DEMONSTRATION OF DYNAMIC TRACK ASSIGNMENT PROGRAM

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Menlo Park, California 94025

In Cooperation with
Southern Pacific Transportation Company
San Francisco, California 94105

June 1979

Phase I Report

FREIGHT CAR
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PREFACE

This interim report documents the first phase of a three-phase effort to develop and demonstrate a dynamic track assignment program. The work was a cooperative effort of the Transportation and Industrial Systems Center of SRI International and the Southern Pacific Transportation Company (SP). The Association of American Railroads Freight Car Utilization Program (AAR/FCUP)--Task Force 2, under the program management of Mr. Donald G. Wooden (program director) and Mr. Richard V. Muehlke (deputy program director), sponsored the work.

The research was performed under the supervision of Mr. W.V. Williamson, manager of Operating and Terminal Systems at SP. Dr. Peter J. Wong, Manager of Operations Research in SRI's Transportation and Industrial Systems Center, was the project leader and directed a team consisting of:

- Ms. C.V. Elliott (SRI) -- Designed and implemented input, output, and inventory management system.
- Mrs. M.R. Hathorne (SRI) -- Designed and implemented track assignment logic and user command structure.
- Mr. P.L. Phillips (SP) -- Provided detailed expertise and data on yard operations.

The authors would like to acknowledge the guidance of the following members of Task Force 2 concerned with utilization and service reliability impacts of railroad operating plans: P.M. Lefstead (Southern Railway Co.); J.S. Christie (Canadian National Railways); R.W. Drucker (Chessie System); G.E. Hamilton (Missouri Pacific Railroad Co.); W.K. Minger (Association of American Railroads); W.L. Paul (Atchison, Topeka & Santa Fe Railway Co.); D.W. Salzman (Union Pacific Railroad); M.H. Westerfield (Chicago, Milwaukee, St. Paul, & Pacific Railroad Co.); and T. Ellen (Federal Railroad Administration).

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EXECUTIVE SUMMARY

Railroad yards are important in three ways:

1. Freight cars necessarily spend a great deal of time in yards.
2. Service quality (origin-destination mean transit time and transit time reliability) is largely a result of yard connection performance.
3. Yards are a major component of operating costs.

Even after bypass train operations are fully exploited, cars must continue to spend a great deal of time in originating yards for consolidation and switching because of the wide dispersal of traffic origination and destination points and the low car count of the average customer release. Thus, any tool that enables a yardmaster to reduce car detention time in yards, improve performance, and improve the efficiency of yard operations will not only benefit car availability and therefore car utilization but also contribute substantially to the railroad industry's ability to enhance revenues and profits. The dynamic track assignment program is such a tool.

The standard industry track assignment technique is static class track assignment, which utilizes the same tracks for the same blocks day after day. Static assignments are used because yardmasters find them most easy to comprehend and administer, not because they are the most effective. In particular, static assignments work well only if there are no significant fluctuations in the average daily traffic volumes per classification to be switched. Because an average traffic day seldom occurs, statically assigned tracks are generally either overflowing or underutilized. This induces the unplanned mixing of blocks on the same track or the unplanned assignment of tracks to blocks, thus slowing trimming and makeup operations.

An effective dynamic track assignment technique would assign blocks to tracks dynamically according to current and projected near-term conditions. As a controlled decision process, such a technique would have as its objectives the maximization of classification track utilization and the minimization of makeup-engine work. Currently, a yardmaster tries to accomplish these objectives using his own ingenuity. As long as his business is light and he has plenty of track room and time, he can do a reasonable job. But as soon as his business picks up, he will assign cars anywhere they will fit in order to keep the hump going. This almost always results in extra trim-engines and/or extra car detention time in the yard.

It is expected that the dynamic track assignment program will increase car availability and thereby car utilization by decreasing yard detention times. The dynamic track assignment program will contribute to a decrease in yard detention time in the following ways:

- Reduction of wait time on class tracks (by facilitating train makeup).
- Reduction of wait time on receiving tracks (by ensuring that the humping operation is not stopped because of inefficient utilization of class tracks).
- Elimination of intermediate terminal handling (by allowing more preclassification in an upstream yard).
- Elimination of wait times on receiving and class tracks (by enabling more preblocked "bypass blocks").

The concept of a dynamic track assignment program started with the SP in the early 1970s with an in-house exploratory effort called CACTUS (Computer Assisted Classification Track Utilization system). A three-day manual test for a specific yard of a preliminary form of the dynamic track assignment decision rules at SP resulted in the following benefits compared to the existing static track assignment method:

- One planned rehump track versus nine unplanned
- At least three clear tracks at all times versus none
- No delay to outbound trains versus many delays
- Five percent less trim-engine time.

The objectives of our present project were to build a computer program that utilized the CACTUS experience but incorporated numerous enhancements and modifications necessary to assist a yardmaster in making real-time track assignment decisions in an actual field trial, to conduct a field trial, and to document the program and field experience in a manner that would facilitate industrywide transferability. To achieve these objectives, the project was divided into three phases:

- Phase 1: Development of prototype program
- Phase 2: Validation and preparation for field trial
- Phase 3: Field demonstration and evaluation.

This report documents the completion of Phase 1. The following work was accomplished:

- A prototype program was developed to dynamically assign classification tracks so that classification track utilization can be maximized and makeup-engine work can be minimized.
- A simple yard inventory system was included capable of providing a track standing inventory of cars (with associated car records) and of moving cars within inventory. (A particular railroad's more sophisticated inventory system can replace this simple inventory system.)
- The prototype program underwent preliminary testing in a laboratory environment.

The prototype program was developed as a stand-alone system and coded using standard FORTRAN on a commercial time-sharing service to facilitate demonstration and transferability.

I INTRODUCTION

Need For Dynamic Track Assignment Program

Many studies have been conducted on car utilization and freight service reliability. One of the main conclusions of all such studies is that the rail terminal has the largest adverse impact on service reliability and car utilization. Operating officials accept this; the evidence is too overwhelming. Consequently, if railroads are to make any meaningful progress toward recapturing lost revenue and profits, terminal control systems that enable yard decisionmakers to operate a terminal more effectively must be developed and implemented. In particular, terminal operations can achieve a higher degree of control by making better use of computer technology and management techniques.

The process of classifying cars at a hump yard has a major impact on capacity, costs, and service. An on-line dynamic track assignment procedure would assist the yardmaster in dynamically assigning cars to classification tracks. These assignments would vary during the day based on the current projected traffic demand and the current state of the bowl. The goal is to assign classification tracks to achieve maximum utilization of the bowl and maximum makeup-engine productivity.* More specifically, makeup-engine productivity can increase if an effective assignment procedure ensures that crossover moves and conflicts between makeup-engines are avoided as much as possible, thus minimizing excessive engine travel and delays due to interference in the yard "throat" between the classification tracks and the departure tracks. The overall effect of meeting these goals will be an improvement in the movement of cars through the terminal.

The standard industry classification technique is static track assignment, which utilizes the same tracks for the same blocks day after day. The assumption is that, on the average, the block generates enough

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*We use the terms makeup-engine, pullout-engine, and trim-engine interchangeably.

cars to fill the track selected. This classification technique is used because yardmasters find it the easiest to comprehend and administer, not because it is the most effective. The principal objections to static assignments are:

- The number of standard blocks almost always exceeds the number of class tracks; this forces mixing of blocks.
- Since averages are composed of highs and lows, an average day seldom occurs, and consequently many assigned tracks are overflowing or underutilized; this induces mixing of blocks.
- Most mixing is unplanned, and unplanned mixing slows down trimming, which makes less classification room available, which slows the hump process and causes more mixing, which slows trimming, and so on.

An effective dynamic track assignment technique would assign blocks to tracks dynamically according to existing conditions. As a controlled decision process it would have as its objectives the maximization of both classification track utilization and makeup-engine productivity. Currently, a yardmaster tries to accomplish these two objectives using present techniques and his own ingenuity. He can do a reasonable job when his business is light and he has plenty of track room and time. But when his business picks up, he will assign a lot of cars anywhere they will fit in order to keep the hump going. This almost always results in extra trim-engines and/or extra car detention time in the yard. An in-depth study of the process at any major yard would, without a doubt, show that classification track utilization, trim-departure facility utilization, and terminal throughput are adversely affected by the way in which yardmasters choose tracks in the classification yard.

Few yardmasters, if any, can completely cope with the dimensionality and variability of the problem. Revenue and productivity have been lost to the inefficient track assignment process that railroads have accepted over the years as something that any yardmaster can perform without help or training. Nevertheless, the situation can be improved. With computer programs containing decision rules, inventory, cresting sequence, and other pertinent data, each block could have the appropriate track assigned in a consistent manner regardless of the yardmaster on duty.

Project Description and Status

The concepts for a dynamic track assignment program started with the SP in the early 1970s with an in-house exploratory effort called CACTUS (Computer Assisted Classification Track Utilization System). A three-day manual test for a specific yard of a preliminary form of the dynamic track assignment decision rules at SP resulted in the following benefits compared to the existing assignment method:

- One planned rehump track versus nine unplanned
- At least three clear tracks at all times versus none
- No delay to outbound trains versus many delays
- Five percent less trim-engine time.

The intent of this current project was to build a computer program that not only utilized the CACTUS experience but also incorporated numerous enhancements and modifications necessary to assist a yardmaster in making real-time track assignment decisions in an actual field trial. More specifically, the project objectives were to:

- Develop an on-line dynamic track assignment procedure to assist the yardmaster in maximizing classification track utilization and makeup-engine productivity.
- Include as part of the software package a simple yard inventory system capable of providing track-standing inventory of cars (with associated car records) and of moving cars within inventory. (A particular railroad's more sophisticated inventory system can replace this simple inventory system.)
- Ensure that the procedure has been "human-factored" to the operating environment of the yardmaster.
- Implement and demonstrate the procedure in a yard.
- Evaluate the benefits of such a procedure.
- Document the procedure and programs in a manner that will facilitate industrywide transfer of procedures and results.

To achieve the above objectives, the project was divided into three phases:

- Phase 1: Development of prototype program
- Phase 2: Validation and preparation for field trial
- Phase 3: Field demonstration and evaluation.

Phase 1, the only phase funded by the AAR/FCUP, has been completed. A prototype program exists and has been demonstrated in an off-line laboratory environment. This report documents the program design, capabilities, and intended operational use.

Improvement of Car Utilization

The dynamic track assignment program has been designed to maximize classification track utilization and makeup-engine productivity. Below we relate these two goals of the program to improved car utilization by showing that yard detention times will be reduced. Studies conducted by M.I.T. on railroad service reliability have demonstrated that yard detention times represent the major portion of a car's transit time. Thus it is evident that if a car's transit time is reduced, it will be able to make more trips and therefore be utilized more effectively.

The maximization of track utilization by dynamically "swinging" track assignments will allow the yard to make more classifications (i.e., do more switching work). This implies that "less" switching work need be done somewhere else on the system to a particular car. The end result can lead to either:

- Sufficient blocking at one yard so that a downstream yard can be completely bypassed. In this case, the bypassing of an intermediate yard can result in a 15- to 30-hr savings in total car transit time.
- Sufficient blocking at a yard to form a preblocked "bypass block" on an outbound train. When the next downstream yard receives this train, the bypass block can be taken directly to the departure track, thus eliminating the wait on the receiving track and the class tracks. The yard detention times of cars in the bypass block will be substantially reduced.

Minimizing train makeup-engine time will lead directly to a reduction in the class track waiting time. This assumes, of course, that if trains are made up faster, the outbound train schedules will be adjusted to allow the train to depart earlier. However, a reduction in time to perform the makeup operation will also lead to a reduction in the time a car spends on the receiving track. In particular, it is generally acknowledged by operating personnel that in hump yards the constraining "bottleneck" to yard throughput is the makeup operation. This implies that the humping operation potentially could be increased if cars could be pulled out of the bowl at a faster rate. An increased overall humping rate in turn would imply that cars would spend less time on the receiving tracks.

In summary, the dynamic track assignment program will increase car utilization by decreasing yard detention times because of:

- Elimination of intermediate terminal handling by performing more preclassification in an upstream yard.
- Elimination of wait times on receiving and class tracks for preblocked bypass blocks.
- Reduction of wait time on class tracks.
- Reduction of wait time on receiving tracks.

II OVERVIEW OF PROGRAM CAPABILITIES AND LOGIC

The program is designed to improve the ability of a yardmaster to respond consistently to daily variation in traffic and operating conditions by dynamically assigning tracks so as to maximize track utilization and minimize trim-engine effort. The program operates under the complete control of local yard management. By appropriately specifying program inputs, the program can be made to produce more static or more dynamic track assignments. This allows the program to be tailored to the operating environment of any yard.

Because each railroad's terminal computer system is different, the program has been designed as a stand-alone system and has been coded using standard FORTRAN on a commercial time-sharing service to facilitate industrywide transfer. Since the program has been designed to stand alone, a simple yard inventory system is part of the software package. This inventory system is capable of providing track lists on request and allows the user to move cars within inventory.

The coding and structure of the program have been designed to facilitate conversion to a railroad-specific terminal computer system. Some railroads may wish to use the entire software package, which includes the dynamic track assignment logic plus the simple yard inventory system. Other railroads may wish to retain only the dynamic track assignment logic and interface this logic with their own more sohpisticated yard inventory system. The program has been designed to facilitate this latter alternative; however, the details and work involved depend on the input and output structure of the specific yard inventory system.

