If in the course of its handler-by-handler/level-by-level checking, the Channel Assigner finds that too many files are requested on a within-cycle level for a given handler, it attempts to locate an existing Input file on that level and on that handler which can be copied on another handler and used on all levels in which it appears within the job, without causing the handler on which it is copied to be over-assigned in any level.

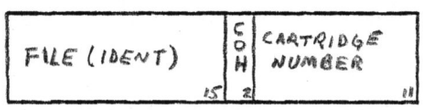
The Channel Assigner works back and forth between COUNTR and the File Control Table during this analysis. From information contained in the within-cycle level entry in COUNTR, it locates the file request entries for the correct existing Input files (those on this within-cycle level and located in this over-assigned handler) and then goes back to COUNTR to analyze handler assignments on all within-cycle levels in which the tested files appear within the job.

Files are tested in the following order:

a. All files marked CAC (if any) in the level containing the over-assigned handler, regardless of current handler assignment.

b. All other existing Input files on the level which are assigned to the over-assigned handler, in order of their appearance in the File Control Table.

As soon as, and if, a file is found which will satisfy the above noted condition, it is selected as the file to copy and the search stops. An entry is made in the temporary COPY table (old CACTAB) as follows:



COH : copy on handler # __

In addition, the following steps are taken:

a. The new handler on which the file will now appear is noted and assignment to the new handler is indicated in word 2 of the file request entry for the file (the entire field for 15 levels covers bits 15-59 of word

2). The file request entry is then flagged "assigned".

b. The file request entry is marked with the two-bit code 1Ø, "copy on another handler" in bits 13 and 14 of word 3.

c. A 1 is added to the "CAH" field in every within-cycle level on which the file appears in COUNTR. If the file selected was already marked CAC, "copy on another cartridge", a 1 is subtracted from the CAC field in every within-cycle level on which the file appears in COUNTR.

d. The counts in all within-cycle levels on which the file appears in COUNTR for this job are altered to show the new storage location of the file.

If none of the existing Input files satisfied the "free handler" condition, the entire procedure is repeated, except that in this case, the file which causes the least number of conflicts, i.e., the least number of required copies and is now physically located on the least number of cartridges or in the least number of segments on the same cartridge , is selected for copying. The same type of copy entry is made in the COPY table as in the former case. It should be noted that in the second case, assuming the file will require only one copy, that the file must of necessity be available on two handlers. For example, if file R is initially required on over-assigned handler Ø in level 3 and can be copied on handler 2 in that level, but must remain on handler Ø in level 5, since on level 5 no other handlers are available for copying, then file R must be made available to the program on both handler Ø and handler 2.

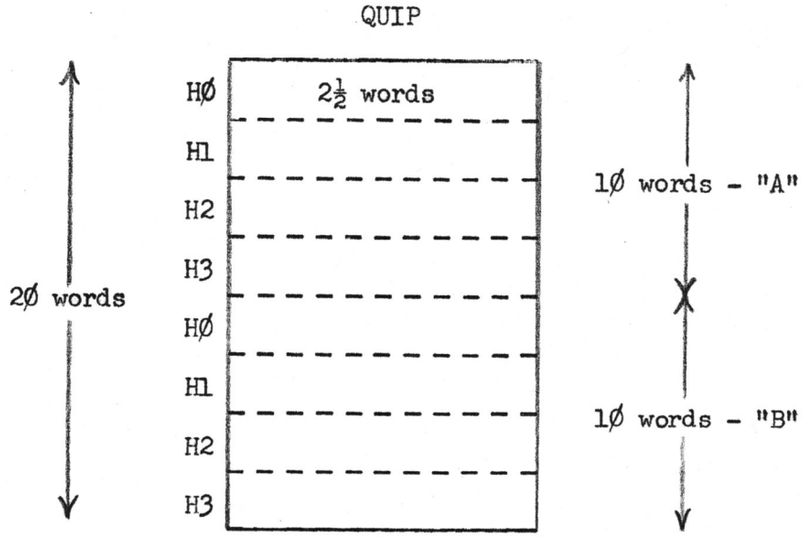
In either case, the copy of the file is considered a Hold file, a file that will not be used past the job in which it is required. The copy is not an addition to the permanent Tractor files.

