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Title: The Effect of Warehouse Layout on Order-picking Efficiency

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This paper addresses the order-picking problem in a warehouse and establishes some criteria for the planning, design, and improvement of a warehouse layout to increase the order-picking efficiency. A simulation model has been developed to study the effect of warehouse layout on the order-picking throughput. Three major design elements of the warehouse layout are considered: crossing aisles, picking aisles orientation, and dock location. The system throughput is measured in terms of the traveling and waiting time of the picking vehicles. The results indicate that the order-picking efficiency can be substantially improved by orienting the picking aisles perpendicular to the dock, placing or locating the crossing aisles parallel to the dock and by locating the dock on the longitudinal side of the warehouse.

The Effect of Warehouse Layout on Order-picking Efficiency

by

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DEDICATION

This Thesis

is dedicated in memory of

my brother,

MAHMUD S. MAHMUD

for his care, understanding, encouragement,

and support.

He is to be admired

for his strength, endurance, positive attitude,

hard work, and intelligence.

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I. INTRODUCTION

Order-picking is defined as the warehouse activity of performing picking tours throughout the aisles, retrieving the ordered items from their storage locations, and delivering them to the dock. The order-picking process is varied in the way in which it can be performed. A common way is that the operator is scheduled to pick all items of a complete order in one tour. The tour starts from the dock, the operator receives the picking-order ticket, picks the items and ends at the dock for unloading the items of a completed order. This method of order-picking is referred to as "complete order-picking". In another method, known as "Zone/Batch order-picking," the warehouse is divided into picking zones and the picking orders are batched according to the location of the items in the picking zones. In this method the operator is scheduled to pick all items of multi-orders in a batch located in a picking zone. This method is especially used when different types of material handling equipment are required for items of various sizes, shapes or weights, and/or when the same items are repeated in different picking orders. A third method is called "pick-and-back" or "out-and-back." This method is mainly applicable in the automated storage and retrieval systems. The crane retrieves a single item or load at a time. In most order-picking operations, picking is done by the operators walking or riding vehicles or carts. The type and capacity of the vehicles or carts are varied depending on the items' size, shape, weight and the number of items per order.

The assignment of items to storage locations is also accomplished in a variety of ways. One well-known approach is referred to as ① the "activity or popularity approach." The items are assigned to the storage locations based on their turnover frequency or activity rate. Items with a higher activity rate are located in storage locations closer to the dock. The advantage of this method is to minimize the traveling distances for order-picking. But a traffic congestion problem can be expected to be created in the active aisles, especially when the number of picking vehicles increases. Another method is called the ② "random or equally likely approach." In this method the items are randomly assigned to the storage locations. this approach is expected to minimize the congestion problem of the order pickers by "equally likely" distributing the active items throughout the picking aisles. On the other hand, the traveling distances are expected to increase when this method is used. A third method is used by ③ grouping together the items which are complementary based on their function or use and which have a very high chance of being ordered together within an order. Each group is located in a picking zone in the warehouse and zone order-picking is used. This method is expected to minimize the traveling distances.

The order-picking list usually indicates the item number, location and quantity. Items are listed according to their picking sequence. A common method used to determine the picking sequence of items is referred to as the "nearest-neighbor" method. The first item on the list is in the nearest location to the dock followed by the item which is closest to the first item, and so on. Another method that has recently been applied with the use of the computer is to generate the order-picking list and optimize the items sequence for picking by utilizing the "shortest route" or "traveling salesman" technique to minimize the traveling distance.

Warehouse layout has an effect on the order-picking process. If the various functions in the warehouse are not properly relatively located, considerable travling may be required to perform the picking process. There are three major function elements for the warehouse layout. First, the crossing aisles are usually wide enough to permit two-way traffic. They are used to connect the picking aisles and to facilitate the vehicles' movement. The crossing aisles are also used for waiting in front of the picking aisles to prevent the traffic congestion problem from occurriung within the picking aisles. Second, the picking aisles normally are narrow and permit only one-way traffic. They are used for access to the items in their storage locations and for picking and replenishment operations. The picking aisles are usually arranged in either parallel or perpendicular order to the dock. Third, the dock in the warehouse is considered to be the central or focal point where each picking process starts and ends. The dock is also used for orders accumulation and for shipping and receiving goods. Normally the dock is located adjacent to one of the walls of the warehouse building that is close to the receiving and shipping doors.

The order-picking cost represents the major part of the warehouse overall operating cost and is recognized as an area in which a great savings can be accomplished by increasing the order-picking efficiency and thereby improving the system performance. There has been much work and a great deal of research done to improve the efficiency of order-picking in the warehouse. Areas such as warehouse automation and product layout have been considered in the search for cost reduction. Although the automated storage system has revolutionized the conventional storage methods, it is not necessarily or always the answer to go from an inefficient conventional system to a sophisticated automatic one. In many cases, it is not justifiable to implement an automated system due to the small capacity and low volume of storage activity relative to the high cost of the automated storage system.

Another important and challenging area has an impact on the order-picking process and is less costly to improve and implement. This is the physical-layout design of the warehouse, and it deals with the relative locations of the various functions contained in the warehouse. Unfortunately, this area has not received enough attention and only a very little literature on this subject is available. All of the research which has been done tries to optimize the system by developing mathematical models rather than analyzing the system's operation and performance under various conditions to study the interaction effect of certain factors and thereby objectively arrive at a satisfactory conclusion.

The focus of this study is to improve the physical design of the warehouse layout in order to increase the efficiency of the order-picking process. The function elements of the layout to be considered include the dock location relative to the warehouse building, the picking aisles orientation in relation to the dock location, and the presence of the crossing aisles. The study will be done by developing a simulation model which represents the system's operational characteristics. Through the use of a simulation technique as a tool, an insight into the system is provided which can yield data as to how variables interact, which enables the study of the effects of the considered factors on the system's operation and performance. The system performance is measured in terms of the picking vehicles' traveling and waiting time, which reflect the traveling distance and the traffic congestion of the order-picking operation.

The resulting savings in the vehicle travel and waiting time are of greatest interest to the user, designer and planner of such systems because the traveling and waiting time represent the major part of the picking process and directly effect the order-picking efficiency. This reduction in traveling and waiting time would mean an increase in the productivity of the system and thereby decrease the warehouse operating cost. The savings can be used either in the planning and design of new systems or modification and improvement of the existing ones. Therefore, it is worthwhile to examine this area for further improvement.

II. PROBLEM ANALYSIS

Literature Review

A great deal of research has been done in the area of warehousing and layout, but it seems that no computer simulation assisted study has been developed to analyze the order-picking process in a conventional warehouse. Most of the literature in the field uses some of the traditional mathematical-solution techniques to study some of the factors effecting the warehouse layout. The use of mathematical models is limited to a particular situation or to a narrow area, however, the common objective of the mathematical models is to optimize the system rather than analyze the system's operation and performance under various conditions and to study the interaction effect of certain factors and thereby objectively arrive at a satisfactory conclusion.

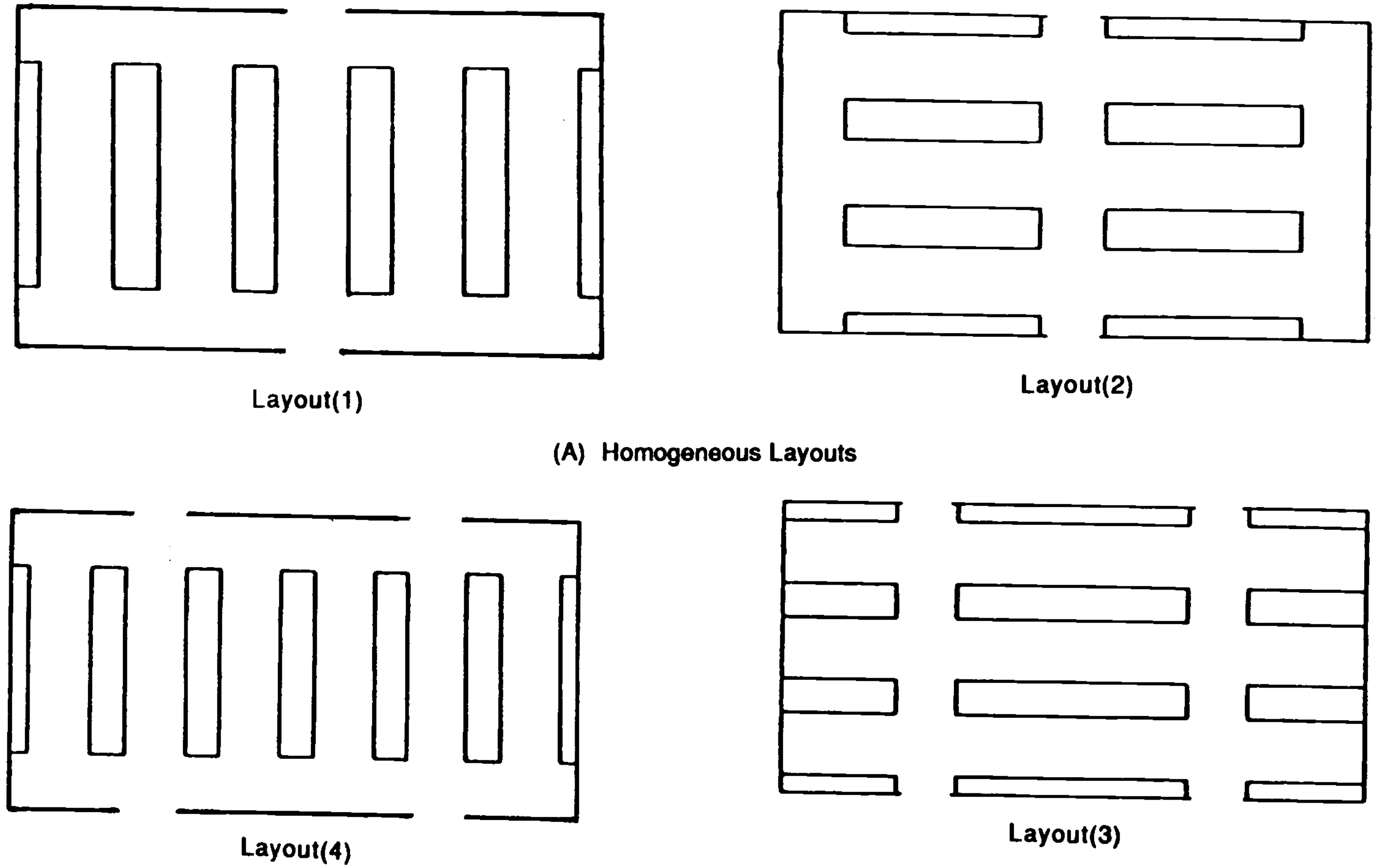
Francis (1967) studied some problems of rectangular warehouse design and layout. In his article, he studied the problem related to finding a warehouse layout and design that would minimize the total cost of item movement between the facilities which are the items' storage locations and a known point which is considered to be the dock location.