Advantages of Dynamic Track Assignment

An effective dynamic track assignment program can maximize classification track utilization by:

- Allowing more classifications to be made from a fixed number of classification tracks. Figure 1 shows three inbound train consists arriving at times 1, 2, and 3. The first train arrives with blocks A and B, the second train arrives with blocks A and C,

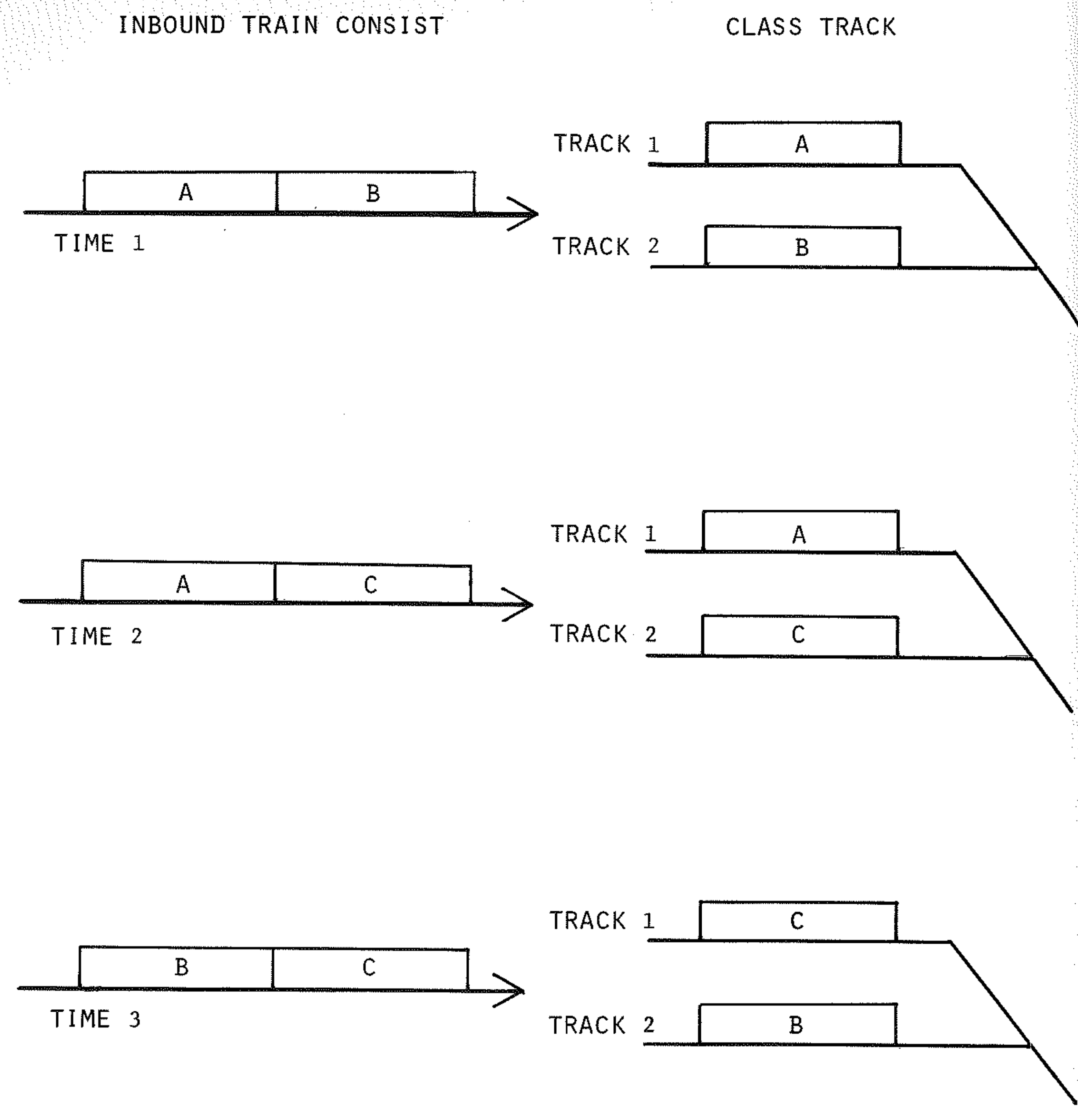

FIGURE 1 DYNAMIC ASSIGNMENT: MORE CLASSIFICATIONS FROM FIXED NUMBER OF CLASS TRACKS

and the third train arrives with blocks B and C. Although there are only two classification tracks, by dynamically assigning the tracks when they become clear, three blocks can be made.

- Better matching of track length with block size. Figure 2 shows two inbound train consists arriving at times 1 and 2. The first train arrives with blocks A and B where block A is the largest. The second train arrives with the same blocks; however, block B is the largest. The two class tracks shown are different lengths; by dynamically assigning the tracks, the varying block sizes can be accomodated without requiring an additional track to accommodate cars overflowing a large block assigned to a small track.

Makeup-engine work required to build a train can be minimized (i.e., makeup-engine productivity can be maximized) using an effective dynamic track assignment procedure, thus:

- Minimize engine movements and conflicts with other engines by putting blocks for the same train in the same or adjacent areas of the classification track. Figure 3 shows blocks A and B scheduled for the same outbound train placed in the same or adjacent areas of the classification tracks. Putting blocks close together can facilitate outbound train makeup by minimizing engine movements and conflicts with engines working the same ladder. The necessity for inefficient engine crossover movements from one side of a classification yard to the other also can be minimized.
- Enhance doubling operations by putting blocks on adjacent classification tracks which are in sequence on outbound trains. Figure 4 shows two blocks, A and B, on adjacent classification tracks. These two blocks can be doubled and pulled with one move to the departure yard.

Basic Program Definitions and Concepts

To understand the procedure and program logic, the following terms must be defined:

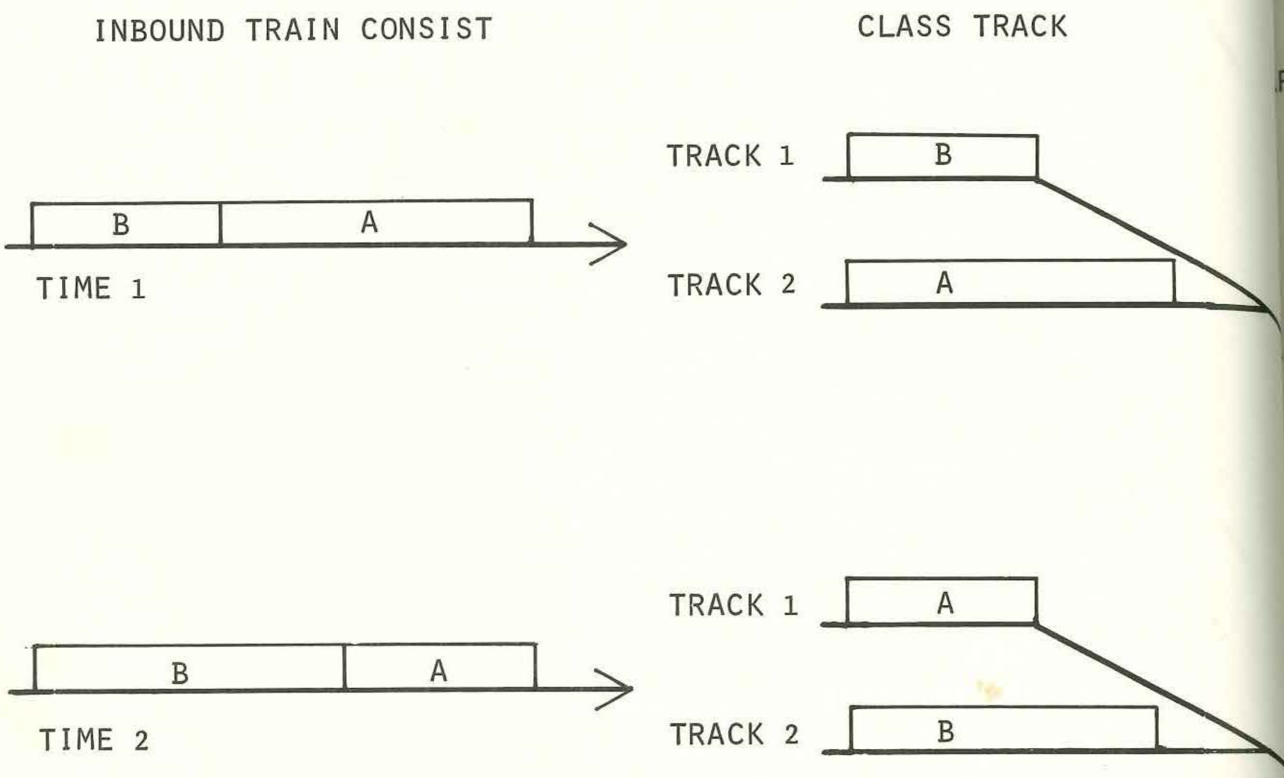

FIGURE 2 DYNAMIC ASSIGNMENT: BETTER MATCHING OF TRACK LENGTH WITH BLOCK SIZE

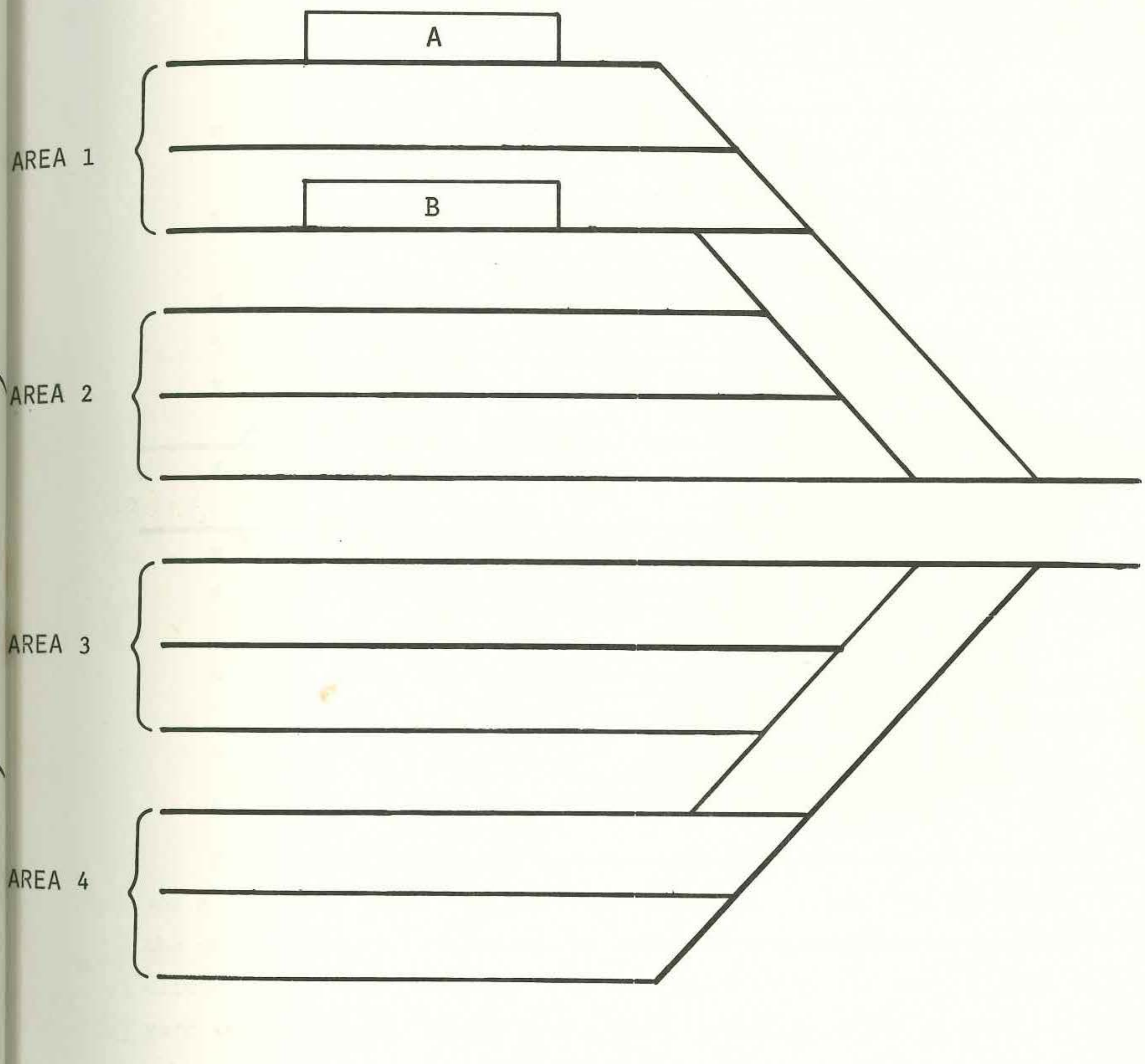

FIGURE 3 MINIMIZE ENGINE MOVEMENTS AND CONFLICTS BY PUTTING BLOCKS FOR SAME TRAIN IN SAME OR ADJACENT AREAS OF CLASS YARD

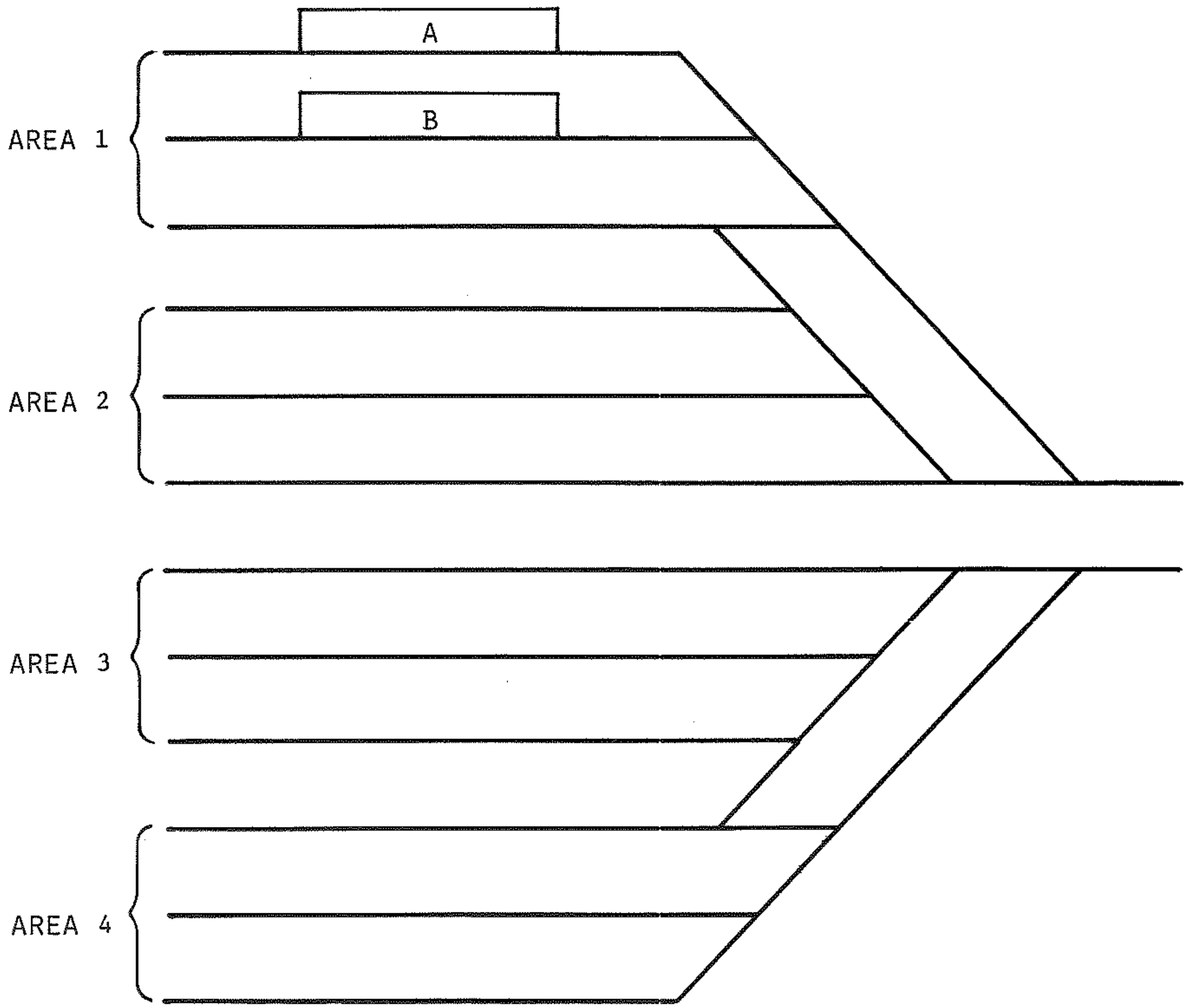

FIGURE 4 ENHANCE DOUBLING OPERATIONS BY PUTTING BLOCKS ON ADJACENT TRACKS WHICH ARE IN SEQUENCE ON OUTBOUND TRAINS

- SPLIT--All cars of the same block may not be scheduled on the same outbound train. The block is "split"; the first part of the block (before the split) is treated as a separate entity from the second part (after the split) for purpose of assigning a track.
- PRIMARY AREA--Area in the bowl of first choice for track assignment to a block.
- SECONDARY AREA--Area in the bowl of second choice for track assignment to a block.
- ASSIGNED BLOCK--A block already assigned to a track.
- STARTER BLOCK--A block that needs a track assignment.
- COMPANION BLOCKS--Blocks that should be on adjacent tracks to enable doubling of tracks and minimization of trim work.
- CONSOLIDATION BLOCK--A block formed by consolidation of two or more standard blocks.
- LOCKED TRACK--A track unavailable for assignment.
- CLEAR TRACK--A track that has no cars and is not assigned to a block.
- IDLE TRACK--A track that is assigned to another block but has sufficient room and time for inserting a second block without mixing the two blocks.
- REHUMP TRACK--Track for cars to be rehumped.