After it has selected a file for copying and has performed all necessary bookkeeping, the Channel Assigner returns to the handler field which initiated the search in the within-cycle level in COUNTR. If the handler is not now over-assigned, the next handler field is checked in that level. If the handler is still over-assigned, the search process is restarted, except this time the copied file is ignored. When the check has been completed for all handler fields in the within-cycle level, the entire process is repeated for the next within-cycle level in COUNTR until all levels have been checked.

When all levels have been checked and the COPY table contains entries for all "copy on another handler" files, a file-by-file check is made down the file request entries in the File Control Table and entries are inserted in the COPY table for each "copy on another cartridge" file. Except where a "CAC" file was selected for copying on another handler, all "CAC" files will be copied on the handler to which they are now assigned. The COPY table is limited to a 1ØØ word length, which allows 264 files to be copied for any production cycle.

Available cartridges, including overflow cartridges (in the event a copied file requires more than a single cartridge) are selected through the system tables QUIP and TUSC (Tractor Unit Storage Control), which provide a catalog of currently

available cartridges. These tables appear as follows:



There is a one-bit entry for each Tractor storage slot in both sections A and B. Note the subdivisions by handler in both sections. These bit indicators have the following meanings:

Section A - Ø = cartridge in this slot is unavailable for Output assignment (permanent, full Hold, unusable cartridge, empty slot, etc.)

1 = cartridge in this slot is available for Output assignment (clean or partially filled Hold)

Section B when the corresponding bit in section A is a one -

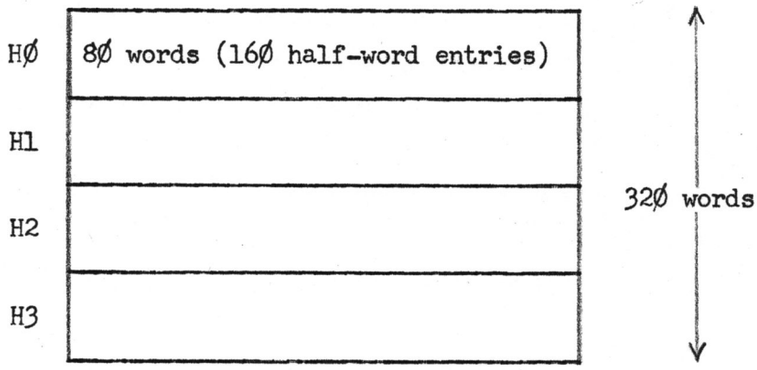
Ø = cartridge in this slot is a partially filled Hold cartridge

1 = cartridge in this slot is a "clean" cartridge.

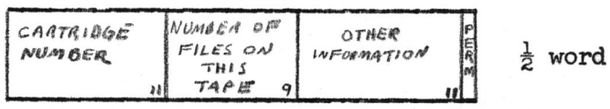
Note that the "A" indicator must be 1 if the cartridge in that

slot is to be used by the Channel Assigner. The Channel Assigner will always attempt to select "clean" cartridges first for copying. For this purpose, the ideal combination of indicators "A" and "B" will be 11.

TUSC



This table is an expanded form of QUIP, and contains additional necessary information for each Tractor storage slot. A TUSC entry, one for each slot, appears as follows:



The TUSC entry as shown is not complete. Both QUIP and TUSC are permanently in memory during a production cycle.

4. "Wait" Check

A file can "wait" through any number of levels, provided the Tractor transport to which it is assigned is not required in any of the levels on which the file waits (See discussion of a "wait" level, page 3.). To allow a file to wait through a level or through n levels eliminates the need for time-consuming storing and re-fetching of the file when it is again

needed for a later level by the program or for a later level in another program in the job.

In order to check on "wait" conditions, the Channel Assigner performs the following steps for each within-cycle level entry in the COUNTR table.

a. The "total files" field in word 1 is compared against the number of Tractor transports available. If these quantities are equal, there can be no "waits" on this level, since all available Tractor transports are required for active files. The "no wait" indicator is set to 1 in word 2 of this within-cycle level entry, and an advance is made to the next within-cycle level entry.