Francis developed two mathematical models which consider the cost of item movement within the warehouse and the costs due to the warehouse perimeter. He assumed that the warehouse has one dock, and that items with different turnover frequencies are equally likely moved between the dock and storage locations. All item movement is assumed to be of direct back and forth nature between the storage locations and the dock. Then as he concluded:

> A particular type of warehouse layout, called an ordered rectangular layout, is defined, and an ordered rectangular layout is obtained which minimizes the total cost of item movement over all such possible layouts.

Bassan, Roll and Rosenblatt (1980) considered two configurations of shelves. In the first configuration, the shelves are arranged perpendicular to the longitudinal wall of the warehouse building. In the second, the shelves are arranged parallel to the longitudinal wall. Also, two organizational situations are considered. First, the whole warehouse is considered as a single homogeneous unit, while in the second, the warehouse consists of several independent units. The four layout alternatives are shown in Figure II-1.

Bassan and his colleagues assumed that items are delivered to the warehouse through a door (dock) located on one side of the rectangular warehouse and taken out through another door located on the opposite side of the warehouse. Both doors (docks) are considered equivalent to a single door. In the homogeneous alternative, one set of two doors is located at the middle of the longitudinal walls opposite each other, while in the zoned alternative, each zone has its own pair of doors located in the same manner at the middle of the zone. Each zone has its distinct items stored within and also has its own customers, while in the case of the homogeneous warehouse, there is an equal probability for an item to be located in any of the storage spaces in the warehouse.



(B) Zoned Layouts

FIGURE II-1 The Different Layouts Considered by Bassan, Roll and Rosenblatt

They developed a mathematical model to compare the overall cost of each alternative. The overall cost considered includes: the material handling cost, the costs connected to the warehouse area, and the costs that are proportional to the building perimeter. In their general comments they write:

> It was found that perimeter costs are of importance and may play (together with the handling costs) a decisive role in the choice between internal layout patterns.

Ballou (1967) developed a linear-programming model to be used as a guideline for more optimal arrangements of products in a typical warehouse, both in the reserve and the assembly sections. He approached the problem by considering that each item in the warehouse has a handling cost associated with it, depending on its particular location. He tried to assess the trade-offs in handling costs among the various stock arrangements by utilizing the linear programming technique to research all the feasible layout arrangements and then suggests the one with the lowest total handling cost.

He concludes:

> The largest plan suggested by the linear-programming analysis resulted in total yearly handling costs that ranged from 11% to 23% lower than those encountered when the existing layout methods were applied to the example problem.

Problem Formulation

Consider a typical storage warehouse system with one dock, where the order-picking process is performed by picking vehicles upon requested or scheduled orders. Each picking order consists of multi-items. Each vehicle is assigned a complete picking order in "one picking tour". Starting from the dock, the vehicle receives the picking order, travels through the picking aisles in a sweeping manner starting from one side of the warehouse and continues picking items from aisles closer to the dock first until it finishes picking the last item in the picking order. Then it returns to the dock for unloading the completed picked order, and a new picking order is scheduled. In the order-picking tour, the vehicle selects the shortest path each time it travels from one item location to the next. Each time a picking aisle is occupied by a picking vehicle, the other vehicles have to wait outside the aisle until the aisle is cleared. Once a vehicle has entered the picking aisle, it is required to pick all the ordered items located in that aisle before it leaves for the next aisle. The popularity approach for item location is used; items with higher turnover frequency are located closer to the dock.

By doing so, the layout of the warehouse can have a major impact on the performance of the system. However, an alternative which reduces the vehicles' traveling time and waiting time, and consequently increases the productivity of the system can be found.

One way of doing this is by introducing the crossing aisle first to facilitate the movement of the picking vehicle when it travels through the picking aisles, and second, to divide the one-way traffic picking aisles into two sections. This alternative is expected to reduce the traveling time and waiting time.

The second way is by trying to orient or arrange the picking aisles in two different ways. The first way is to orient the picking aisles perpendicular to the dock, and then, the second way is to arrange the picking aisles parallel to the dock. A study of the two possible ways of aisle orientation systems can reveal how far the aisle-orientation factor can reduce the vehicle traveling time and waiting time, and hence help to increase the efficiency of the system.

The third way is to locate the dock in two alternate locations. First, the dock can be located in the longitudinal side of the warehouse, and then, it can be located in the cross side of the warehouse. A comparison of the two dock location systems can lead to a possible way of decreasing the traveling and waiting time of the picking vehicles and hence improve the performance of the system.

Factors Under Study and Performance Measures

The number of factors which may be analyzed and compared is very large. For this purpose, general assumptions have been made to reduce the magnitude of the problem and to concentrate on some of the factors in this study. The factors considered with their layouts compared are shown in Table II-1 and Figure II-2. As can be seen, for each factor four different pairs of layouts are considered. They are designed in a way to represent and reveal only the effect of each factor by keeping all other factors and variables constant.

Factors	Pairs of Layouts Compared
Effect of Crossing Aisles	Layouts (1) & (5) Layouts (2) & (6) Layouts (3) & (7) Layouts (4) & (8)
Effect of Aisle Orientation	Layouts (1) & (3) Layouts (2) & (4) Layouts (5) & (7) Layouts (6) & (8)
Effect of Dock Location	Layouts (1) & (2) Layouts (3) & (4) Layouts (5) & (6) Layouts (7) & (8)

TABLE II-1 Factors Under Study

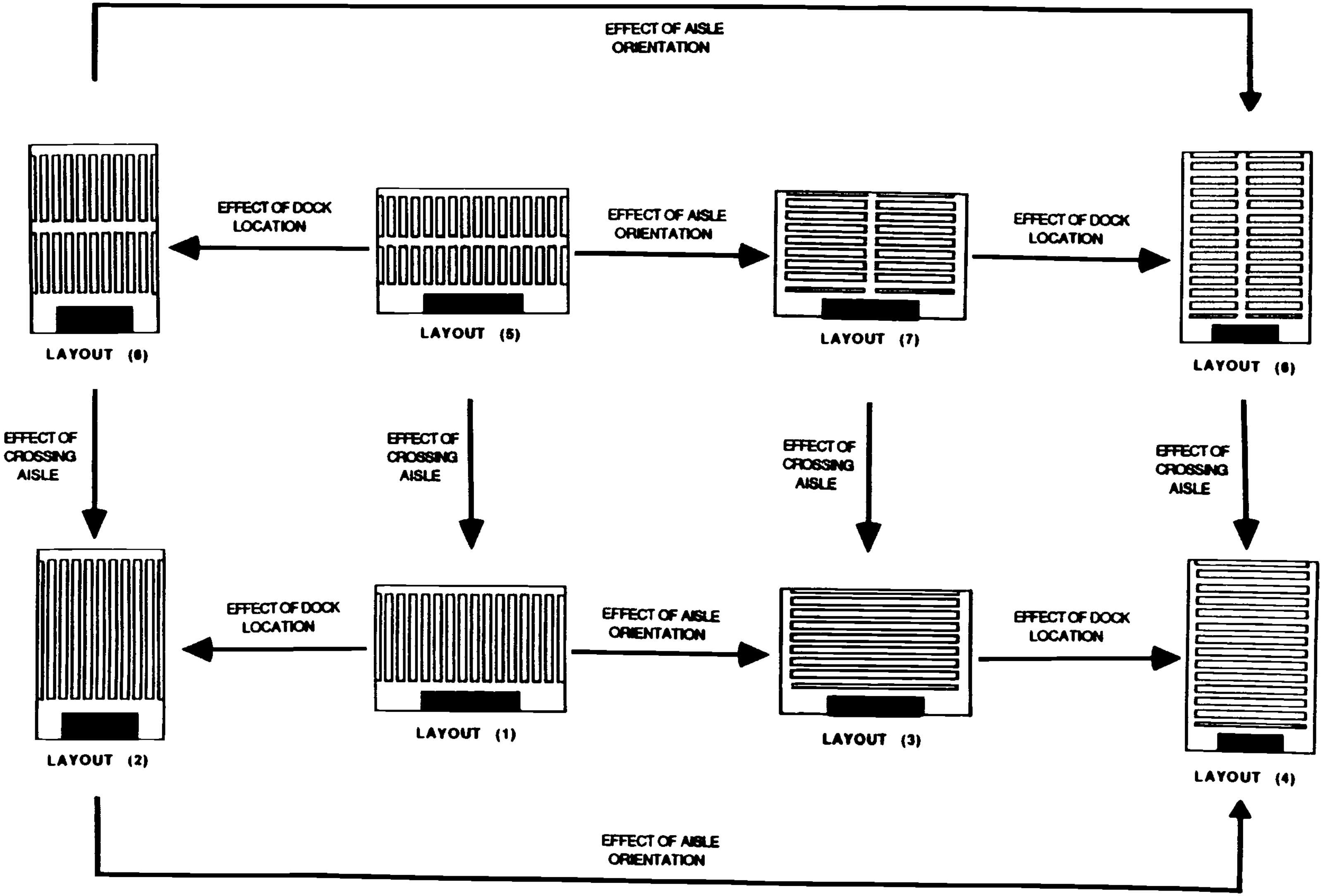


FIGURE II-2 Factors and their Layouts Considered Under Study

The first factor deals with the presence of the crossing aisles in the layout of the warehouse. It examines the effect on the picking vehicle movement through the picking aisles and its impact on the traveling time. Also it studies the effect of dividing the one-way traffic of the picking aisles into two separate sections to assess the impact on the waiting time of the vehicle for the busy aisles. The presence of the crossing aisles in the warehouse is expected to result in a considerable reduction in both the traveling and waiting time. The expected decrease in traveling time is due to the effect of the expected short-cut movements the vehicle can make with the presence of crossing aisles. On the other hand, the chances of the vehicle waiting for busy picking aisles are expected to be lower by fifty percent. This is due to the fact that half of the picking aisle is occupied as busy by dividing the picking aisle into two sections. For this reason the waiting time is expected to be reduced too.

The second factor is to study the effect of the picking aisles orientation with relation to the dock. It examines two different alternatives of aisle arrangement. In the first one, the picking aisles are arranged perpendicular to the dock, and in the second, they are arranged parallel to the dock. If the picking aisles are not laid out properly, considerable traveling may be required to go from one location to the next. The way the picking aisles are laid out effects the length and number of these aisles in the warehouse. As the length of picking aisles decreases and their number increases, a reduction in the traveling and waiting time may be expected due to the same reasoning discussed earlier in regard to the effect of the crossing aisles. Of course, this effect is not expected to hold all the time due to the interaction effect with other factors such as the dock location from where all picking cycles start and end.