To minimize makeup-engine work, each block is assigned a primary and a secondary area. Referring to Figure 5, we see that blocks departing the east departure yard should be assigned to area 1 or 2; this will eliminate the inefficiencies of a crossover move from one side of the yard to the other. Furthermore, those blocks which are to make the same train should be assigned to the same area; this is likely to eliminate conflict between makeup-engines building different trains working on the same ladder. Blocks that are in sequence on the same train are designated companion blocks and should be placed on adjacent tracks if possible so that pull time on both blocks by doubling is minimized.

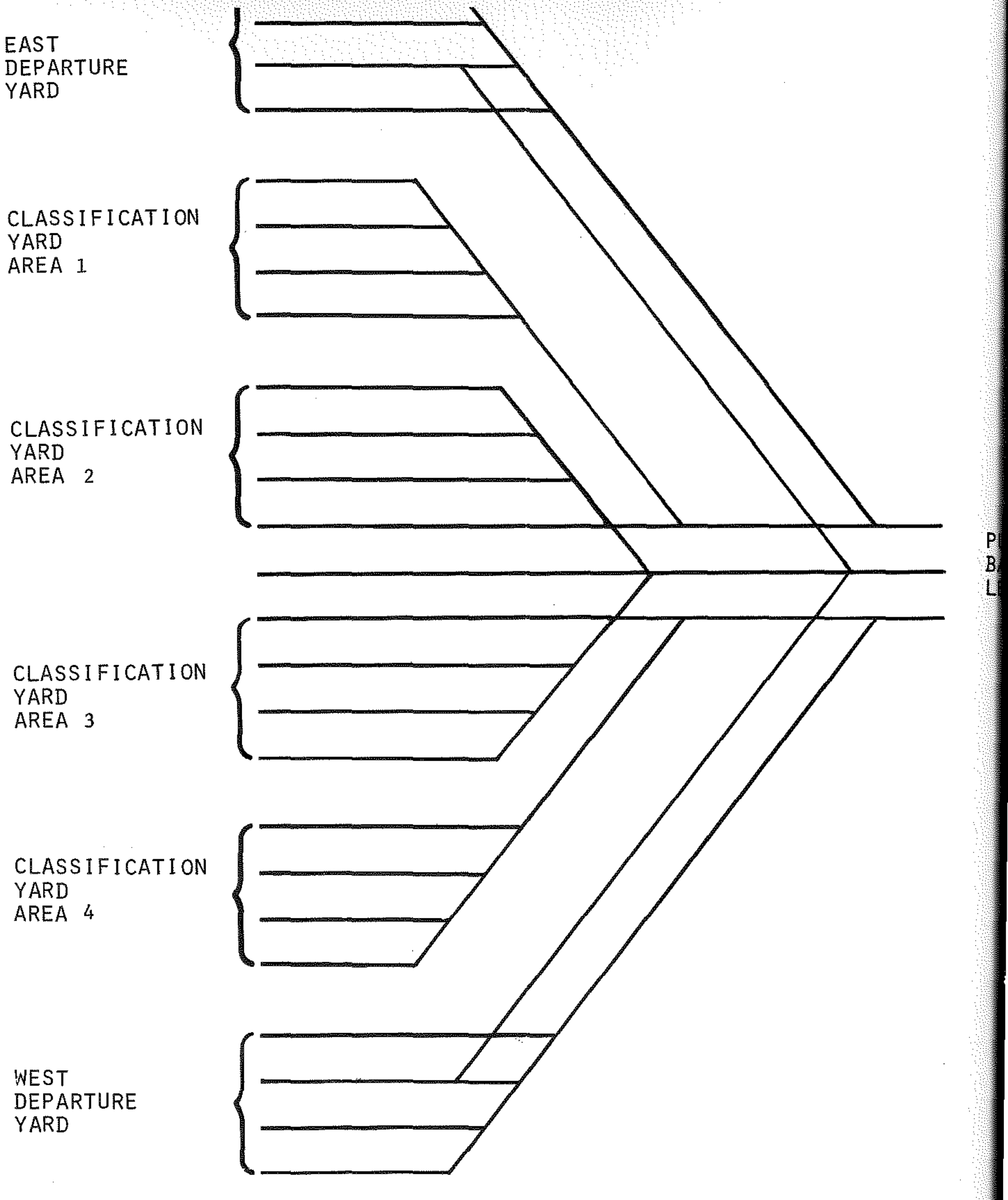

FIGURE 5 PULL-BACK HUMP YARD

To maximize track utilization, the number of cars in a block is used to determine whether a clear, idle, or rehump track is assigned to a starter block. For example, Figure 6 shows that if block A has a large number of cars, then it is assigned to a clear track; if it has an intermediate number of cars, then it is assigned to an idle track; and, if it has a small number of cars, then it is assigned to a rehump track. The criteria for "large," "intermediate," and "small" are defined for each block by the user. In this manner, tracks are assigned to fit the needs of the block without wasting excess track space.

Hump Sequence, Planning Worksheet, and Split Determination

The program requires as input the sequence of cuts to be humped. The hump sequence can be specified in the following ways:

- Direct specification by the yardmaster.
- First-in-first-humped basis.
- Priority parameter basis. The program can identify each car with a priority parameter. This parameter can be a function of known information about the car (e.g., classification, car type, and commodity).* The hump sequence would be based on the highest average priority per car per cut.

Periodically, say at the beginning of each shift and as appropriate thereafter, the yardmaster requests the program to print out a planning worksheet (see Figure 7). The worksheet is essentially a matrix where the blocks to be made in the yard are listed along the side, and the sequence of cuts to be humped is listed along the top. The columns of the matrix display for each cut to be humped the number of cars for each block. These numbers reflect cars that either are already in the receiving yard or will be in the receiving yard as indicated by advanced consist information. The rows display for each block the projected accumulation of cars in the future by cut sequence. The far right of the worksheet indicates projected total cars, total length, and total tonnage of incoming cars for each block.

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*In the case of the Missouri Pacific Railroad Co., the priority parameter can be the number of previously missed connections for each car since this is stored in the railroad's car scheduling system.

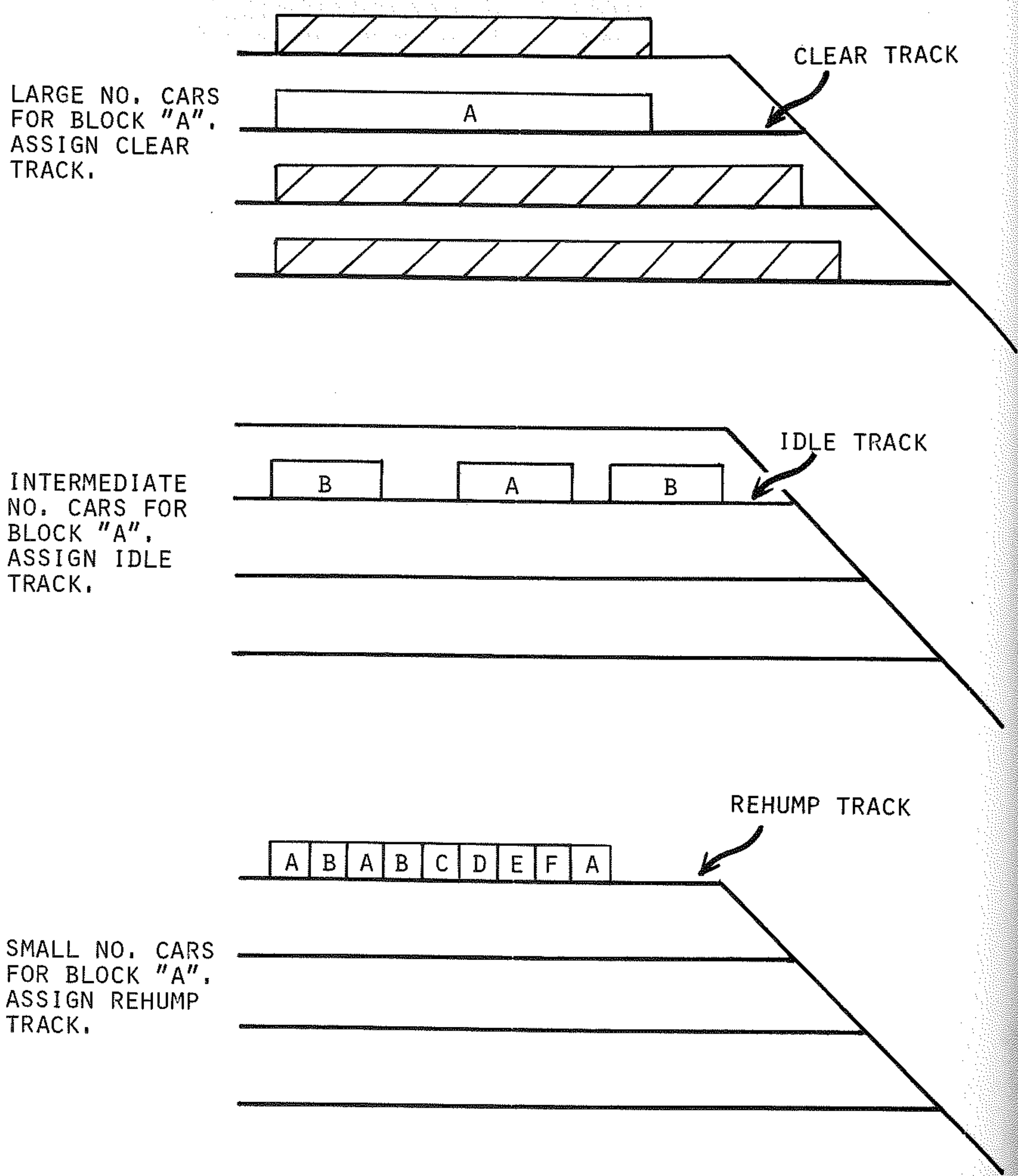

FIGURE 6 CRITERIA FOR TRACK ASSIGNMENT

	CUT 1	CUT 2	CUT 3	. . .	. . .	CUT N	CARS	LENGTH	TONNAGE
BLOCK 1									
BLOCK 2									
BLOCK 3									
.									
.									
BLOCK M									

FIGURE 7 SIMPLIFIED PLANNING WORKSHEET

The yardmaster will examine the worksheet and determine for each block how many cars from cuts to be humped in the future will be grouped together to make the same outbound train; this is called the split determination. This group of cars of a particular block will be treated as a unit for purposes of track assignment.

The worksheet process is repeated whenever the hump sequence is changed, yard conditions or operations change, and/or incoming traffic projections change.

Track Assignment Logic

When each cut is to be humped, the yardmaster indicates to the program any changes to the track status (i.e., lock tracks or unlock tracks; see Figure 8). Using the information from the worksheet planning process (e.g., split determination), the program determines the appropriate number of cars (N) in each block. Next, each block in the cut is processed in order of size. If the block is an assigned block (i.e., already assigned to a track), the cars are designated to the assigned track. If the block is not assigned, the block is treated as a starter block. Overflowed cars for an assigned track are treated as a starter block.

The starter block logic is shown in Figure 9. Based on operating judgment, each block is assigned two threshold numbers, R_1 and R_2, which determine whether the block is to be assigned to a clear track (i.e., $N \geq R_2$); to an idle track (i.e., $R_1 \leq N < R_2$); or to a rehump track (i.e., $N < R_1$). If a block is to be assigned to a clear track, the primary area for the block is searched for a clear track. If more than one choice is found in the primary area, the track with the nearest companion block is found. If no clear track is found in the primary area, the secondary area is searched. In the event that no clear track is found in either the primary or secondary area, the yardmaster is notified.