   If the number of Tractor transports exceeds the number of active files required for the level, the following analysis of the level takes place:

b. For each handler field, the total existing non-wait Input files are added to the total "wait" files required on that handler. This sum is compared against the number of Tractor transports available for the handler. If the latter figure exceeds or is equal to the former, "wait" Inputs for this handler can in fact wait through this level. If, however, "wait" Inputs plus non-wait Inputs exceed the number of available Tractor transports for the handler, the proper bit is set to 1 in the four-bit "no wait on handler" field (one bit for each handler) in word 2 of the within-cycle level entry. The excess

is then deleted from the "wait" count for this handler in word 1 of the COUNTR entry.

c. The counts of Hold and Work "wait" files are summed for this level and added to the totaled Hold and Work non-wait files and to the remaining Input (both "wait" and non-wait) files for this level. If this total does not exceed the number of currently available Tractor transports for this level, all "wait" files (except deleted Inputs, if any) appearing on this level can in fact wait through the level.

If, however, total "waits" plus total non-waits exceed the number of available Tractor transports, "wait" files are deleted from the counts in word 1 of the entry in the following order until there is no "wait" overage:

(1) Work, if any

(2) Input, if any remain

(3) Hold, if any

Corresponding deletions are made from the "wait" counts in word 1 of the within-cycle level entry. If the process of deletion removes all wait files, the "no wait" indicator is set to 1 for the level in word 2 of the level entry. The "no wait" Hold, Work or handler (Input) indicator is also set to 1 if all Work, Input, and/or Hold "wait" files are deleted.

This entire procedure (steps a, b, and c) is repeated for each within-cycle level entry in COUNTR until each level has been checked.

D. Level-by-Level Assignment of Files

1. Handler Assignment - Hold and Work Files

Initial handler assignment is made for Hold and Work files. Existing Input files (those already in Tractor storage) are not assigned in this step. For each file request entry for a Hold or Work file in the File Control Table, the following analysis is made:

a. The file is temporarily assigned to handler Ø on each level on which it appears in the COUNTR table of within-cycle levels. If on any of these levels, this assignment causes Handler Ø to be over-assigned, a four-bit table of indicators, GUDHND, initially set up to appear as follows,

HØ	H1	H2	H3
1	1	1	1

is altered to indicate that this file cannot be assigned to handler Ø, by setting the indicator for that handler to Ø. GUDHND now appears as follows:

HØ	H1	H2	H3
0	1	1	1

This procedure is repeated for all handlers on all levels on which the file will appear.

b. When all levels on which the file is to appear have been tested, GUDHND is checked for 1's.

(1) If a single 1 remains, the file is assigned to the handler indicated by that 1. It is flagged <u>assigned</u> in its file request entry(s) in the File Control Table. COUNTR entries for all levels on

which the file appears are altered to show the assignment on the handler selected. The actual handler assignment is inserted in word 2 of the file request entry(s) for the file and in the file location entry(s) for the file.

(2) If more than one "1" remains in GUDHND, and if the file "waits" on any level(s), the levels on which it will wait are analyzed according to the available handlers for the file. If the file can "wait" on one of the available handlers, that handler is selected for assignment. If not, the rightmost available handler as indicated in GUDHND is selected.

(3) If no 1's remain in GUDHND, this file will be assigned to the handler that will require the least number of files (preferably existing Input files) to be copied. An Input file is selected for copying from this handler to another handler in the level (or levels) which will have an over-assigned handler when the subject Hold or Work file is assigned. The copied file will be confined to the handler on which it is copied in this level(s) only.

This entire procedure is repeated for each file request entry in the File Control table until each Hold and Work file is assigned to handler.

2. Handler Assignment - Existing Input Files

Handler assignment is already included in the within-cycle level counts in the COUNTR table for existing Input files. A straight pass is made down the File Control Table, and from the already existing location entry(s) for files of this disposition, the handler assignments are inserted in word 2 of the file request entry(s) for existing Input files.

At this point, all handler assignments have been made and all within-cycle levels in COUNTR reflect this condition.

3. Tractor Transport Assignment

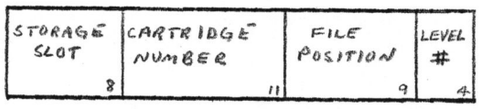
This portion of the Channel Assignment program is not at this time completed in detail. However, in general, Tractor transport assignments are made for each file on a simple left to right basis on each level. Care is taken to analyze "wait" conditions and assignments on the immediately preceding level to insure that duplication of Tractor transport assignment does not occur on any level.