The third factor considers the effect of the dock location. In regard to this factor, two alternatives of dock location are examined. In the first alternative, the dock is located on the longitudinal side of the warehouse, and in the second alternative the dock is located on the cross side of the warehouse. Obviously, the dock location by itself does not have any effect on the vehicle waiting time, but in relation to the other factors, such as the picking aisles, it would. The dock location is expected to have an effect on the travel time, but it is closely related to the way the picking aisles are arranged in relation to the dock. For example, locating the dock on the longitudinal side of the warehouse may favor traveling time when the picking aisles are arranged perpendicular to the dock, but may not favor in the traveling time other way.

The primary objective of this study is to examine the effect of three elements of the warehouse layout on the order-picking process. In order to select a performance measure for use as a measure to the system throughput, it is necessary to start with the order-picking cycle time (OPCT) definition. The OPCT is defined as the total time required for a vehicle to finish picking a complete order. This includes the time required for traveling to perform the complete order-picking tour, time spent waiting in queues for access to busy aisles, time required for picking items from storage locations, unlaoding time of the picked order at the dock, and any idle or delay time required by the operator or vehicle. Due to the variation of the idle or delay time required by the operator or vehicle, it is omitted from consideration in the performance measure of the system. The picking and unloading time may vary. This depends mainly on the total number of units picked per order. It also depends on the means by which the material is handled and picked, which in turn is effected by the size, shape and weight of the items and the height of their storage locations. All these variables are not under consideration for the scope of this study. For this reason picking and unloading times are excluded from the performance measure of the system. However, in this study, the system performance is measured in terms of the vehicle average traveling and waiting time per a complete order-picking cycle. Both measures are the most important parameters effecting the order-picking process in warehouse. The traveling time directly reflects the traveled distance, especially when using constant vehicle speed without any consideration to the rate of acceleration and deceleration. The travel time can be defined as the total time required for the vehicle movement in order to finish a complete order-picking tour, starting from the dock, traveling to the different item locations required for a complete order and finally returning to the dock. On the other hand, waiting time gives an indication of any traffic congestion problem within the system. The waiting time (Wt) is defined as the total time spent by a vehicle in queues waiting for access to busy picking aisles in order to finish a complete picking order.

III. ASSUMPTIONS AND GENERAL APPROACH

Assumptions

In order to access the effect of the crossing aisle, picking aisles orientation and dock location on order-picking process, it is necessary to make certain assumptions regarding the warehouse operation. First, it is assumed that the system under consideration consists of a rectangular warehouse. Its size is constant. It has one dock used for unloading the picked orders. The items are stored in racks. The height of these racks and number of shelves on which the items are stored are excluded from the analysis because they wouldn't have a significant bearing on the results. Usually, storage height is predetermined by the type, shape and size of stored items, as well as by the capacity of handling euqipment. All these factors are outside the scope of this study. Storage racks adjacent to a wall or parallel and next to the dock are single-sided; all other racks are assumed to be double-sided, with access to both sides. The passages between the racks are called picking aisles. They are assumed to permit one-way traffic from either direction at a time. The cross aisles and aisles adjacent to the dock are wide enough to permit two-way traffic.

Each item is stored in one region in the racks. This region can be divided between two racks on both sides of the same aisle, which are considered to have the same traveling distance to the dock. The activity approach is used to locate the items in the warehouse. Items with higher turnover frequency are located closer to the dock.

The replenishment time for stored items is not considered in the analysis. In other words, the supply or the availability of the stored items is assumed constant and always sufficient to fulfill the orders. The number of items stored in the warehouse is assumed to be constant throughout the analysis.

For picking purposes, it is assumed that an order consists of a quantity of multi-items which are picked in one picking tour by moving through the aisles of the warehouse. The picking process is carried out by a driver in a vehicle. There is no capacity restriction prohibiting the vehicle from finishing picking an order in one complete tour. Each vehicle assigned an order starts picking items located on the right side of the warehouse and moves in a sweeping manner through the aisles. It is assumed that each time a vehicle finishes picking the ordered items in an aisle and wants to move to the next aisle, it selects the shortest path. Finally, after a vehicle finishes picking all the items in the order, it returns to the dock for unloading. Another order is assigned to the vehicle immediately after it finishes unloading. The picking frequency of each item type stored in the warehouse is assumed known, and has a constant rate. The number of items per order and number of units per ordered item are assumed to have Poisson distribution, with a minimum of one item per order and one unit from each ordered item. Also, each item can occur only once in a given order.

By taking all these assumptions into consideration, a computer simulation program has been formulated to fit and precisely describe the systems of the eight layouts under study.

System Design and Specifications

Layout Design

The following are some general specifications which have been followed in laying down the design of the eight different layouts under study, to make sure that all the layouts are evaluated under similar working conditions. First, the shape and size of the warehouse is held constant with dimensions 420 x 280 feet. Then, the width of single-sided racks is 8 feet, which will make the storage system more flexibile to accommodate other storage types like pallet storage system for further studies. Also, the width of picking aisles (one-way traffic) is 12 feet, and the width of crossing aisles (two-way traffic) are 16 feet, which is considered to be wide enough to permit the use of other types of material-handling equipment. On the other hand, the percentage of spaced utilized for storage is kept consistant for all layouts in the range of 43% $\pm$ 3%. In each layout, the racks' length is divided into levels. Each item location is given a level number as shown in Appendices B-1 to B-8. The middle level is assigned the zero value. The upper half is given positive numbers and the lower half negative numbers. The levels are made to determine the shortest path for the movement of the vehicle from one aisle to another. For instance in layout (1), provided in Appendix B-1, suppose a vehicle finished picking an item located at level (+3) and wants to move to pick the next item located at level (-2) in another aisle. The shortest path will then be determined by adding the two level numbers. If the resulting number is positive, then the shortest path for the vehicle will be to go up the current aisle and then down through the next picking aisle. In the case that the resulting number is negative, then the opposite is true. If the resulting number is zero, then either way will be the same distance.

Item Location

There are 100 items stored in the warehouse. Their turnover frequency is predetermined by a method which will be discussed later in this section. In each layout the distance from the dock to each storage location is determined. The items with higher order frequency are located closer to the dock, and the numbers of items relative to their order frequency is translated or given different numbers in each layout. This is related to the movement of picking vehicles through the aisles of each layout. The vehicles are assumed to start the picking cycle at the dock, and then move to the far right side and start sweeping through the aisles picking by following the ascending order of the translated item location numbers as shown in Figure III-1.

Vehicles and Order Picking

The type of vehicles assumed to be used for picking are driver-operated picking vehicles, with an average speed of 3 miles per hour (264 feet per min.). The vehicles have no capacity limitation. That is, the vehicle capacity can be extended by attaching carts to it. The operator drives the vehicle through the aisles, and steps down at each ordered item location to pick the number of units required with a picking rate of 12 seconds/unit (0.2 min./unit). The number of

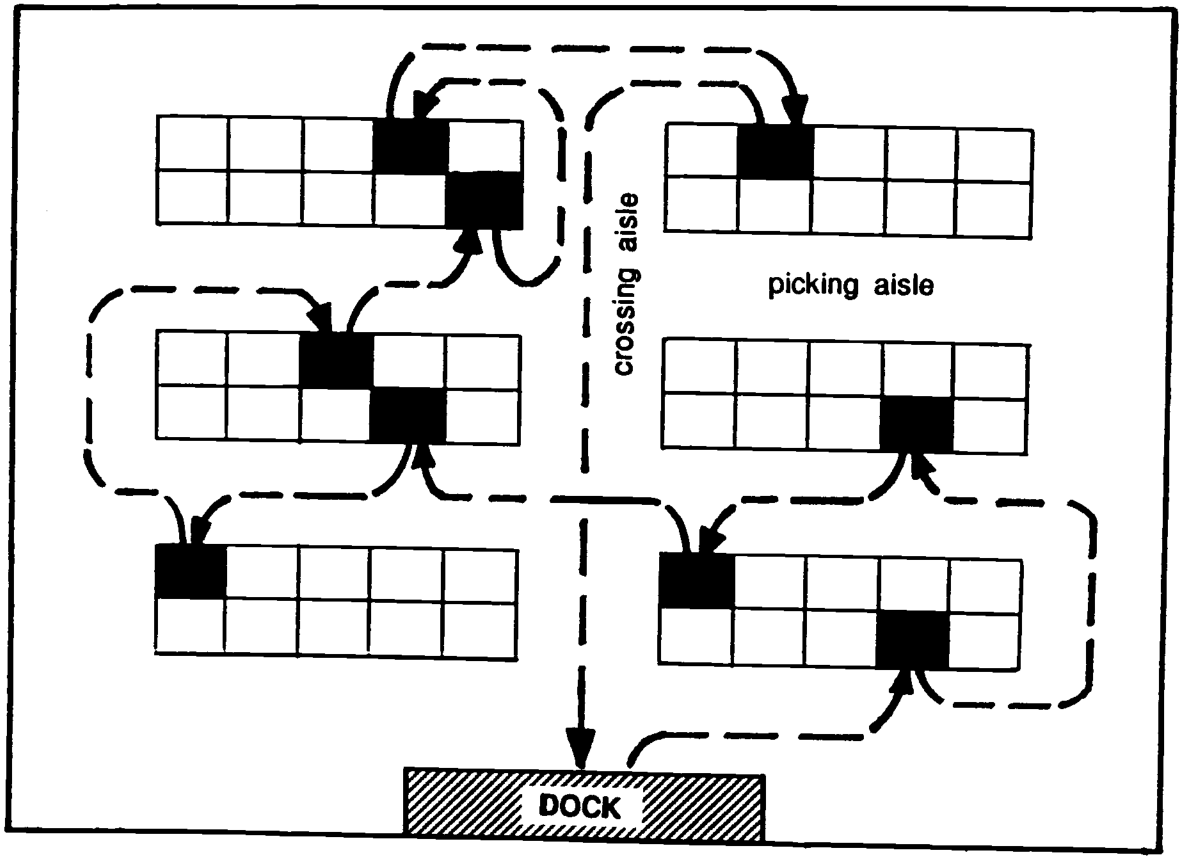


FIGURE III-1 An Example which shows the Movement Path of the Vehicle for a Complete Order-Picking Cycle picking vehicles used for picking is fixed at two and is kept constant in all the layouts. The number of items scheduled for picking per order is generated from a Poisson distribution with a mean of 10, a minimum of 1 and a maximum of 20 items/order. In addition, the number of units required per ordered item is represented by a Poisson distribution with a mean of 5, a minimum of 1 and maximum of 10 units/ordered item. The minimum number of units and items ordered is restricted to one to prevent scheduling orders of zero units or items.