An idle track is an already assigned track that has sufficient "space" to store a second block and sufficient "time" to insert the second block so that no mixing of the two blocks will occur. If a block is to be assigned to an idle track, the primary area is first searched

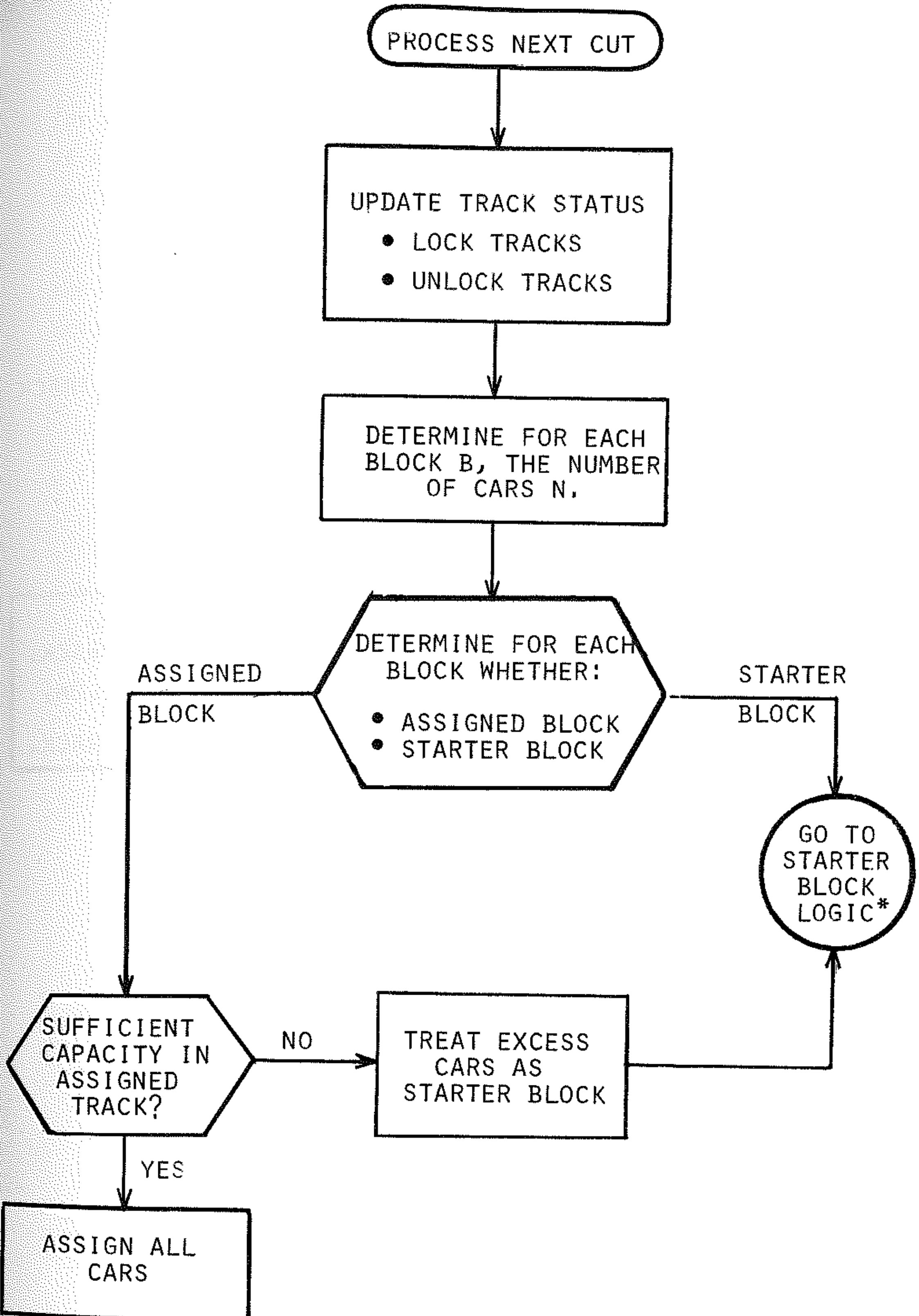

FIGURE 8 OVERALL ASSIGNMENT LOGIC

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*SEE FIGURE 9.

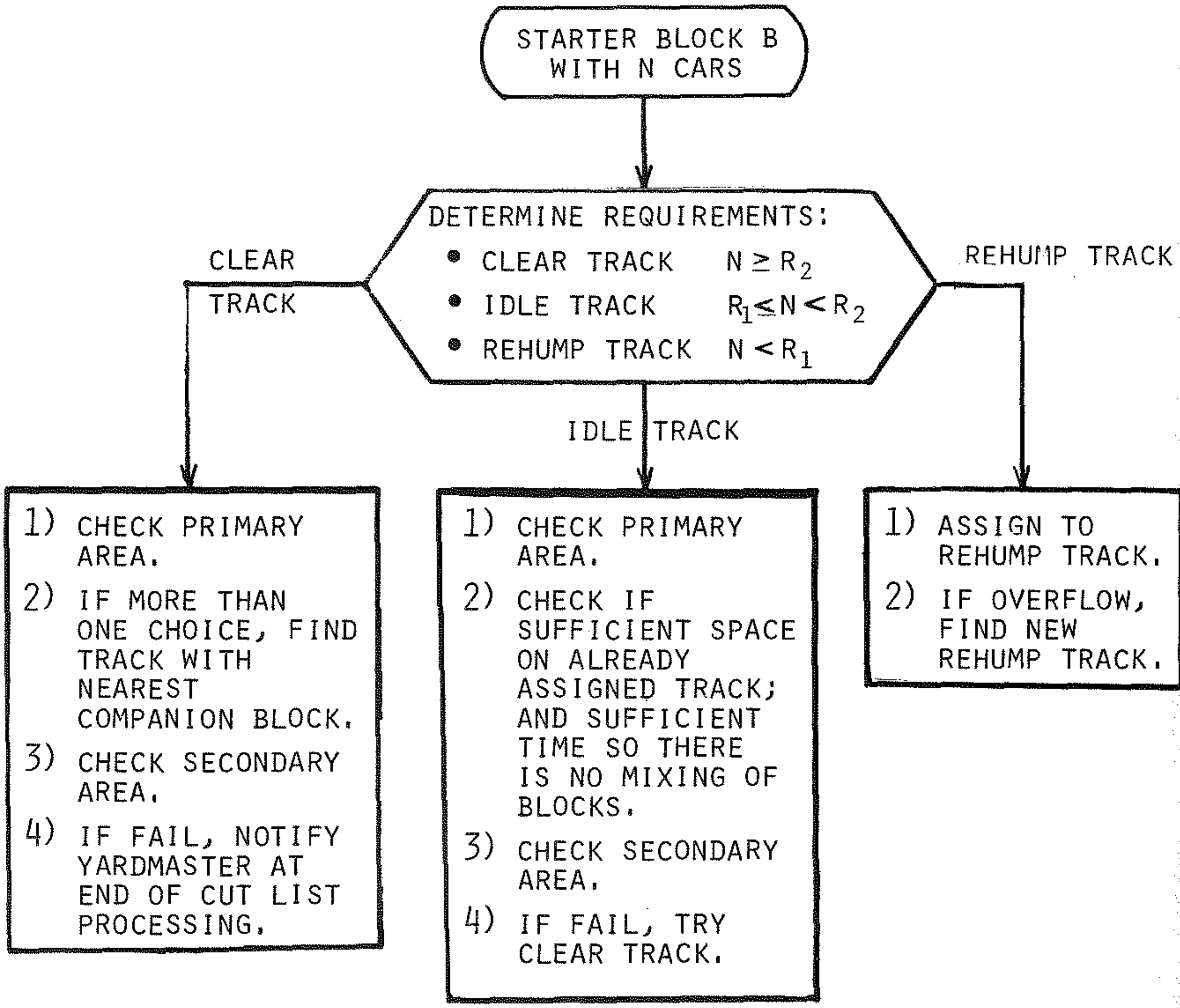

FIGURE 9 STARTER BLOCK LOGIC

for an idle track followed by a search of the secondary area (see Figure 9). If a failure results from searching both areas, a clear track is sought for the block.

If a block is to be assigned to a rehump track, the program assigns the block to the appropriate rehump track. In the event that the rehump track is at capacity, a new track for the excess rehump cars is determined.

III USE OF THE DYNAMIC TRACK ASSIGNMENT PROGRAM

The dynamic track assignment program is a powerful tool yet is simple to use. Figure 10 gives an overall picture of the input requirements for the program and the possible outputs. The inputs are of three different types:

- Those that seldom change--the yard configuration and block description table.
- Those that change with each start-up and infrequently during execution--the initial yard inventory and the critical length and track utilization parameters.
- Those that change constantly--the yardmaster action commands and new train arrivals.

At initialization time, the yardmaster is prompted as each type of input is read to see if he would like a report echoing back the input. After the initialization phase has been completed, he can still obtain copies of these reports by using the appropriate action command. The yardmaster is then prompted for the critical length and track utilization parameters. At this point the program is ready to accept a series of action commands. Each action command will prompt the yardmaster with a list of the required parameters if there are any.

Time-Line Scenario

An example of the yardmaster's interaction with the dynamic track assignment program might best be illustrated by a time-line scenario (see Figure 11). The action commands are described in detail later in this section.

In Figure 11 we see the actions a yardmaster might take at the beginning of a day--adding new train consists and obtaining a current worksheet and track summary report. He can then use these reports to help him take any necessary actions before humping the first cut. He should add as many cuts to the planning period as possible to utilize the system efficiently and keep his inventory up-to-date. At this time he should consider any splits, consolidations, track assignments,