4. Cartridge Assignment - Hold and Work Files

This portion of the Channel Assignment program is also not completed in detail. Cartridges are selected through the systems tables QUIP and TUSC. Available "clean" cartridges are always selected where possible, although in an effort to eliminate excessive cartridge usage and handling, the same cartridge will be used for a number of Work files when conditions of assignment on the levels so permit. Hold files on each level will be assigned to "clean" cartridges until the number of remaining "clean" cartridges available to the cycle goes below a certain number, which will be related to the number

of "clean" cartridges available at the start of the cycle. After that point, Hold files will be put on the same cartridges as other Hold files, where existing assignment on the levels so permit. Care is taken to insure that no Hold or Work file is assigned to the same cartridge, under any conditions, as any other Hold or Work file which appears on the same level with it. File location entries are updated as assignment for a file is completed as to handler, tape transport, and cartridge. In addition, "look-ahead" entries, as shown here,

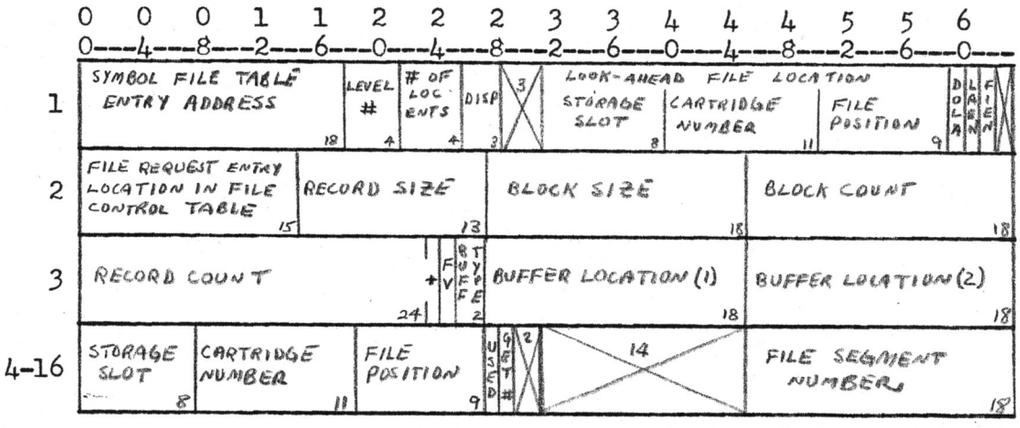
LOOK-AHEAD ENTRY ($\frac{1}{2}$ word)



are inserted when necessary in the first available location in the File Control Table. These entries apply both to Tractor transport and file, and will be used to indicate to the MCP (Machine Control Program) the next file to be located and placed on the Tractor transport now being used for this file on this level.

E. Copying

The COPY table is at this point completed for the production cycle. The Channel Assigner analyzes the entries for these files in this table and in the File Control Table and makes a FLASC (File Location and Assignment Control) table entry for each tape transport to be used for copying in COPY level 1. A FLASC entry consists of a 16 word entry for each level for each Tractor transport. The entire table for one level is 128 words in length. A FLASC table entry appears as follows:



When the necessary FLASC entries are completed for COPY level 1, a branch is made to the MCP and the copying of the files is carried out. Upon completion of the actual copying, the Channel Assigner checks the FLASC entries to determine whether any copied file "overflowed" onto another cartridge or cartridges. If this did occur, file location entries in the File Control Table are updated to indicate this condition.

If the number of files to be copied is so great that all files cannot be copied in one level, the above procedure is repeated (but always as COPY level 1) until all files have been copied.

At this point, all assignments have been completed for all the files used by all the problem programs in the production cycle and a branch is made to Channel Assignment Control.

III. Summary

The Problem Program Channel Assignment program makes Tractor tape cartridge and transport assignments for all files which are required for problem programs in the production cycle. It optimizes these assignments so that fetching and storing of cartridges is kept to a minimum.

The Channel Assigner can be called in at any time to assign or reassign in the event that the number of available Tractor transports changes.