Simulation Model

Simulation Program Procedure

The simulation language used in this study is GASP IV. The model used to describe the system is classified as the discrete model. This is because time is the only independent variable in the system, and all other variables are dependent and discretely changed at specified points in the simulation time. To obtain a complete simulation of the system under study, some user subprograms have been written. The listings of these subprograms and their descriptive flow charts are shown in Appendices B-9 to B-18. In addition, the definition of all variables, files, and GASP subroutines and functions used are provided in Appendix A. the following section will describe the overall simulation program procedure.

The general simulation procedure is summarized in Figure III-2. As can be seen, there are two main events or dependent variables that describe the operation of the system. The first is scheduling the

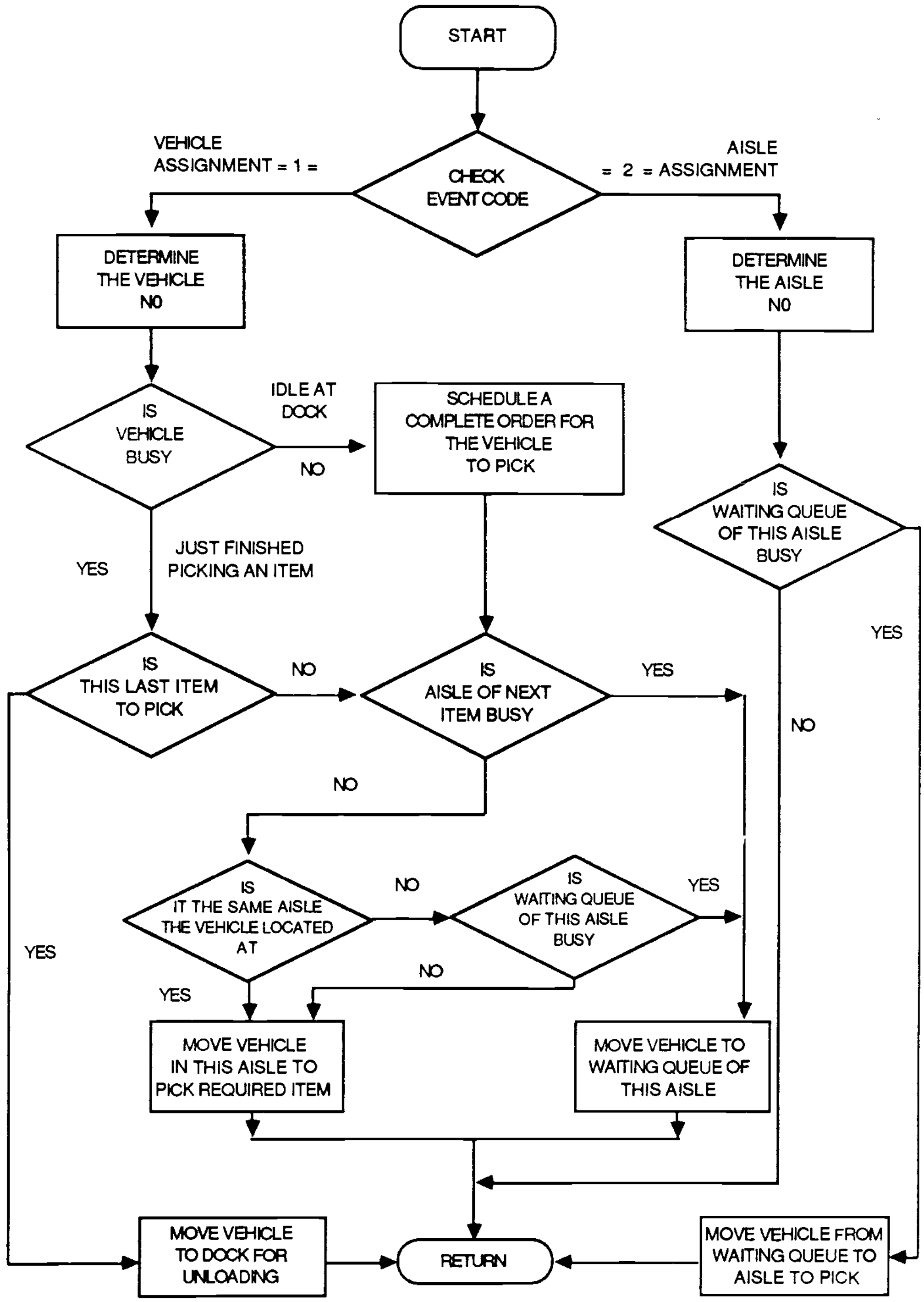


FIGURE III - 2 General Flow Diagram of the Simulation

vehicle assignment when it finishes picking an item or a complete order. The second is scheduling the aisle assignment after it is cleared from a picking vehicle. Subroutine EVENTS mainly transfer control to one of the two events. In the case of first event, it determines the vehicle number and checks whether or not it has completed picking an order. In the case of a vehicle that has finished a complete picking cycle, another picking order is scheduled for the vehicle with the restriction of not repeating the order of an item in the same picking order. If the vehicle has just finished picking an item and still has some more items left to pick, then the vehicle is removed from the aisle file of that item and the entry of the next item to pick is called from the vehicle file. The item number and its aisle is determined and the aisle file is checked to determine whether or not the aisle is busy. If the aisle is busy, then the item entry is stored in the waiting queue file of that aisle, the time the vehicle started waiting is determined, and the vehicle status is set as waiting. If the aisle is empty from picking vehicles, then the waiting queue of that aisle is checked to see if there is a vehicle waiting. If the waiting queue is also empty, the vehicle is moved to that aisle to start picking. The traveling and picking time is calculated, and the vehicle status is set as picking. The number of items left for the vehicle to pick is decreased by one and the end of the picking event is scheduled. When the vehicle finishes picking the last item in the order, it is moved to the dock for unloading. Traveling, unloading, and total picking cycle time is then calculated, and the vehicle status is set as idle. The vehicle's next assignment event is scheduled.

In the case of the aisle assignment event, the first step is to determine the aisle number; the waiting queue of that aisle is checked. If the aisle has a vehicle waiting, then the vehicle is removed from the waiting queue file and moved to the picking aisle to pick the required item. The vehicle status is set as picking and the number of items left for the vehicle to pick is decreased by one. Time variables of the vehicle, the waiting, traveling and picking time are calculated, and the next vehicle assignment event is scheduled.

Subroutine PICK basically deals with the vehicle movement throughout the aisles of the warehouse. It calculates the traveling, picking and unloading times of the vehicle and updates the vehicle location after each move. Due to the variation in the aisle patterns of the different layouts which effect the vehicle movement differently, subroutine PICK is designed in three different models. Each model is used for layouts with similar aisle patterns.

In regard to the initial condition of the warehouse, it is assumed that the two picking vehicles are located at the dock waiting for an order to be scheduled for them and that all of the aisles and their waiting queues are empty. As can be seen from the typical storage area at time zero, which is given in Appendix C-17, File (1) has two entries as assignment events of the two vehicles. All other files are empty. Subroutine INTLC is used to initialize the location variables of the two vehicles at the dock in the beginning of the simulation.

The final condition of the system at the end of the simulation is shown in Appendix C-18. It shows a sample of the file storage area of the layout (1) at time 3,000 minutes. It is an exmaple of the final situation in the warehouse at the end of the simulation time. As can be seen in File (1), it has two entries as assignment events for vehicles (2) and (1): to pick their next items at time 3,000 and 3,002 minutes, respectively. File (2) shows that vehicle (1) still has eight items to pick. In the same manner File (3) shows vehicle (2) still has two items to pick. The rest of the files are empty except Files (11) and (14). File (11) has an entry which shows that vehicle (1) is picking item (54) from aisle (8). File (14) has an entry for vehicle (2) picking item (68) from aisle (10). It can be seen in File (2) and (3) that the entries have been arranged in ascending order according to the value of item number so that the vehicle will pick items with least value first since the items are numbered in ascending order starting from the front right to the left side of the warehouse. This has been done to meet the assumption that the vehicle will start picking items located in the front right side of the warehouse and continue sweeping through the aisles to pick the rest of the items ordered.

Input Data

The input data can be divided into two main parts. The first part which is given in Appendices C-9 to C-16 and C-19 may be obtained from the layouts shown in the Appendices B-1 to B-8. This data is read in the main program and describes the location of the one hundred items stored in the warehouse as well as the dock location which is considered as number (1) in all layouts. This information is needed to keep track of the picking vehicles' movement in the warehouse. The first variable describes the aisle number of each item location [AISL(I)]. The second variable determines the level of each location in the layout [HLV(I)]. The next two variables describe the X and Y coordinates of each location in the layout [X(I) and Y(I)].

The last variable in this first part of data is concerned with the cumulative turnover frequency of each item [FX(I)]. This frequency is obtained originally from the ABC curve which is drawn to pass smoothly through the point 20%/80% as it is shown in Figure III-3. Item numbers related to their frequencies taken from the curve are located in each layout by using the popularity approach. The items with higher turnover frequency are located closer to the dock. Then the numbers of the items located in each layout are given equivalent numbers to be used as input data in the program. The equivalent numbers are set differently in each layout. These equivalent item numbers are arranged in each layout in a way that allows the vehicle to move throughout the picking aisles in a sweeping manner following the ascending order of the item numbers as discussed earlier in this section. This has been acocmplished in the program by storing the item entries of each order in the vehicle's file and removing them for picking purpose with the priority of the least value first (LVF). By reading in the main program this cumulative frequency (FX(I)) and its corresponding item numbers used in the