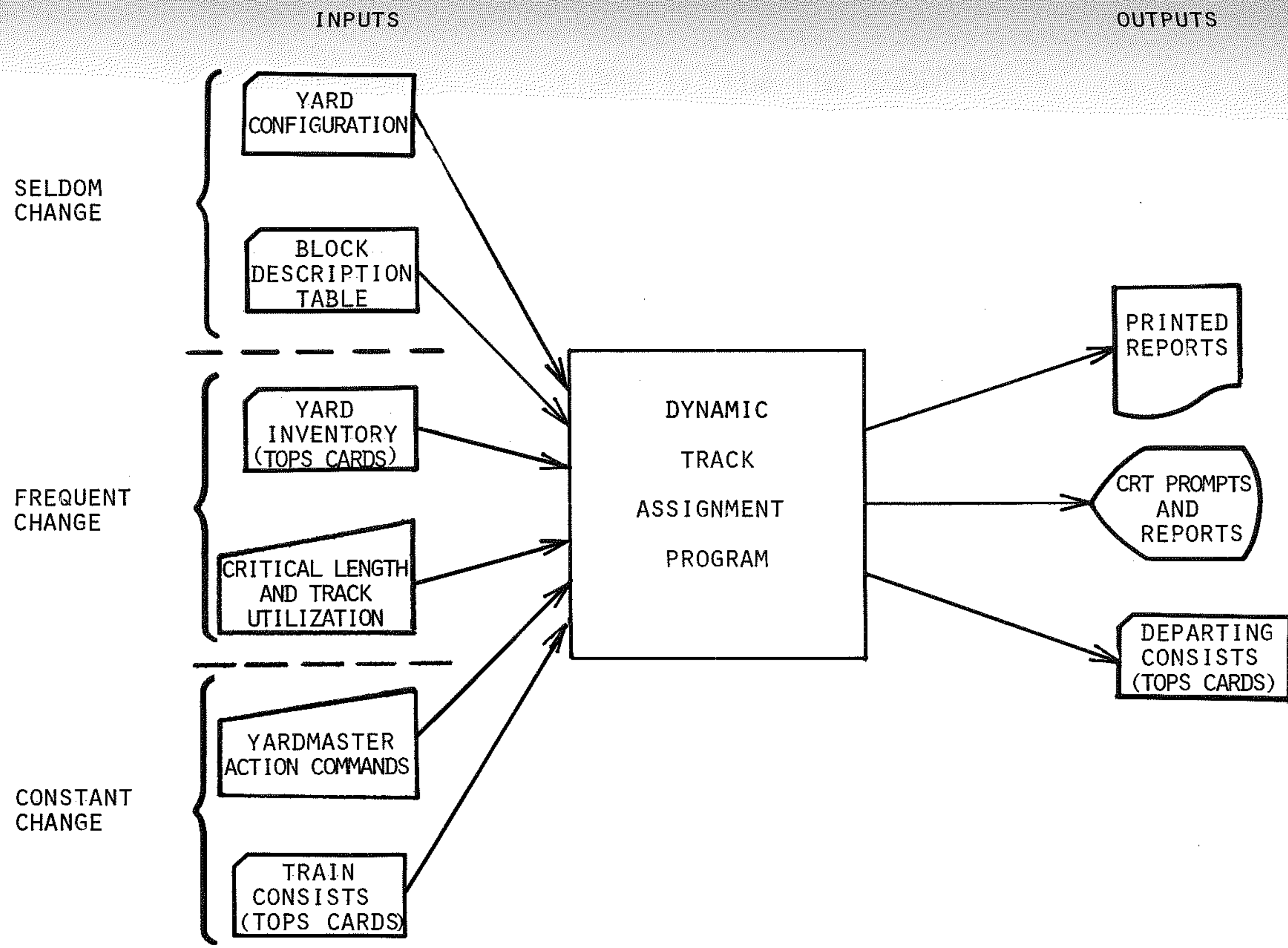

FIGURE 10 DYNAMIC TRACK ASSIGNMENT PROGRAM

TYPICAL YARDMASTER'S DAY

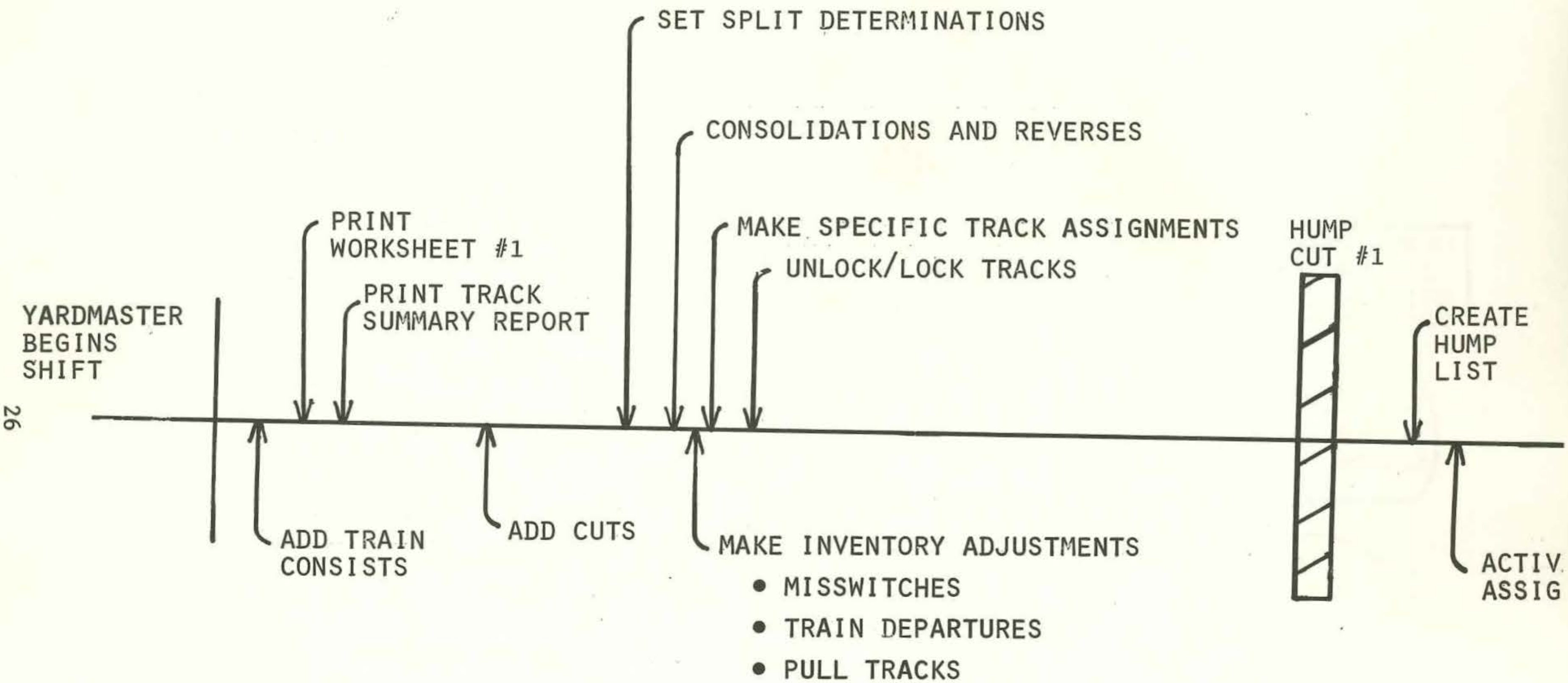

FIGURE 11 TIME-LINE SCENARIO

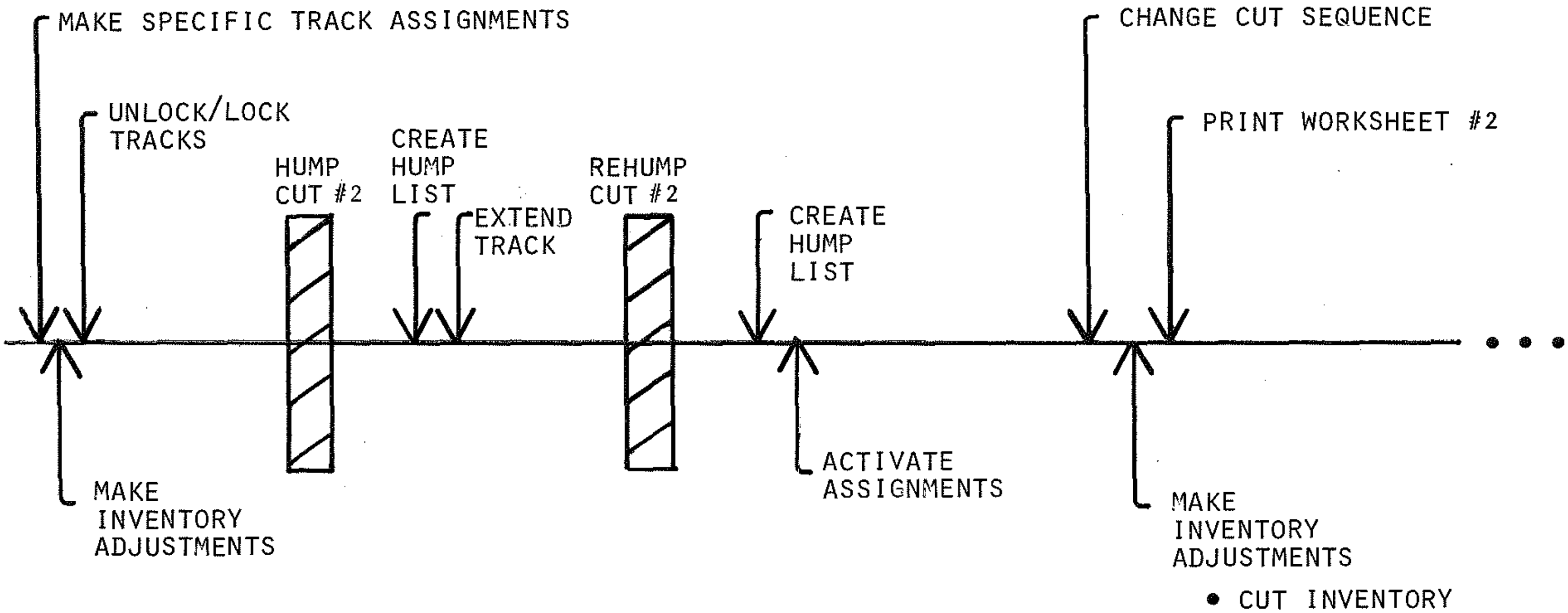

FIGURE 11 (CONCLUDED)

and track status changes. No-hump and special handling cars must be taken care of individually with the Move Command.

After humping the first cut, a hump list is automatically produced. If the yardmaster is pleased with the track assignments made by the program, he can simply give the Activate Assignment Command and be ready for the next cut, going through the same sequence of steps described above.

At any time he is not pleased with the hump list, he can enter actions that will change the track assignments, as long as he does this before he activates the assignments. He can then reissue the Hump Command, and a new hump list will be produced based on the added information.

This cycle continues throughout the day, with the yardmaster interacting with the program to produce the desired hump list and maintaining the inventory as required.

Inputs

Inputs to the dynamic track assignment program are minimal. It is necessary to provide information about the tracks in the yard, rules for blocking and track assignments, and the initial inventory on the tracks.

Yard Configuration

The yard configuration input consists of the following:

- Track type
  - Receiving
  - Classification
  - Departure
- Track number
- Length.

Block Description Table

The block description table includes all the rules for making track assignments for each individual block. Inbound cars are assigned to an outbound block based on their block number. Tracks are assigned to these outbound blocks as required, depending on their primary and secondary track areas, companion block groups, car limits for clear versus idle versus rehump assignments, and rehump group if needed.

The following is a list of inputs for the block description table:

- Block number
- Block description
- Block range--inbound
- Companion block group
- Primary track area range
- Secondary track area range
- Number-of-cars limits for type of track assignment
- Rehump group.

Inventory

The initial inventory for the classification and departure tracks requires the following data:

- Track header card
  - Track number
  - Block assignment (if one exists, for classification tracks only)
- Car records
  - Car identification
  - Kind of car
  - Loaded/empty
  - Length
  - Tonnage
  - Block number
  - Priority
  - Special handling.

For arriving train consists, the track header card should also include:

- Train identification
- Train arrival time.

Action Commands

The yardmaster interacts with the program through action commands (see Table 1). These commands give him as much control over the track assignments as he demands, to the point of static track assignments if necessary. He also has control over the output reports and the responsibility

Table 1

ACTION COMMANDS

1: Consolidate blocks
2: Cancel block consolidation
3: Set split
4: Cancel split
5: Assign block to clear track
6: Assign block to track
7: Cancel block assignment
8: Unlock track
9: Lock track
10: Add train
11: Depart train
12: Add cut
13: Schedule rehump
14: Change hump sequence
15: Hump cut
16: Activate assignments
17: Add cars
18: Remove cars
19: Move cars
20: Extend track
21: Change parameters
22: Planning period worksheet
23: Block summary report
24: Track inventory list
25: Status-of-track report
26: Track summary report
27: Hump list
28: Block description table
29: Track description table
30: Hump sequence report
31: List action commands
32: Stop execution

of maintaining the inventory. He can add train consists, enter cuts into the planning period, depart trains, and move cars from track to track to stay consistent with the real world. For the best track assignments it is very important to maintain a current inventory.

1: Consolidate Blocks

This command will combine several standard blocks into one primary block for the purpose of track assignment. The track assignment for the primary block (first block entered) is maintained if it exists and assignments to the other blocks are canceled. When a new track assignment is required, the assignment is based on the sum of all the cars for the consolidated blocks and their total length. The area to which the track is assigned and the type of assignment depend on the parameters of the primary block defined in the block description table.

2: Cancel Block Consolidation

This command reverses the action of consolidating blocks. Each block will be treated separately again. If there is a current track assignment for the consolidated block, it will remain in effect for the primary block but will be canceled for all other blocks.

3: Set Split

This action will put a limit on the number of cars considered for a particular block when a track assignment is required. When this limit is reached during the humping activity, the track will automatically be locked and a new assignment made for the remaining cars.

Splits set for consolidated blocks must be made for the primary block even though the limit refers to cars from all the blocks. The number of cars from each individual block will depend upon the order in which the cars are humped.

4: Cancel Split

This command will cancel the split determination. Splits are automatically canceled when their limit of cars has been reached.

5: Assign Block to Clear Track

This command allows the yardmaster to override the ranges used to determine the type of track assignment. He can ensure that the block be assigned to a clear track regardless of the number of cars.

6: Assign Block to Track

If the yardmaster is not satisfied with the track assignments made by the program, he can override them by making his own assignments. A track may have more than one block assigned to it. Track assignments remain in effect until the track is locked; the assignment is canceled by action command 7, a block consolidation, or a split determination; or when the track is filled.

7: Cancel Block Assignment

This command will cancel the current track assignment for the block. The next car humped of this block will cause a new track assignment to be made by the program.

8: Unlock Track

Status of track will be set to unlocked, allowing cars to be humped into it.

9: Lock Track

Status of track will be set to locked; no cars will be allowed to enter. All block assignments to that track will be canceled.

10: Add Train

This command is given when new train consists are entered into the yard. The train identification and arrival times are saved. Car inventory records are checked for errors. If the yardmaster does not assign a track, a clear track in the receiving yard is automatically assigned. Trains can be yarded on any type of track. The new trains are not considered in the planning period until an Add Cut Command is given.

11: Depart Train

This action will remove all cars from the track specified. A car inventory record card is punched for each car leaving the system. This is a simplified version of the Remove Cars Command.

12: Add Cut

To enter a cut into the planning period, cars must have already entered the yard via the Add Train Command. A maximum of 12 cuts can be entered in the planning period at one time. For maximum utilization of the system the yardmaster should maintain as many cuts as possible in the planning period.

13: Schedule Rehump

This action is used to add a rehump track as a cut into the planning period. The rehump track's status is automatically changed to clear, and a new rehump track is assigned when necessary.

14: Change Hump Sequence

At any time the yardmaster has the option of shifting the cuts in his planning period. If a split was set on a cut involved in the sequence change, it will automatically be canceled.

15: Hump Cut

This action causes the program to assign each car in cut sequence #1 to a classification track, either clear, idle, or rehump. The cars are not actually moved until the Activate Assignments Command is given. Hence the yardmaster has the option of approving the hump list or redoing the Hump Cut Command after making changes to the inventory, track status, or block assignments.

16: Activate Assignments

When this command is given, the cars are actually moved to their new track assignments based on the current hump list. The cut will be removed from the planning period and all other cuts will be shifted by one. All idle track assignments or splits satisfied will automatically be canceled.

17: Add Cars

This action allows the yardmaster to update his inventory by adding cars to any track. For each car added he must supply all of the car's attributes.

18: Remove Cars

The yardmaster can remove single cars or a group of cars from the inventory with this command. A car inventory record card is punched for each car that is removed.

19: Move Cars

This important command helps the yardmaster maintain a current inventory in the system. If a car is misswitched, it should be physically moved to its correct location, or the inventory should be updated to show that car at its current location. Track assignments cannot be made accurately if the inventory is not maintained.

20: Extend Track

This action allows the yardmaster to put more cars on a track than it will physically hold as far as the program is concerned. He may put cars on the lead temporarily for operating reasons, and this command avoids the need for a new track assignment.

21: Change Parameters

This action gives the yardmaster an opportunity to change parameters used in making clear track assignments, the critical length parameter, and the track utilization percentage. A later version is planned to allow the yardmaster to change parameters in the block description table.

22: Planning Period Worksheet

The planning period worksheet (Figure 12) includes information about all cuts in the planning period (maximum of 12) and the current bowl inventory block by block. It also lists current track assignment, splits, and consolidations.

BLK NO	BLK DES	CON BLK	TRK ASG	INV	BKRVP 01338 1135 101	OAOGW 01007 1530 103	LABRT 01007 1425 102	EUWCY 02006 1535 104	-- TOTALS -- CARS	LEN	TONS	SPLITS CUT/ CARS
282	RVPBY-BKRM	0	220	6	0	0	0	0	6	372	499	0/ 0
69	RVKFY-KFBN	0	223	9	7	0	0	0	16	870	550	0/ 0
67	RVKFY-KFAL	0	222	7	0	0	0	0	7	375	452	0/ 0
57	RVKFY-SHAS	0	224	5	0	0	0	0	5	330	195	0/ 0
420	RVLAY-LA	0	0	73	0	0	0	1	74	4226	6137	0/ 0
460	RVCIY-CI	0	201	8	0	0	0	0	8	456	749	0/ 0
235	33223-WOOD	0	0	1	0	0	0	0	1	58	63	0/ 0
236	33223-SACF	0	244	1	0	0	0	0	1	42	75	0/ 0
274	RVFRY-FRES	0	210	6	0	0	0	0	6	358	528	0/ 0
560	33323-EWIN	0	240	7	1	0	0	0	8	398	225	0/ 0
116	RVNPP-NORT	0	209	5	24	0	5	0	34	2474	2904	1/15
374	RVSFY-SF	0	214	2	0	0	0	0	2	84	130	0/ 0
384	RVSFY-NEWA	0	213	2	0	0	0	0	2	93	133	0/ 0
394	RVSFY-MULF	0	212	1	0	0	0	0	1	61	56	0/ 0
201	32723-ANDE	0	0	0	1	0	0	0	1	67	41	0/ 0
30	RVEUY-EUGL	0	0	0	0	0	28	0	28	2473	2029	0/ 0
49	RVMEY-GPAS	0	0	0	1	0	0	0	1	57	29	0/ 0
50	RVMEY-MEDA	0	0	0	5	0	0	0	5	258	146	0/ 0
55	RVMEY-MONT	0	0	0	2	0	0	0	2	114	58	0/ 0
113	RVNPY-NPLD	0	234	8	4	0	0	0	12	680	917	0/ 0
118	RVNPE-NPMT	0	0	0	5	0	0	0	5	294	157	0/ 0
106	RVRGY-DRGU	106	228	2	4	0	0	0	6	342	305	0/ 0
103	RVRGY-DRGF	106	228	2	1	0	1	0	4	307	210	0/ 0
107	RVRGY-DRGP	0	0	0	3	0	2	0	5	377	301	0/ 0
109	OAOGW-DRGC	0	248	4	1	3	0	0	8	455	260	0/ 0
119	OAOGW-UPCF	0	247	1	0	51	0	0	52	3342	1876	0/ 0
265	RVMYY-STKS	0	221	4	0	0	0	0	4	239	194	0/ 0
320	RVSJA-SJ	0	208	1	0	0	0	0	1	58	67	0/ 0
117	RVOGY-SLM	0	235	2	1	2	0	0	5	310	173	0/ 0
111	RVOGY-SLL	0	0	0	2	0	0	0	2	131	112	0/ 0
100	RVOGY-OGDE	0	0	0	0	15	0	0	15	855	500	0/ 0
480	RVWCY-WC	0	211	3	0	0	0	56	59	3425	4084	0/ 0
35	RVEUE-EUGM	0	0	0	4	0	0	0	4	214	122	0/ 0
1	CABS	0	0	0	1	1	1	1	4	172	102	0/ 0
200	RSVILLE	0	0	0	6	0	3	0	9	614	450	0/ 0
	TOTALS			160	73	72	40	58	403			

URRENT RACK SSIGNMENT

OCKS 106 D 103 NSOLIDATED

SPLIT AFTER 15 CARS IN FIRST CUT

FIGURE 12 PLANNING PERIOD WORKSHEET

23: Block Summary Report

The block summary report (Figure 13) lists the blocks in order with their current track assignment, if there is one, and other tracks that have cars of this block on them.