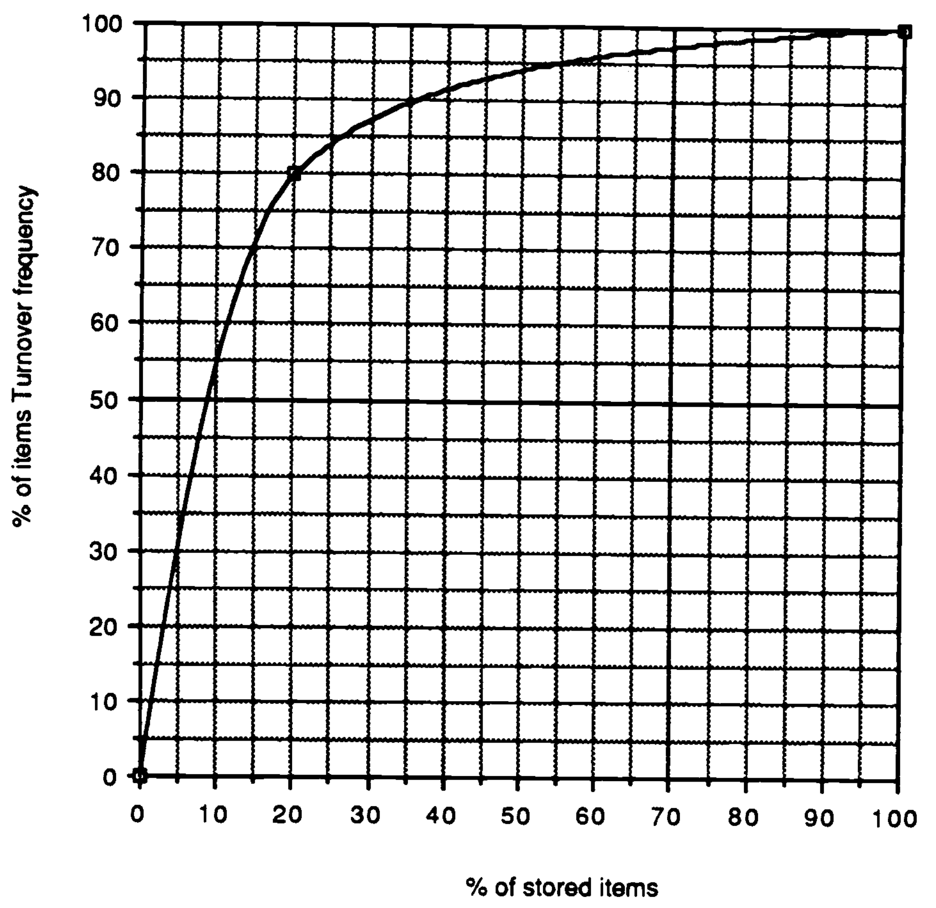


FIGURE III-3 ABC Curve 20/80

program (XIN(I)), the subroutine DPROB can be employed to generate deviates from this given probability mass function.

The second part of the input data for each layout simulation run is given in the Appendices C-1 to C-8. Some cards of this part of input data bear discussion. The first card of the histogram cards (HIS) is set to find the resulted items' turnover frequency generated by subroutine DPROB from the input data of the items' turnover frequency since the output of items' turnover frequency is expected to be different from the original frequency which is derived from ABC curve 20/80. This is due to the restriction used in subroutine EVENTS, which implies that sampling from the input frequency function is to be generated without replacing items to be ordered more than once within the same picking order.

The second set of cards is the priority cards of the filing system (PRI) which are prepared in a certain manner. For instance, in File (1) the event file, the priority to remove the entries from the file is set to follow the rule of the least value first (LVF) of the time event [ATRIB(1)]. It implies that the vehicle first in is first served. In Files (2) and (3) the vehicle files, the priority is also based on (LVF) but according to the item number [ATRIB(3)]. This is done to allow the vehicle to pick items in ascending order based on their number which represents the closeness of item location. The rest of the files in each layout can be divided into two parts. The first part for the picking aisles and the second for their waiting queues. The priority in all the aisles and their waiting queues follows the rule of first come first served, according to the vehicle number [ATRIB(5)]. The third set of cards is the parameter cards (PAR). The first card sets the parameters for the NPSSN function to generate from Poisson distribution the number of items to be picked per order with a mean of (10) items, a minimum of (1) item, and a maximum of (20) items per order. The second parameter card is to generate from Poisson distribution the number of units to be picked from each ordered item with a minimum of (1) unit, a mean of (5) units, and maximum of (10) units per item. In the (INI) data card, MSTOP = 1 which specifies that the simulation run of each layout is to end at TTFIN = 3,000 units. It means that the simulation time of the order-picking process in all layout simulation runs is constant and continued for 3,000 minutes (50 hours). On the (ENT) data card, two entries ares scheduled in the event file, each one for a vehicle. This is done to initiate an order to be scheduled for each vehicle at zero simulation time. In other words, it implies that at the beginning of the picking operation the two vehicles are set idle at the dock waiting for an order to be scheduled for them to start picking.

IV. RESULTS

Introduction

To make sure that there is no bias due to the initial conditions in the statistical data collected, a plot for the time of the traveling, picking, waiting, and order-picking cycle of each vehicle against the simulation running time is plotted to provide a feeling for any unsteady period throughout the simulation run. One example is provided (Appendix D-9) which shows there is no presence to an unsteady or transient state throughout the simulation time (3,000 units). This may be due to the initial conditions the simulation model started with. The initial conditions were close or typical to the long-run (stead-state) operational conditions of the simulated system. Also the pattern and type of activity the system is simulated to perform was a regular and single-type activity in which the complete order-picking cycles starts and ends at the dock. This assures that the simulation results are being taken from a simulation steady state period and do not have bias.

Due to the assumption that the ordered items are not permitted to be repeated within the same picking order, a restriction in the computer program has been made as discussed in an earlier section. The restriction used is expected to effect the probability function used in the program from generating the required ratio of the items' turnover frequency, which is 20% of the items required to be picked 80% of the time. For this reason, an ABC curve of the resulted turnover frequency is plotted for each layout simulation run to make sure that the turnover frequencies used for all layouts are similar and do not have large variations which may effect the system performance. Figure IV-1 summarizes the resulted ABC curves of all layouts. The results reveal that there is no significant variation in the resultant frequencies used throughout the layout alternatives. As can be seen from the resulted ABC curves, the item frequency ratio is within the range of $20/(72 \pm 2)$.

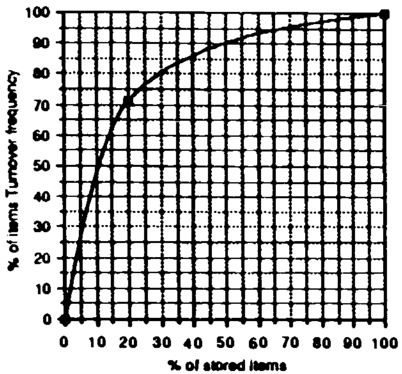
Analysis of Results

As discussed in the earlier section, the traveling time and waiting time represent the performance measures of the system of the different layout alternatives. The two parameters are considered to give an inside feeling of the system response as well as an indication of the alternatives' throughput.

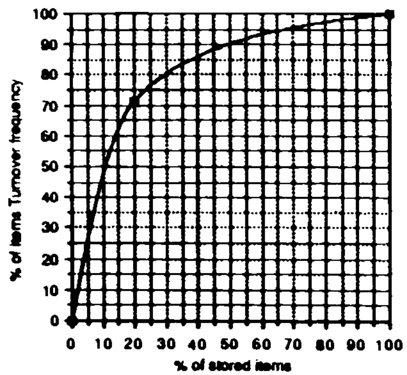
As a reminder, the travel time is defined as the total time required for a vehicle's movement in order to finish a complete order picking tour, starting from the dock, traveling to the different items' locations required for a picking order and finally returning to the dock. The waiting time is defined as the total time a vehicle spends in queues waiting for access to busy picking aisles in order to finish a complete picking order.

Each pair of layout alternatives for each factor is selected in a way to represent and show only the effect of that factor and to keep all other variables constant.

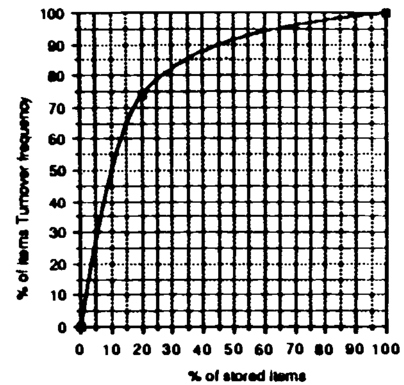
All of the resultant data are collected from a representative sample of over 100 observations as can be seen from Appendices D-1 to D-8.



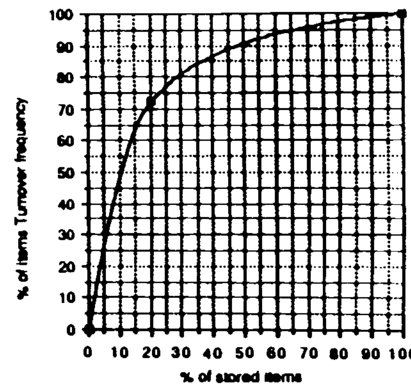
ABC Curve 20/72.1 (Layout 1)



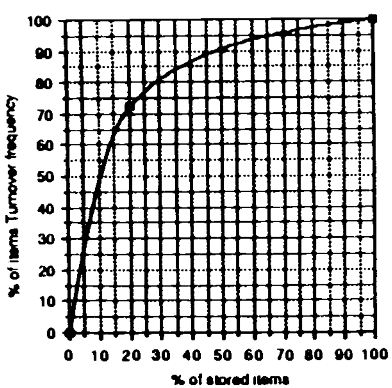
ABC Curve 20/71.4 (Layout 2)



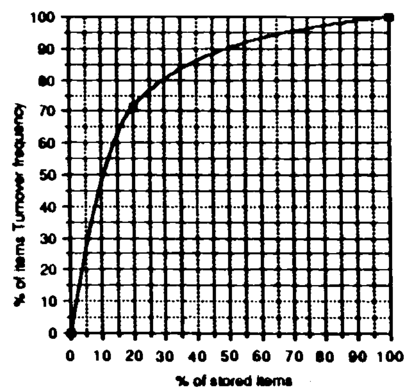
ABC Curve 20/74 (Layout 3)



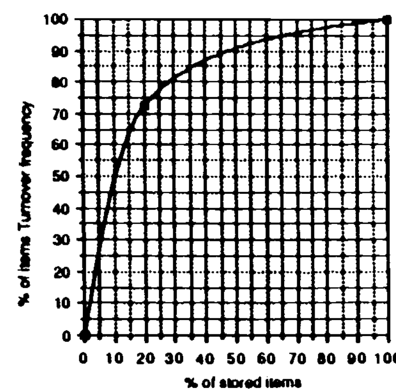
ABC Curve 20/72.3 (Layout 4)



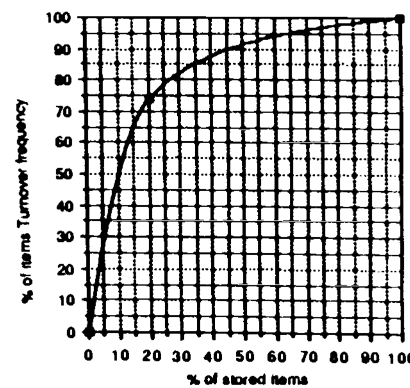
ABC Curve 20/72.2 (Layout 5)



ABC Curve 20/71.3 (Layout 6)



ABC Curve 20/72.6 (Layout 7)



ABC Curve 20/73.8 (Layout 8)

FIGURE IV-1 The Resulting ABC Curves of all Layouts within a Range of 20/ (72 ± 2)

Effect of Crossing Aisle

The system's throughput and the percentage change for the four pairs of layouts are presented in Figures IV-2 and IV-3. Comparing the results of each pair of layouts, it is clear that the presence of the crossing aisle reveals improvement in the throughput. As can be seen from the figures, the four layout pairs are acting in a manner similar to each other. In the first layout pair, layout (5) shows improvement over layout (1) in the traveling time by 3.6%, waiting time by 12.9%, and the sum of traveling and waiting time by 4.2%. In the second pair, layout (6) is improved over layout (2) in the traveling time by 5.3%, waiting time by 33.9% and the sum of traveling and waiting time by 8.4%. As may be seen the third and fourth layout pairs show a much higher rate of improvement. This increase is related to the effect of the parallel orientation of the picking aisles to the dock. In the third pair, layout (7) shows improvement over layout (3) in traveling time by 27.9%, waiting time by 49%, and in the sum of the traveling and waiting time by 30.4%. The fourth pair as well shows a high improvement: layout (8) improved over layout (4) in traveling time by 19.4%, in waiting time by 43.9%, and in the sum of traveling and waiting time by 22.3%.

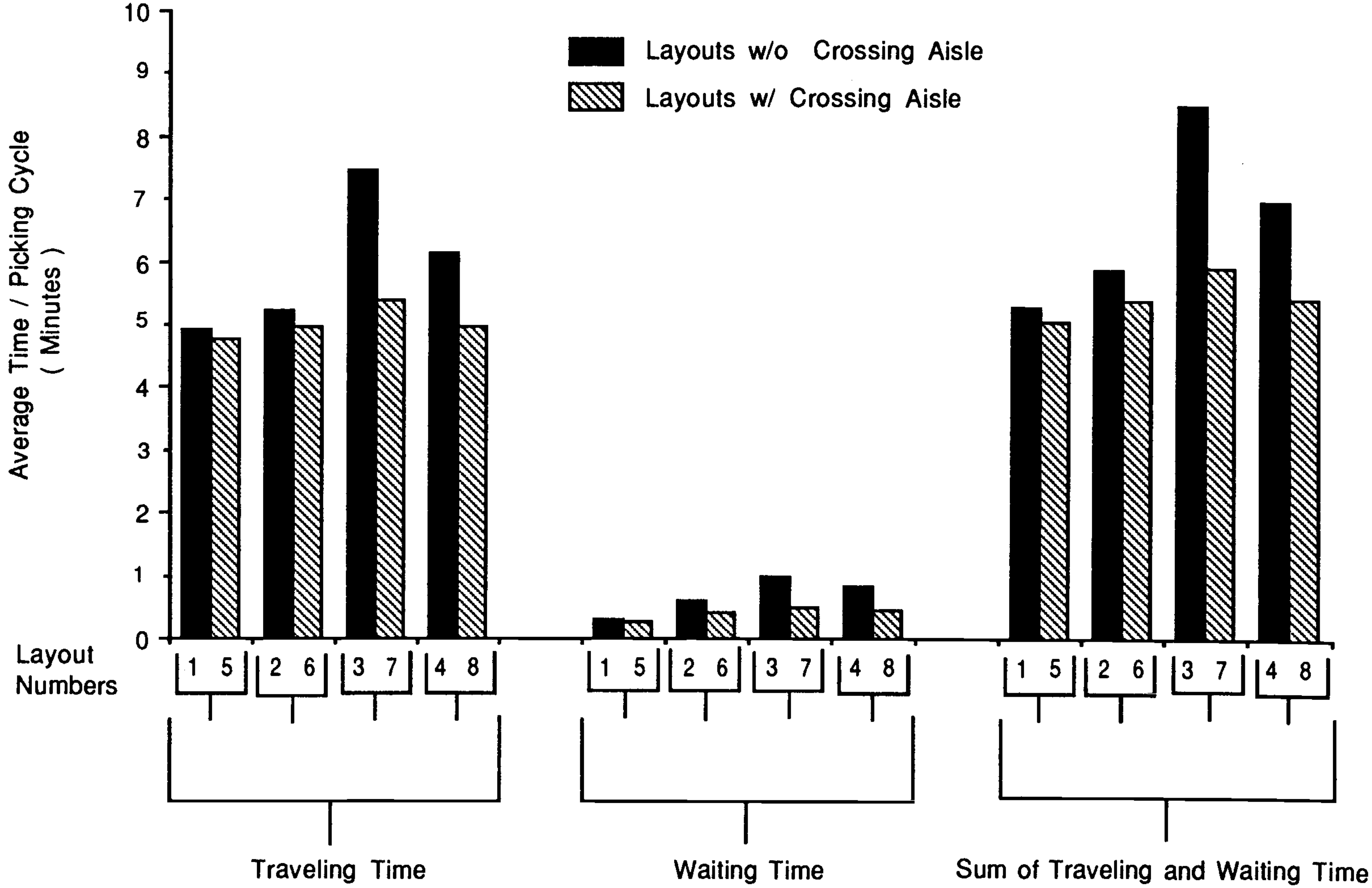


FIGURE IV-2 Effect of Crossing Aisles on Traveling and Waiting Time

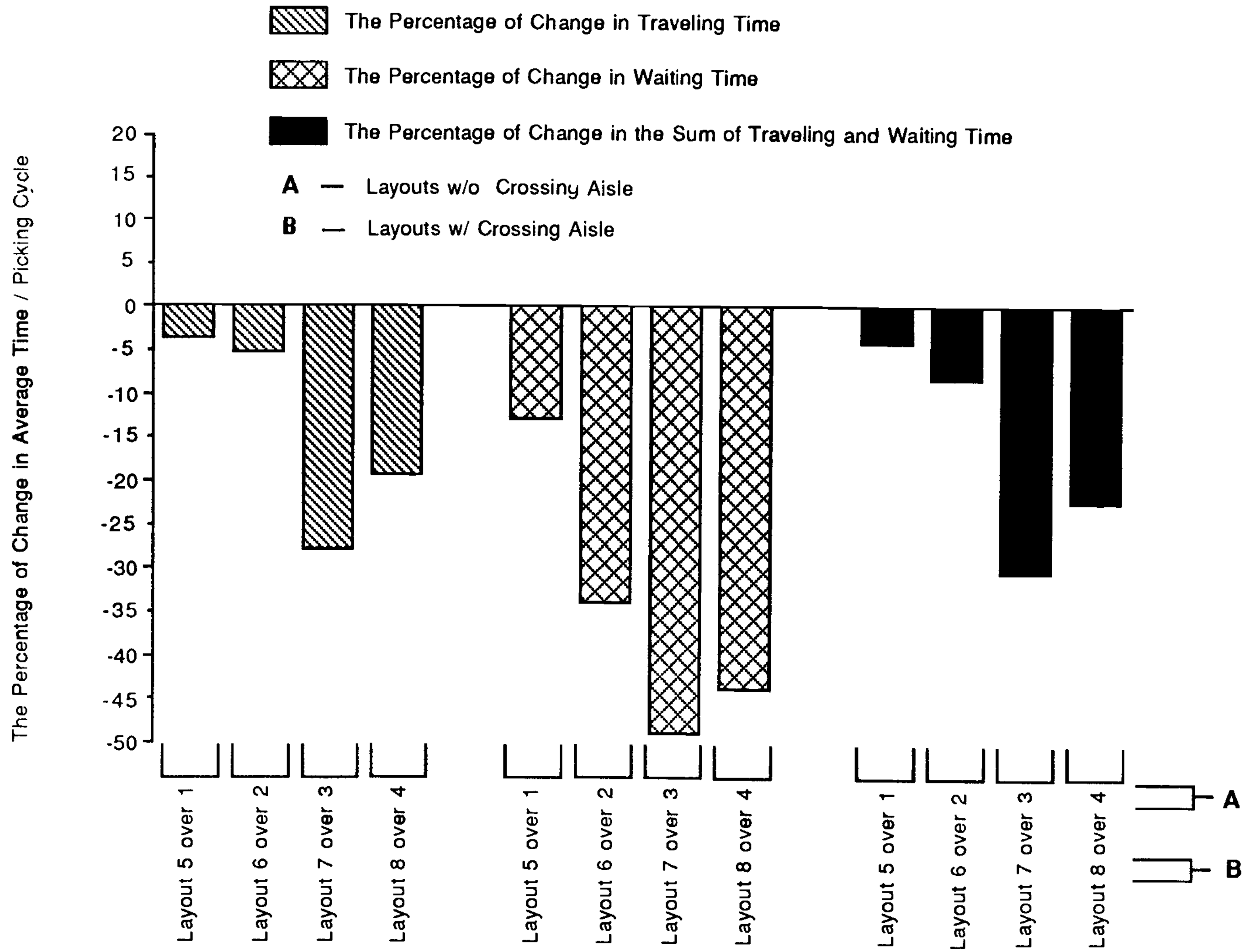


FIGURE IV-3 The Percentage of Change in Traveling and Waiting Time due to the Effect of Crossing Aisle

Effect of Aisle Orientation

The system responses of the four layout pairs in terms of traveling and waiting times and their percentage change are shown in Figures IV-4 and IV-5. The results of this factor demonstrate an overall improvement in the four pairs of layouts. This comparison shows that when the picking aisles are oriented perpendicular to the dock, the layouts reveal an overall improvement. In the first pair of layouts, layout (1) reveals a significant improvement over layout (3) in traveling time by 34%, in waiting time by 69%, and in the sum of traveling and waiting time by 38.1%. In the second layout pair, layout (2) shows a considerable reduction over layout (4) in traveling time by 14.7%, in waiting time by 24.4%, and in the sum of traveling and waiting time by 15.8%. In the third pair, layout (5) is also improved over layout (7) in traveling time by 11.7%, in waiting time by 47.1%, and in the sum of traveling and waiting time by 14.8%. The fourth pair shows a slight overall improvement. Layout (6) shows a slight increase over layout (8) in traveling time by 0.2%, an improvement in waiting time by 10.9%, and a slightly improved performance in the sum of traveling and waiting time (0.7%).