24: Track Inventory List

The track inventory list (Figure 14) lists all cars and their attributes on a particular track. The cars are listed in the order in which they are on the track.

25: Status-of-Track Report

The status-of-track report (Figure 15) gives the current information about a particular track. The first line includes the track number, total length of the track, track status, length of space available, and the total number of cars and their tonnage. The following lines list all the cars in the order in which they are on the track.

26: Track Summary Report

The track summary report (Figure 16) lists the classification tracks in numerical order with their current status, most recent block assignment, and other block assignments.

27: Hump List

The hump list (Figure 17) gives the new track assignment and position for each car and indicates the type of assignment, starter block, idle track, or rehump group number. The hump list is automatically produced when the Hump Cut Command is requested; however, it can be requested separately if required.

28: Block Description Table

The block description table (Figure 18) lists all the parameters needed to make track assignments for each outbound block. It gives the block ranges for inbound blocks, companion block groups, primary and secondary track areas, the lower/upper limits for clear, idle, and rehump assignments, and rehump groups.

***** BLOCK SUMMARY REPORT *****

BLOCK NO.	CURRENT TRK ASG	OTHER TRACKS
1	207	NONE
30	0	NONE
35	249	NONE
41	0	NONE
49	238	NONE
50	239	NONE
55	238	NONE
56	0	NONE
57	224	206 223
67	222	206
69	223	206
100	0	NONE
103	228	227
106	228	NONE
107	245	NONE
109	248	NONE
111	238	NONE
113	234	NONE
116	246	209
117	235	NONE
118	0	207
119	247	NONE
142	0	NONE
161	0	NONE
170	0	NONE
200	243	NONE
201	215	NONE
235	0	206
236	244	NONE
239	0	NONE
240	0	NONE
244	204*	NONE
248	0	NONE
264	0	NONE
265	221	NONE
274	210	206
282	220	206
307	0	NONE
308	0	NONE
320	208	NONE
364	0	NONE
365	0	NONE
367	0	NONE
368	0	NONE
369	0	NONE
374	214	NONE
375	0	NONE
378	0	NONE
379	0	NONE
383	0	NONE
384	213	NONE
385	0	NONE
386	0	NONE
387	0	NONE
388	0	NONE
389	0	NONE
390	0	NONE
393	0	NONE
394	212	NONE
395	0	NONE
396	0	NONE
397	0	NONE
399	0	NONE
420	0	202 203 206
421	0	NONE
460	201	206
480	211	NONE
500	0	NONE
511	0	NONE
512	0	NONE
520	0	NONE
521	0	NONE
522	0	NONE
530	0	NONE
531	0	NONE
532	0	NONE
540	0	NONE
541	0	NONE
542	0	NONE
550	0	NONE
551	0	NONE
552	0	NONE
560	240	206
561	0	NONE
562	0	NONE
572	0	NONE
581	0	NONE
582	0	NONE
611	0	NONE
623	0	NONE
700	0	NONE
760	0	NONE
801	0	NONE
820	0	NONE
843	0	NONE
888	0	NONE
993	0	NONE

*TRACK HAS NOT YET RECEIVED CARS BELONGING TO THIS BLOCK

FIGURE 13 BLOCK SUMMARY REPORT

***** TRACK INVENTORY LIST *****

TRACK NO. 202 21 CARS

POS.	CAR ID. NO.		L/E	KIND	LNGTH	WGHT	CODE	TAG NO.		BLOCK
1	RBOX	21367	L	B5	55	87	UOS	420	0	420
2	NSL	100922	L	B5	55	88	UOS	420	0	420
3	NP	96170	L	R5B	58	96		420	0	420
4	ACFX	85789	L	T	49	101	DAN	420	0	420
5	GN	7068	L	D4	44	76	UOS	420	0	420
6	GN	4546	L	B4	44	81	UOS	420	0	420
7	SP	507730	L	FB5	57	80		420	0	420
8	SP	508098	L	FB5	57	76		420	0	420
9	SSW	10360	L	B5	55	71		420	0	420
10	SP	231074	L	B5	55	70		420	0	420
11	SP	204001	L	B5	56	97		420	0	420
12	SP	225586	L	B5	56	94		420	0	420
13	SP	509434	L	FB6	67	110		420	0	420
14	SSW	86558	L	FB6	66	71		420	0	420
15	SP	698610	L	RB5	58	75		420	0	420
16	SP	230480	L	B5	55	66		420	0	420
17	DRGW	40078	L	B5Y	58	103	UOS	420	0	420
18	CNW	150125	E	D5C	58	31		420	0	420
19	SP	698646	L	R5B	58	89		420	0	420
20	SSW	78844	L	CH4	55	131		420	0	420
21	BNFE	9386	L	RML	54	64		420	0	420

FIGURE 14 TRACK INVENTORY LIST

```
*** STATUS-OF-TRACK REPORT ***

TRK 101, 5330 FT, STAT 1, AVAIL  970 FT, CARS  73/4214 TONS
    1/   1,   2/ 106,   1/ 103,   1/ 118,   1/ 107,   1/ 113
    2/ 200,   2/  69,   1/  35,   1/ 201,   1/  69,   1/  55
    1/  35,   1/  49,   1/  35,   2/ 111,   1/ 107,   2/  69
    4/ 118,   1/  35,   1/  50,   1/ 117,   2/ 200,   2/  50
    1/ 109,   1/  55,   1/  50,   2/ 200,   2/  69,   1/ 107
    1/ 560,   1/  50,   2/ 106,  24/ 116,   3/ 113,

TRK 202, 2901 FT, STAT 1, AVAIL 1731 FT, CARS  21/1757 TONS
   21/ 420,

TRK 209, 1744 FT, STAT 1, AVAIL 1275 FT, CARS   5/ 355 TONS
    5/ 116,
```

NO. OF CARS/
BLOCK NO.

FIGURE 15 STATUS-OF-TRACK REPORT

*** TRACK SUMMARY REPORT ***

TRACK	CLEAR	LOCKED	BLK ASG	OTHER BLOCK ASSIGNMENTS
201			460	NONE
202		L	420	NONE
203		L	420	NONE
204			244	NONE
205	C		0	NONE
206			RHMP 2	69 460 420 282 460 274 57 67 69 560
				67 420 235 420 460 274
207			1	118
208			320	NONE
209		L	0	116
210			274	NONE
211			480	NONE
212			394	NONE
213			384	NONE
214			374	NONE
215			201	NONE
216	C		0	NONE
217	C		0	NONE
218	C		0	NONE
219	C		0	NONE
220			282	NONE
221			265	NONE
222			67	NONE
223			69	57
224			57	NONE
225	C		0	NONE
226	C		0	NONE
227			0	103
228			106	103
229	C		0	NONE
230	C		0	NONE
231	C		0	NONE
232	C		0	NONE
233	C		0	NONE
234			113	NONE
235			117	NONE
236	C		0	NONE
237	C		0	NONE
238			RHMP 1	55 49 111 55
239			50	NONE
240			560	NONE
241	C		0	NONE
242	C		0	NONE
243			200	NONE
244			236	NONE
245			107	NONE
246			116	NONE
247			119	NONE
248			109	NONE
249			35	NONE

FIGURE 16 TRACK SUMMARY REPORT

*** HUMP LIST ***

NO	TRK NO	POS	BLK NO	CAR ID	STR	IDLE	RHMP GRP	SPEC HNDL CODE
1	207	1	1	SP 1575	X			P7900
2	228	3	106	BAR 252				
3	228	4	106	SPFE 453089				
4	228	5	103	DRGW 15729				
5	207	2	118	FLIX 678		X		P1451
6	245	1	107	BAR 11244	X			
7	234	9	113	SP 233411				
8	243	1	200	SP 652915	X			
9	243	2	200	UP 168612				
10	223	7	69	GN 160367				
11	223	8	69	GN 160370				
12	249	1	35	SP 562829	X			
13	215	1	201	UP 15215	X			AGENT
14	223	9	69	BN 600371				
15	238	1	55	SP 563294			1	AGENT
16	249	2	35	MILW 99878				
17	238	2	49	SP 570009			1	AGENT
18	249	3	35	SP 570377				
19	238	3	111	SSW 85515			1	
20	238	4	111	SSW 85480			1	
21	245	2	107	SSW 85497				
22	223	10	69	NP 76072				
23	223	11	69	NP 76106				
24	207	3	118	UP 74762				
25	207	4	118	UP 76827				
26	207	5	118	UP 71494				
27	207	6	118	UP 22114				
28	249	4	35	SP 228157				
29	239	1	50	MSE 979	X			AGENT
30	235	3	117	MP 711815				
31	243	3	200	SP 675152				049701
32	243	4	200	SSW 21829				049701
33	239	2	50	SOU 47740				AGENT
34	239	3	50	NW 391281				AGENT
35	248	5	109	UP 519720				
36	238	5	55	SP 561163			1	AGENT
37	239	4	50	UP 169861				AGENT
38	243	5	200	UPFE 458675				
39	243	6	200	SP 230192				CRDSTR
40	223	12	69	BN 248050				
41	223	13	69	BN 624127				
42	245	3	107	MP 722516				
43	240	6	560	SP 401140				HFR
44	239	5	50	SP 171041				P0037
45	228	6	106	BO 356864				RESTRD
46	228	7	106	CO 32522				RESTRD
47	209	6	116	SPFE 454474				
48	209	7	116	SPFE 456074				
49	209	8	116	SPFE 451335				
50	209	9	116	PFE 456877				
51	209	10	116	SPFE 450595				
52	209	11	116	SPFE 459997				
53	209	12	116	SPFE 451497				
54	209	13	116	SPFE 454137				
55	209	14	116	SPFE 454130				
56	209	15	116	PFE 456801				
57	209	16	116	SPFE 454458				
58	209	17	116	SPFE 457024				
59	209	18	116	SPFE 452997				
60	209	19	116	SPFE 451050				
61	209	20	116	SPFE 454296				
62	246	1	116	SPFE 453022	X			
63	246	2	116	SPFE 451332				
64	246	3	116	SPFE 450433				
65	246	4	116	SPFE 453494				
66	246	5	116	SPFE 458887				
67	246	6	116	SPFE 453158				
68	246	7	116	SPFE 451430				
69	246	8	116	SPFE 452870				
70	246	9	116	SPFE 451215				
71	234	10	113	PFE 457451				
72	234	11	113	TTX 100982				
73	234	12	113	SPFE 451347				
TOTALS					7	1		

FIGURE 17 HUMP LIST

***** BLOCK DESCRIPTION TABLE *****

BLK NUMBER	DESCRIPTION	BLOCK RANGE FROM		BLOCK RANGE TO		COMPANION BLK	TRACK AREA 1		TRACK AREA 2		IDLE TRACK ASGMT FRM	IDLE TRACK ASGMT TO	REHUMP GRP
282	RVPBY-BKRM	282	0	291	0	1	1	21	22	49	3	6	2
820	RVPBY-PINE	820	0	820	0	1	1	21	22	49	4	8	2
161	OAOGJ-SKTO	161	0	161	0	2	1	7	9	21	0	0	0
69	RVKFY-KFBN	69	0	69	0	3	22	27	29	49	3	6	2
67	RVKFY-KFAL	67	0	67	0	3	22	27	29	49	4	8	2
56	RVKFY-WEED	56	0	56	0	3	22	27	29	49	3	6	2
57	RVKFY-SHAS	57	0	60	0	3	22	27	29	49	3	6	2
420	RVLAY-LA	420	0	420	0	4	1	21	22	49	3	6	2
460	RVCIY-CI	460	0	460	0	4	1	21	22	49	3	6	2
235	33223-WOOD	235	0	235	0	6	22	49	1	21	3	6	2
236	33223-SACF	236	0	236	0	6	22	49	1	21	3	6	2
623	33223-SACT	623	0	623	0	6	22	49	1	21	3	6	2
888	33223-PLAN	888	0	888	0	6	22	49	1	21	3	6	2
500	33223-WALE	500	0	500	0	6	22	49	1	21	3	6	2
41	33223-SACT	41	0	41	0	6	22	49	1	21	3	6	2
274	RVFRY-FRES	274	0	274	0	7	1	21	22	49	4	8	2
387	RVFRY-LODI	387	0	387	0	7	1	21	22	49	4	8	2
397	RVFRY-ELKG	397	0	397	0	7	1	21	22	49	4	8	2
540	33323-OROV	540	0	540	0	8	22	49	1	21	3	6	2
520	33323-MARY	520	0	520	0	8	22	49	1	21	3	6	2
530	33323-MYSN	530	0	530	0	8	22	49	1	21	3	6	2
550	33323-ERLE	550	0	550	0	8	22	49	1	21	3	6	2
560	33323-EWIN	560	0	570	0	8	22	49	1	21	3	6	2
116	RVNPP-NORT	116	0	116	0	9	22	49	1	21	0	0	0
248	RVERY-EURE	248	0	248	0	10	22	27	29	49	3	6	3
244	RVERY-UKIA	244	0	244	0	10	22	27	29	49	3	6	3
240	RVERY-PETA	240	0	240	0	10	22	27	29	49	3	6	3
239	RVERY-LOMN	239	0	239	0	10	22	27	29	49	3	6	3
364	RVSFY-WATJ	364	0	364	0	11	9	21	1	7	0	0	3
374	RVSFY-SF	374	0	374	0	11	9	21	1	7	0	0	3
384	RVSFY-NEWA	384	0	384	0	11	9	21	1	7	0	0	3
394	RVSFY-MULF	394	0	394	0	11	9	21	1	7	0	0	3
383	RVSFY-RICH	383	0	383	0	11	9	21	1	7	0	0	3
393	RVSFY-BUSC	393	0	393	0	11	9	21	1	7	0	0	3
511	32723-REDD	511	0	511	0	12	9	21	1	7	0	0	3
521	32723-GRAY	521	0	521	0	12	9	21	1	7	0	0	3
201	32723-ANDE	201	0	201	0	12	9	21	1	7	0	0	3
531	32723-DIAN	531	0	531	0	12	9	21	1	7	0	0	3
541	32723-REDB	541	0	541	0	12	9	21	1	7	0	0	3
551	32723-CORN	551	0	551	0	12	9	21	1	7	0	0	3
561	32723-CHIC	561	0	561	0	12	9	21	1	7	0	0	3
365	RVOAY-HAYN	365	0	366	0	13	9	21	1	7	0	0	3
375	RVOAY-WOAK	375	0	376	0	13	9	21	1	7	0	0	3
385	RVOAY-EOAK	385	0	385	0	13	9	21	1	7	0	0	3
395	RVOAY-OZOL	395	0	395	0	13	9	21	1	7	0	0	3
386	RVOAY-SUI/	386	0	386	0	13	9	21	1	7	0	0	3
396	RVOAY-DAVI	396	0	398	0	13	9	21	1	7	0	0	3
368	RVFRZ-MADE	368	0	368	0	14	9	21	1	7	0	0	3
378	RVFRZ-RIPO	378	0	378	0	14	9	21	1	7	0	0	3
388	RVFRZ-MODE	388	0	388	0	14	9	21	1	7	0	0	3
369	RVFRZ-LIVI	369	0	369	0	14	9	21	1	7	0	0	3
379	RVFRZ-TURL	379	0	379	0	14	9	21	1	7	0	0	3
389	RVFRZ-TRAC	389	0	389	0	14	9	21	1	7	0	0	3

FIGURE 18 BLOCK DESCRIPTION TABLE

29: Track Description Table

The track description table (Figure 19) lists all tracks by their numbers and lengths. A separate list is prepared for receiving and departure tracks.