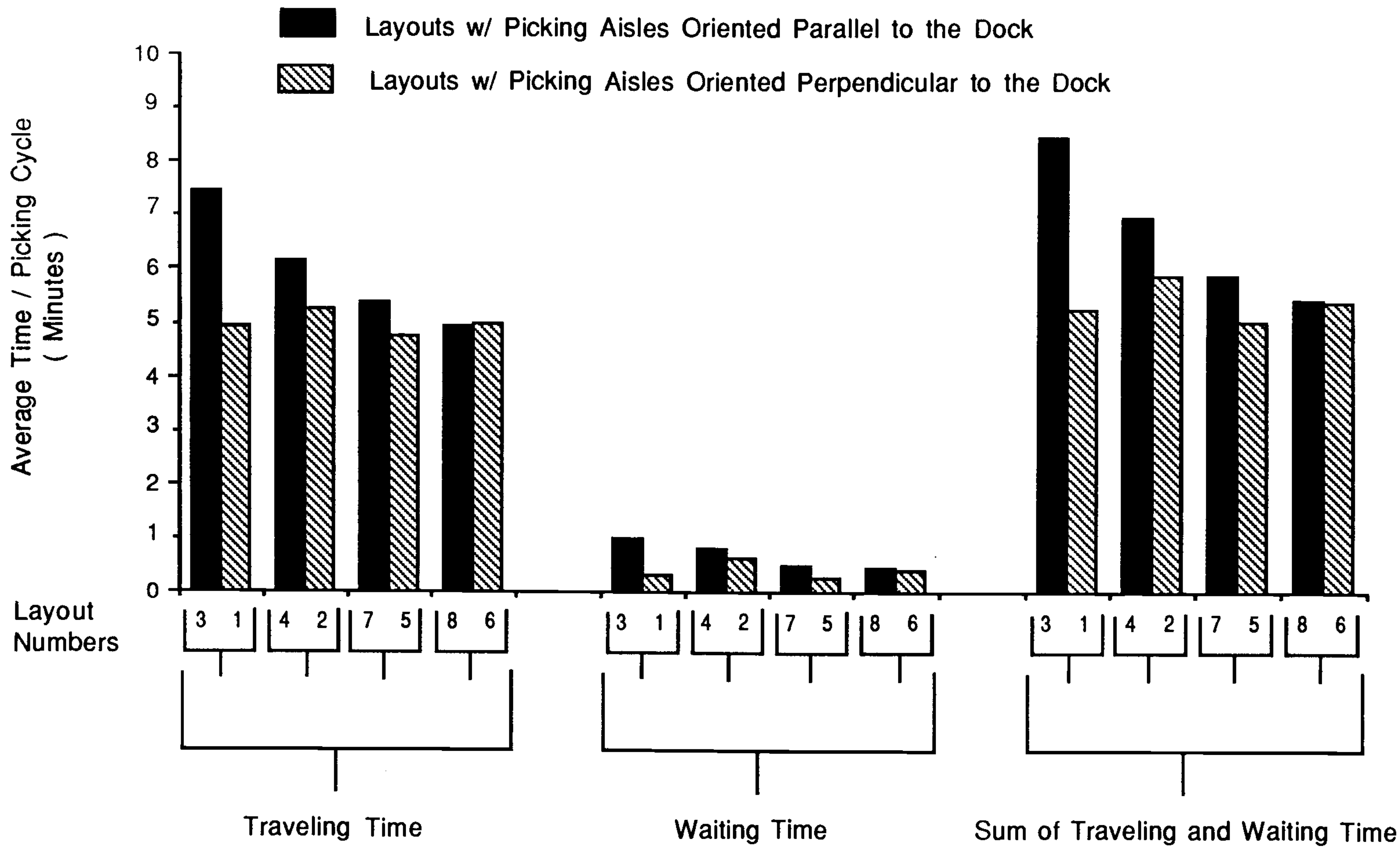


FIGURE IV-4 Effect of Aisles Orientation on Traveling and Waiting Time

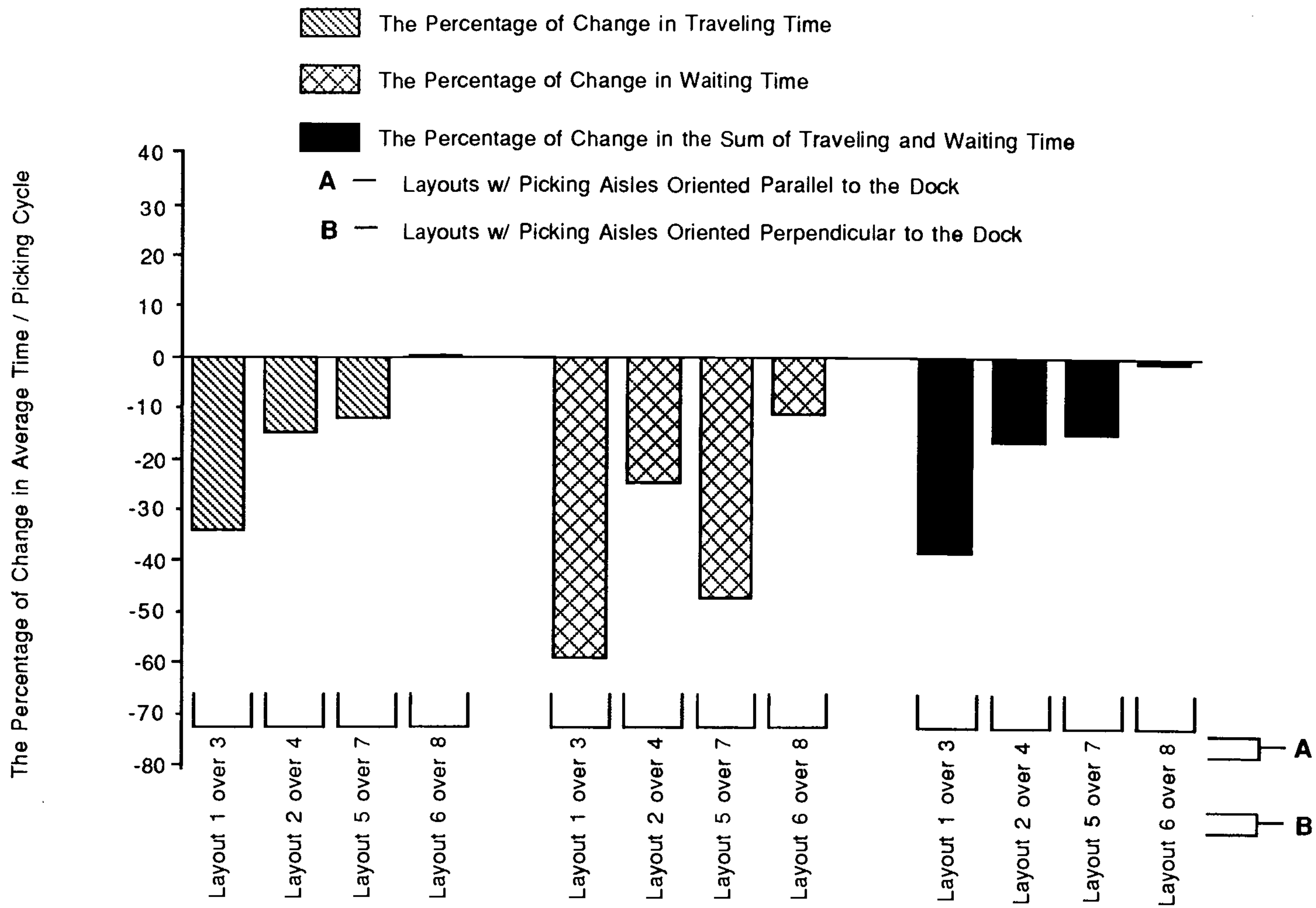


FIGURE IV-5 The Percentage of Change in Traveling and Waiting Time due to the Effect of Aisles Orientation

Effect of Dock Location

The effect of this factor perhaps is better illustrated by Figures IV-6 and IV-7. As can be seen from the figures, the effect of the dock location can be classified into two categories with relation to the aisle orientation. In the first category, the dock is located perpendicular to the picking aisles. In this case, the results show that a considerable improvement is obtained by locating the dock on the longitudinal side of the warehnouse. This category is represented by layouts (1) and (2) and layouts (5) and (6). Layout (1) reveals a significant improvement over layout (2) in traveling time by 5.7%, in waiting time by 50%, and in the sum of traveling and waiting time by 10.4%. Layout (5) shows an improvement over layout (6) in traveling time by 4%, in waiting time by 34.2%, and in the sum of traveling and waiting time by 6.3%.

The second category illustrates the dock located parallel to the picking aisles. In this case, the effect of locating the dock on the longitudinal side of the warehouse is adversely evident. The traveling and waiting time clearly show an increase. In this category, layouts (3) and (4) and layouts (7) and (8) are compared. Layout (3) shows an overall increase over layout (4) in the traveling time by 21.8%, in waiting time by 22%, and in the sum of the traveling and waiting time (21.8%). Layout (7) reveals an increase over layout (8) in traveling time by 8.9%, in waiting time by 10.9% and in the sum of the traveling and waiting time by 9.1%.