30: Hump Sequence Report

The hump sequence report (Figure 20) lists the current sequence of cuts in the planning period.

31: List Action Commands

Action Command 31 will provide the yardmaster with a list of the actions and their code numbers. This version of the program requires the yardmaster to enter his actions by code number. English language commands are planned for a later version.

32: Stop Execution

This action terminates the program. The current status of the system is lost at this point. A restart procedure is planned for a later version.

Action Command Prompting and Responses

When the program is ready to start processing the yardmaster's next action, it will prompt him with the following message:

WHAT ACTION DO YOU WISH TO MAKE?

He must then respond with an action code number and the program will again prompt him with a list of the required parameters for that action. For example, the yardmaster replies to the above question with a "1", a block consolidation request:

```
> 1
ENTER BLOCK NOS., PRIMARY BLOCK FIRST
> 106, 103
```

The parameters must be entered in the order requested, separated by commas. In this example he is consolidating blocks 106 and 103, with Block No. 106 being the primary block.

TRACK DESCRIPTION TABLE

*** CLASSIFICATION TRACKS ***

TRACK NUMBER	TRACK LENGTH (FT)
201	2777
202	2901
203	3146
204	3368
205	3149
206	3095
207	2963
208	2877
209	1744
210	2742
211	1706
212	2563
213	2642
214	2692
215	2854
216	2988
217	3245
218	3463
219	3339
220	3064
221	2960
222	2743
223	2604
224	2735
225	2949
226	2829
227	2766
228	2962
229	3957
230	2937
231	2946
232	3050
233	3223
234	2979
235	2859
236	2868
237	3070
238	2606
239	2649
240	2557
241	2803
242	2746
243	2348
244	2355
245	2532
246	2666
247	2556
248	2344
249	2347

FIGURE 19 TRACK DESCRIPTION TABLE

***** LIST OF CURRENT HUMP SEQUENCE AND YARDED TRAINS *****

HUMP SEQ	TRK NO	TRAIN ID	ARRIVAL TIME	NO OF CARS
1	101	01BKRVP338	1135	73
2	103	01OAOGW007	1530	72
3	102	01LABRT007	1425	40
4	104	02EUWCY006	1535	58

NO ADDITIONAL YARDED TRAINS

FIGURE 20 HUMP SEQUENCE REPORT

Next, if the yardmaster wants to correct a misswitched car, the interaction would look like this:

```
WHAT ACTION DO YOU WISH TO MAKE?
> 19
ENTER TRACK NO. (FROM), POS, NO. OF CARS, TRACK NO. (TO), POS
> 202, 13, 1, 201, 6
```

This would move the 13th car on track 202 to the 6th position on track 201.

IV FLOWCHART DOCUMENTATION OF DYNAMIC TRACK ASSIGNMENT PROGRAM

Introduction

In this section the major structures of the program logic are described. The program tries to resolve the assignment of blocks to classification tracks such that trim-engine effort is minimized and available track space is used efficiently. Thus, blocks that go on the same train should occupy tracks close to each other; large blocks should be allocated to long tracks; and small blocks to short tracks.

The most important factor in track assignment is block size. In the dynamic track assignment program, block size is a function of the planning period. We define block size as the sum of cars on those trains that are scheduled for humping during the planning period or up to a block split. The size of the block may be based on the number of cars in one block or in several blocks (if the block is a consolidation block).

Assignment is accomplished by adhering to a predetermined classification and operation scheme based on yard geometry, blocking instructions and, as mentioned above, the number of cars in the block during the planning period. Blocks requiring track assignment fall into three categories according to their size: they are either assigned to a rehump track, an idle track, or a clear track.

One other important factor must be considered in track assignment, namely, companion block assignment. Companion blocks require proximity to an existing companion block. For this reason, preference in track assignment is given to such a block.

First-Scan Clear Track Demand

Each time a cut is humped, the cut of cars is scanned to determine the number of clear track assignments that must be made (see Figure 21). During the process the program looks at each block listed in the block description table. It determines if there are cars in the cut belonging to the block being examined. If so, the assignment status of the block is checked. No action need be taken if the block is assigned or if there are no cars for this block in the cut. The size of the block and its

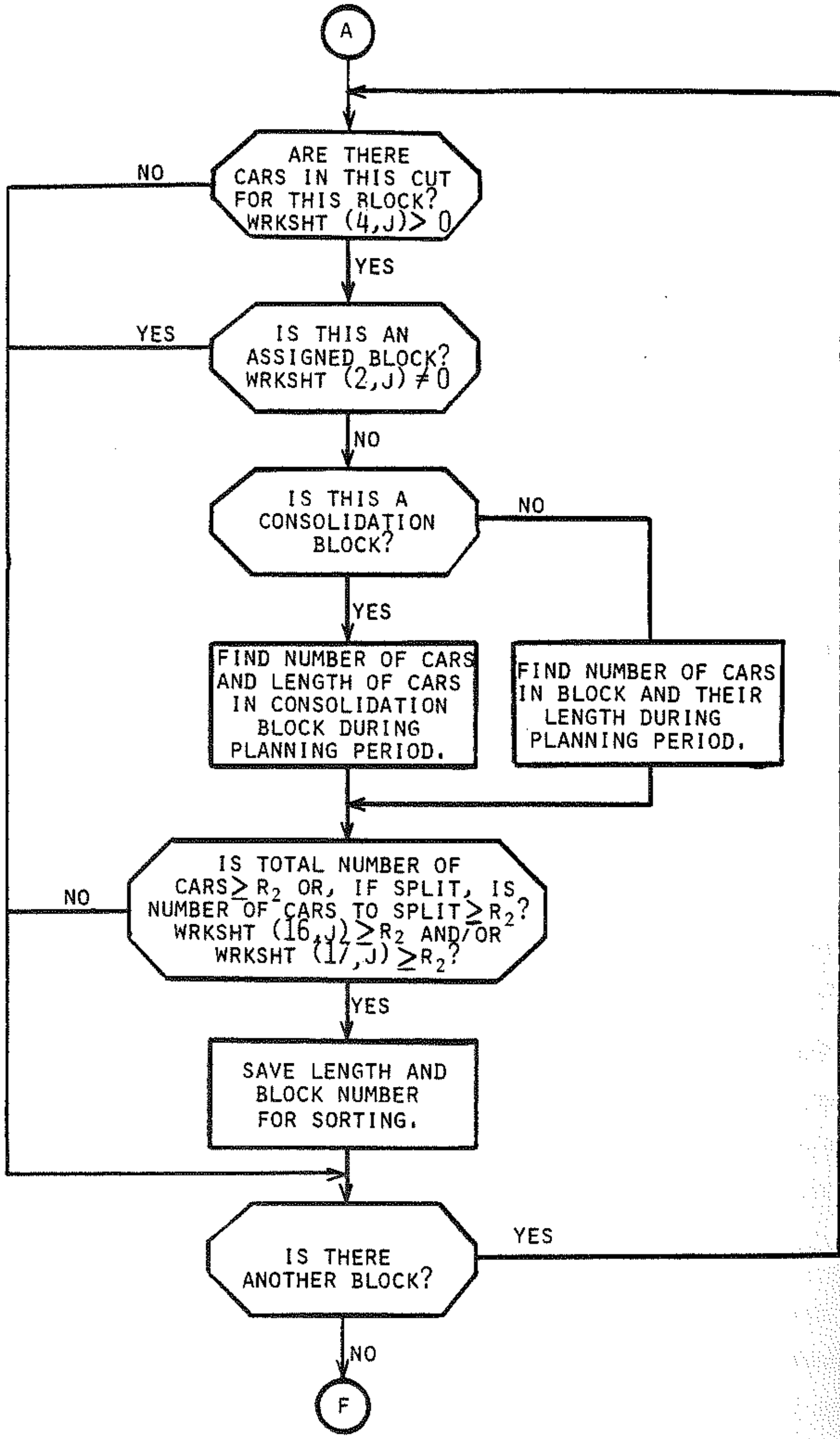

FIGURE 21 STARTER BLOCK ASSIGNMENT

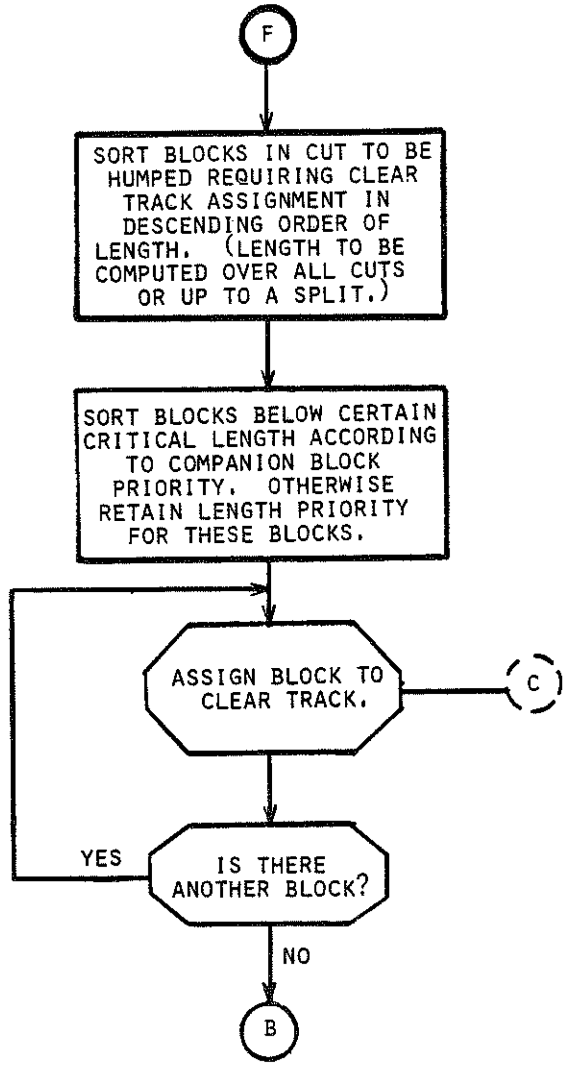

FIGURE 21 (CONCLUDED)

length are obtained if the block is unassigned. Some additional calculations are made if the unassigned block belongs to a consolidation block. The number of cars of all blocks in the consolidation block is found for either the entire planning period or up to a block split. The length of the consolidation block is obtained by summing the lengths of all cars in the consolidation block.

After determining the size of the block, the size is compared to the lower limit of the clear track range, R_2. If the number of cars is greater than or equal to R_2, the block number and the total length of the block are saved for later use. This process continues until all blocks have been looked at.

Next, the saved information of blocks requiring clear tracks is sorted in descending order by length. Now the notion of critical length is applied to this set of blocks to give priority in assignment to large blocks. The critical length is an arbitrary value assigned at the discretion of the user. Critical length influences the order of block processing. For large blocks whose overall length is greater than or equal to the critical length, the order of processing is based on the size of the track length requirements. For blocks whose length is less than critical length, preference in processing is given to companion blocks. A zero critical length gives clear track assignment priority to companion blocks only. If a critical length is in effect, blocks below that critical length are sorted again so that priority is given to companion blocks. In addition, length priorities are retained within the set of companion blocks and the set of those blocks that are not companion blocks but require track assignments.

Track Assignment

Based on the number of cars, N, in the block during the current planning period, the following categories are established by using the upper and lower limits of idle track assignment, R_1 and R_2, respectively:

$N < R_1$	Rehump track
$R_1 \leq N < R_2$	Idle track
$N \geq R_2$	Clear track.

This means a block may get assigned to a rehump track, an idle track, or a clear track based on its planning period or up-to-a-split size alone (see Figure 22).

Clear Track

This assignment is made if the size of the block is greater than or equal to R_2. First, an attempt is made to find a clear track in the primary area of assignment for this block. Failure to do so triggers a search in the secondary area if such an area exists for this particular block. The yardmaster is notified and asked to assign a track if the search for a clear track is not successful in any of those areas.

For a regular block the shortest clear track that can hold the cars is picked. An exception is companion block assignment. Its choice differs from regular assignments in that the track should be as close as possible to the companion block. There is, however, some trade-off if the percentage utilization factor is in effect. This implies that a block will not get assigned according to strict companion block logic unless the track utilization is greater than or equal to the specified value.

Idle Track

Idle track assignment takes place if an assigned track can be found that has enough space and time to allow the placement of a block without mixing the cars of the different blocks. Similar to clear track assignment in finding candidate tracks, the primary yard classification area for the block is searched. The search is extended to the secondary area, if it exists, if the primary area search fails. Tracks that qualify for idle track assignment are sorted by available length. The length is obtained by subtracting from the current excess length the length of the expected assigned cars of the currently assigned block. From all tracks that are available for block insertion, the one with the shortest available length is picked for idle track assignment. If no idle tracks are available, clear track assignment is attempted.

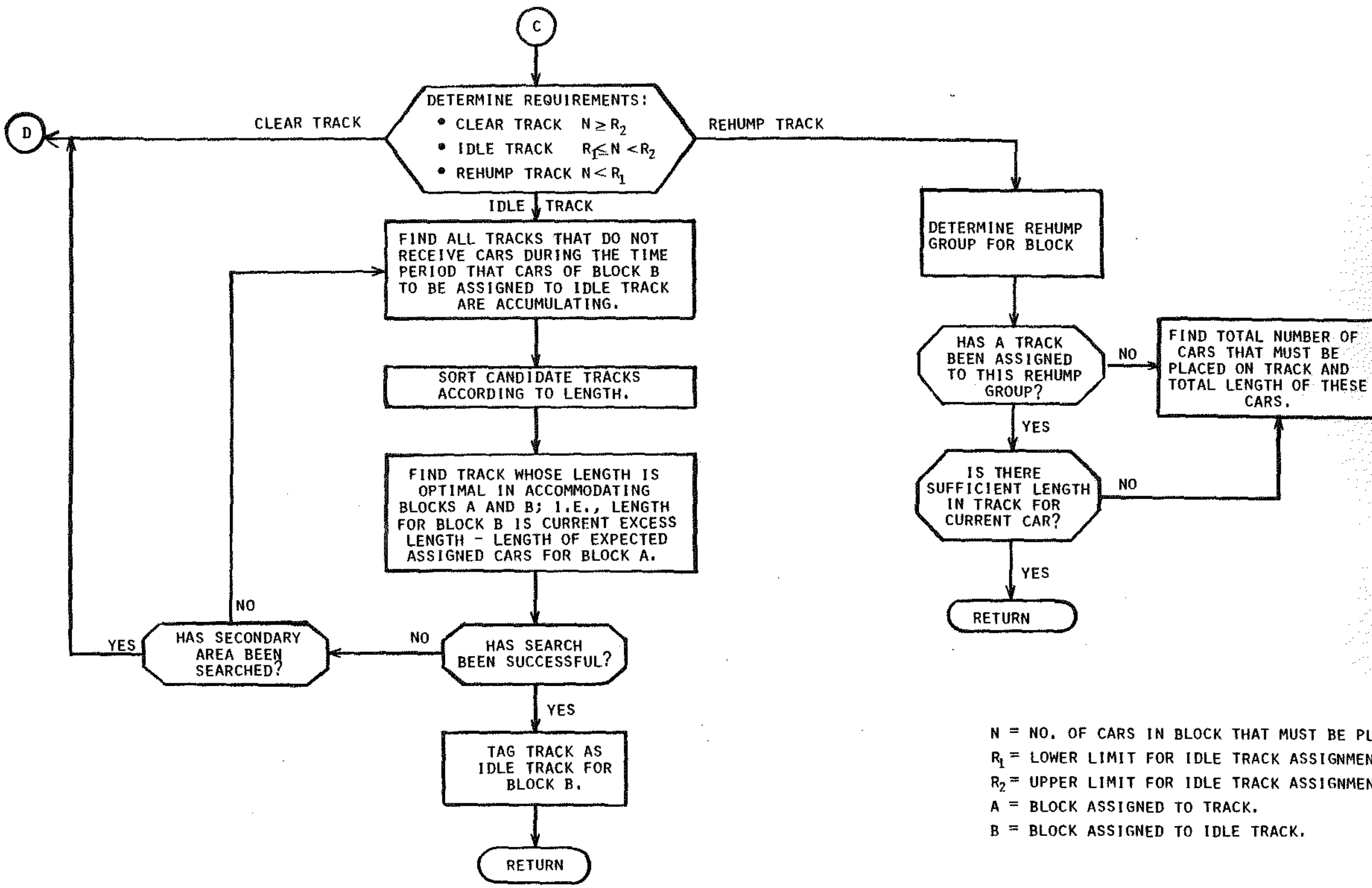

FIGURE 22 BLOCK ASSIGNMENT

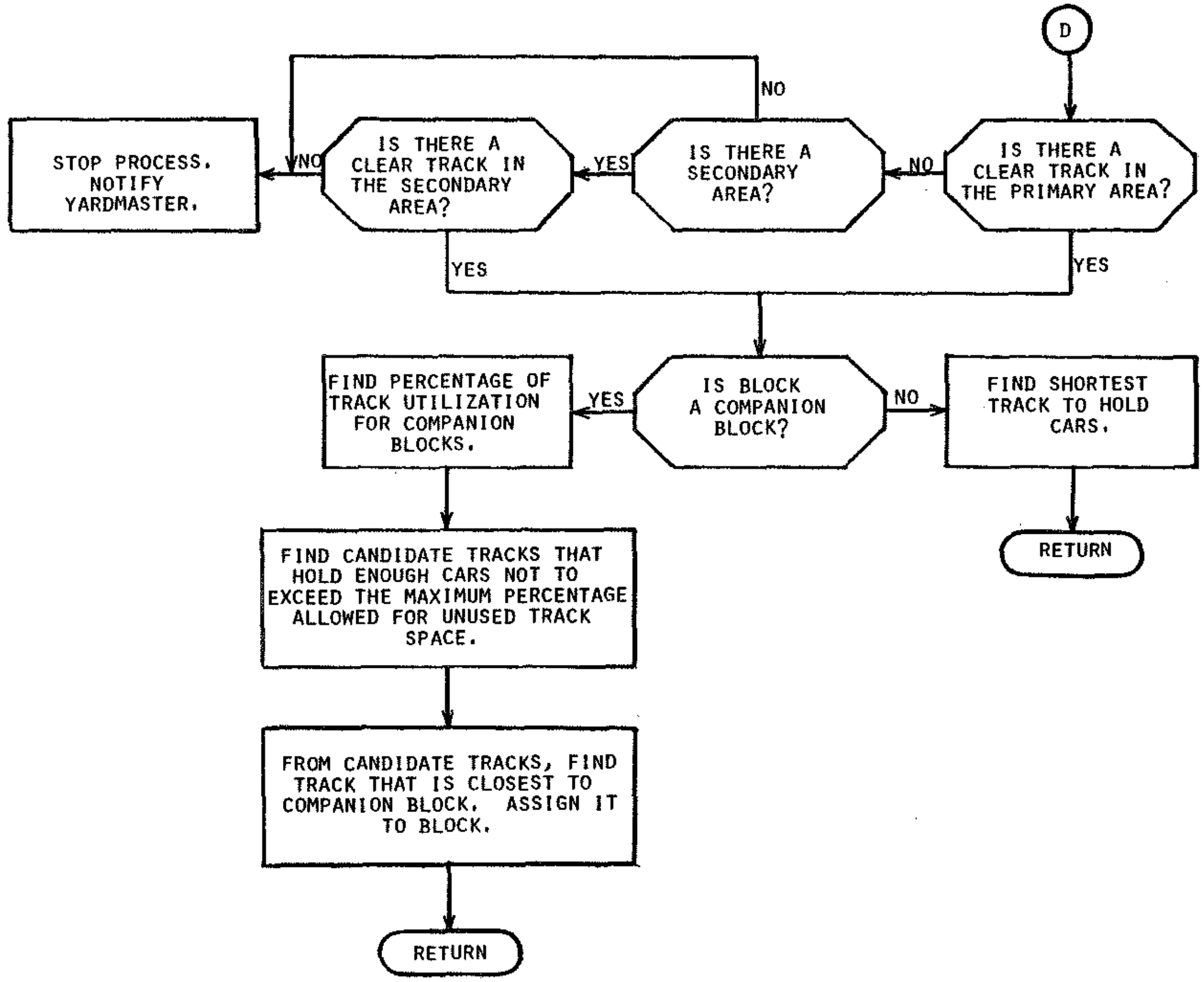

FIGURE 22 (CONCLUDED)

Rehump Track

A block whose size is less than the lower limit of the idle track range, R_1, belongs to a specific rehump group given by the blocking instructions. Rehump tracks are assigned to a rehump group. A rehump group may contain several different block designations. Track assignments are made to the rehump group, not to an individual block. However, a block assignment problem may bring about a track assignment to a rehump group if no assignment has been established. The track length required for this track is found from the lengths of the cars accumulating in the rehump group during the planning period. Track assignment to the group is done according to the logic for clear track assignment.

If a rehump group is assigned, no further track assignments are necessary for blocks in this rehump group unless there is not sufficient length available in which to place the current car. A new track assignment is sought for the rehump group if the space on the currently assigned track is exhausted.

Hump Activity

Present track assignment logic gives priority to clear track assignment of unassigned blocks. This is done by establishing the demand for such clear tracks first. Other assignments of blocks to tracks, such as rehump tracks or idle tracks, are done during the humping operation (see Figure 23) as each car is examined individually to establish its proper place in the classification yard.

A car may belong to an assigned block or an unassigned block. Since clear track assignment has been taken care of previously, the following types of track assignment remain to be resolved:

- Assignment to a rehump track
- Assignment to an idle track
- A clear track assignment because of track overflow.

If a car belongs to an assigned block, the next step is to find out if there is sufficient space left on the assigned track to place the current car. If so, the yard inventory is temporarily updated. The update becomes permanent if the assignment is activated. Insufficient

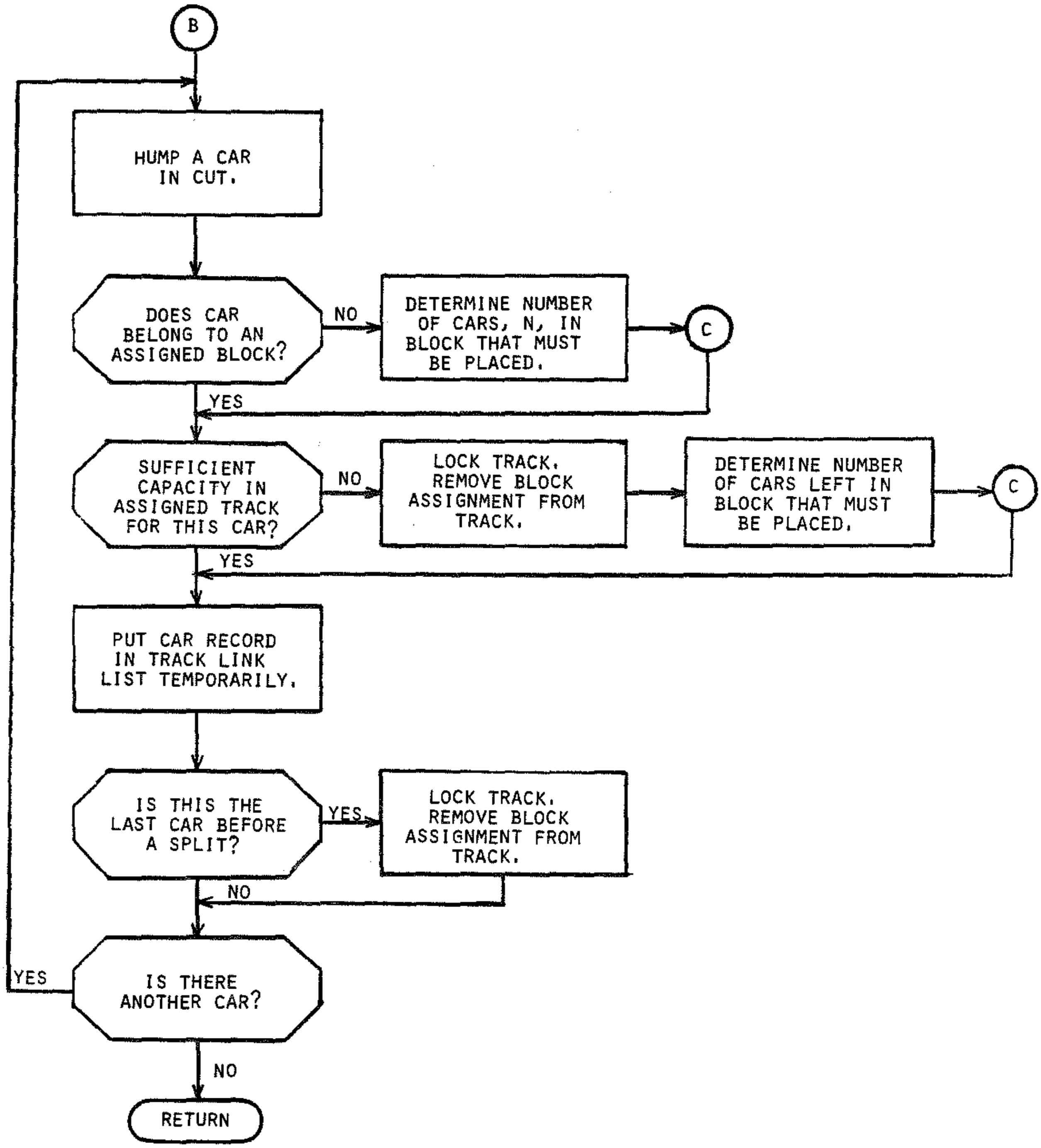

FIGURE 23 HUMP ACTIVITY

track space requires a different action. The currently assigned track is locked, and the block assignment is removed to prevent further placing of cars on this track. The number of cars left in the block that must still be placed is obtained. This number is used to determine the type of the new track assignment for the remaining cars in the block.

A similar action is taken if the car is the last car before a split. The track is locked, and the block designation is removed from the track. The next car in that block after the split will cause a new track assignment when it comes to the hump.

The hump activity procedure is repeated until all cars in the cut have been processed.

GLOSSARY OF TERMS

- ASSIGNED BLOCK--A block already assigned to a track.
- CLEAR TRACK--A track that has no cars and is not assigned to a block.
- COMPANION BLOCKS--Blocks that should be on adjacent tracks to enable doubling of tracks and minimization of trim work.
- CONSOLIDATION BLOCK--A block formed by consolidation of two or more standard blocks.
- CRITICAL LENGTH--For large blocks (whose overall length is greater than or equal to the critical length), the order of processing is based on the size of the track length requirements. For blocks whose length is less than critical length, preference in processing is given to companion blocks.
- IDLE TRACK--A track that is assigned to another block but has sufficient room and time for inserting a second block without mixing the two blocks.
- LOCKED TRACK--A track unavailable for assignment. No cars can be added.
- PRIMARY AREA--Area in the bowl of first choice for track assignment to a block.
- REHUMP TRACK--Track for cars to be rehumped.
- SECONDARY AREA--Area in the bowl of second choice for track assignment to a block.
- SPLIT--All cars of the same block may not be scheduled on the same outbound train. The block is "split"; the first part of the block (before the split) is treated as a separate entity from the second part (after the split) for purpose of assigning a track.
- STARTER BLOCK--A block that needs a track assignment.
- TRACK ASSIGNMENT RANGE--A range defined by two numbers, R_1 and R_2, such that if the number of cars in a block is less than R_1, cars are assigned to a <u>rehump track</u>. Assignment to an <u>idle track</u> is made if the number of cars in the block is greater than or equal to R_1 but less than R_2. Clear track assignment occurs if the number of cars is greater than or equal to R_2.

- TRACK UTILIZATION--A block will not be assigned based on companion block logic, unless the track utilization is greater than a specified percentage.
- UNLOCKED TRACK--A track which is unavailable for clear track assignment. The track is available for idle track assignment, however. Track may receive cars until locked.