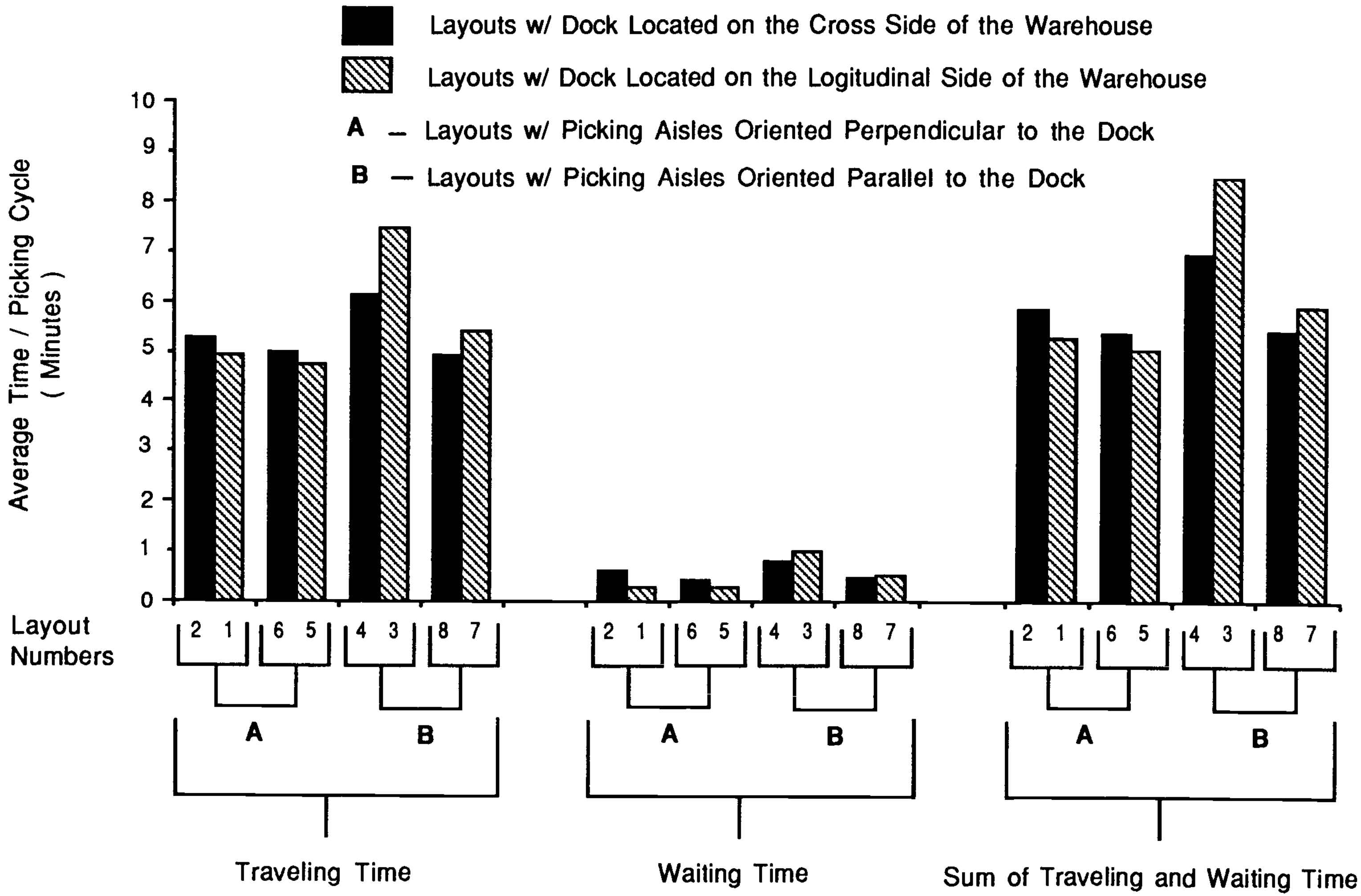


FIGURE IV-6 Effect of Dock Location on Traveling and Waiting Time

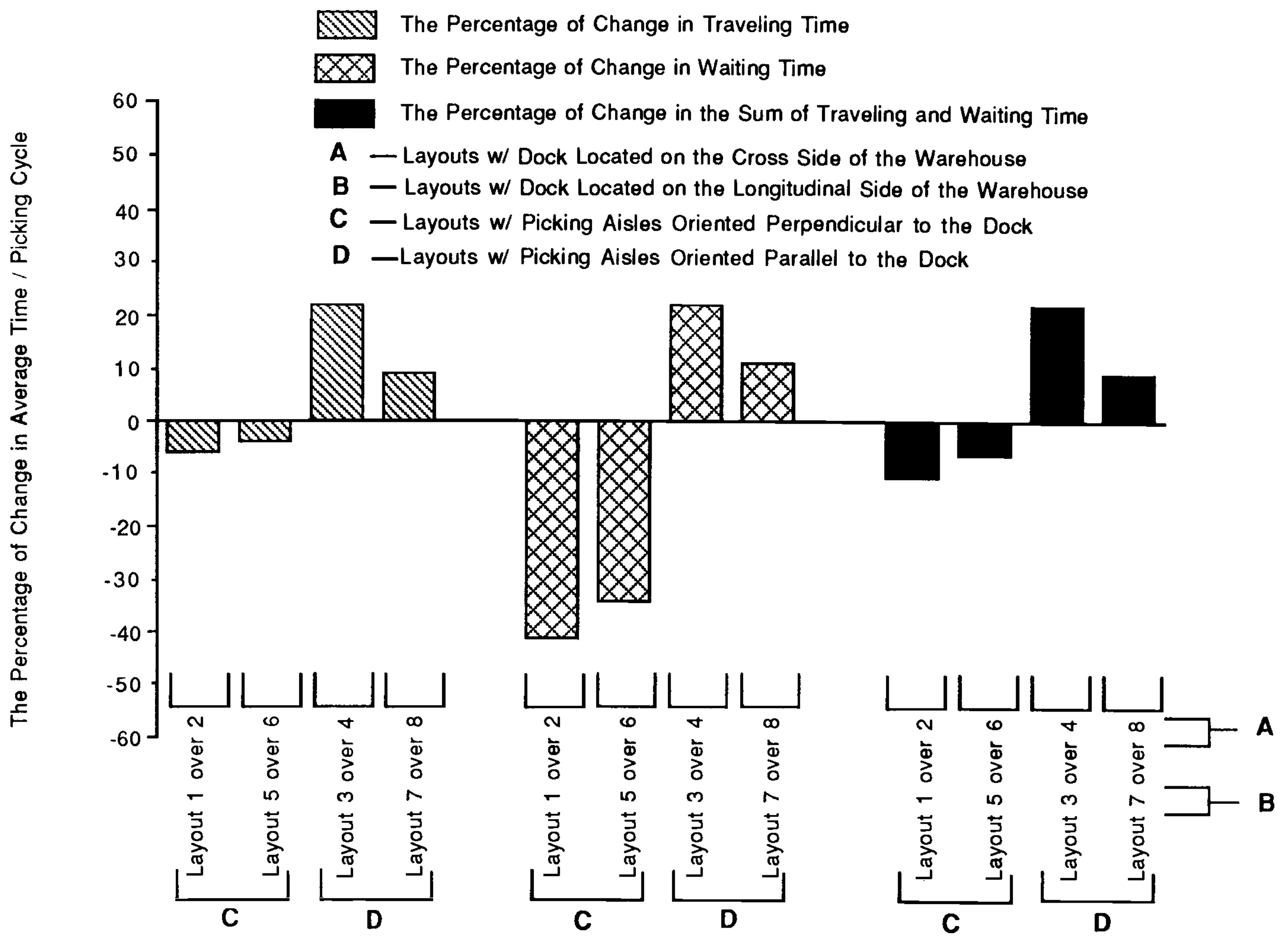


FIGURE IV-7 **The Percentage of Change in Traveling and Waiting Time due to the Effect of the Dock Location**

Number of Order Picking Cycles Processed

Although the order-picking cycle time is not considered as a measure to the system's performance due to the definition and justification reasons discussed earlier under the system performance measures in Section II, statistical data has been collected on the number of order-picking cycles processed by each of the two picking vehicles. The data is included in the summary report of each layout provided in Appendices D-1 to D-8. The results are summarized and presented in Figures IV-8. As can be seen from the histogram, the results of the total number of order-picking cycles processed reveal and confirm exactly the same indications obtained from the traveling and waiting time measures for the three factors under study as discussed earlier in this section.

It can also be noted from the figure and the appendices that all layouts show a total number of picking cycles processed by the two vehicles to be above 200 cycles. Each vehicle processed over 100 picking cycles, which is considered to be a good sample size from which the observations of the statistical data about the system's performance has been collected.

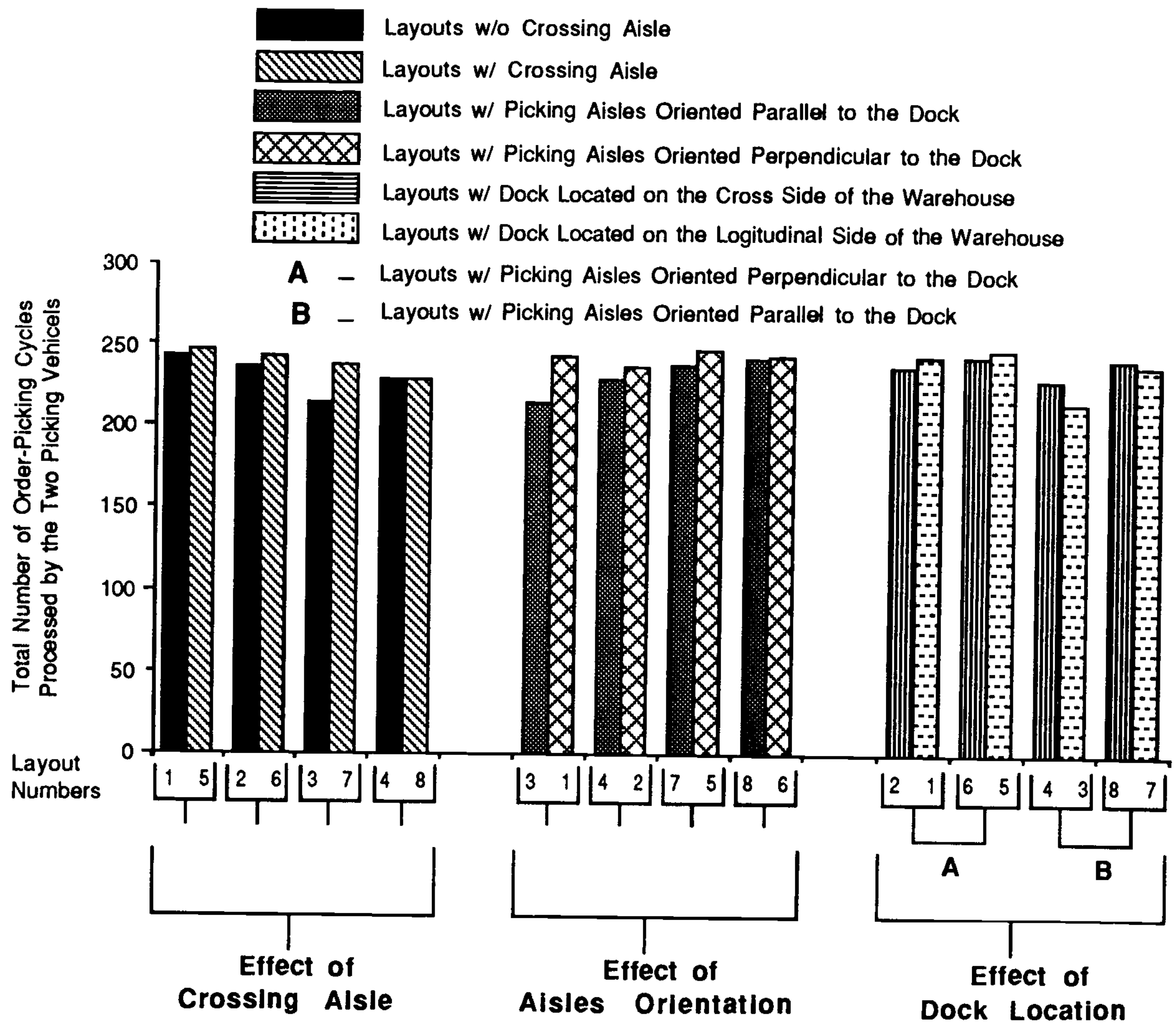


FIGURE IV-8 Total Number of Order-Picking Cycles Processed

V. SUMMARY OF RESULTS AND CONCLUSIONS

Summary of Results

As a reminder, the main objective of this research is to study the effect of different warehouse layouts on the order picking process. Three factors are taken into consideration for this study: the effect of the crossing aisle, the effect of picking aisles orientation, and the effect of dock location. Four different pairs of layouts are considered to study the effect of each factor. By evaluating the effect of each factor considered (as shown in Figure V-1) through the comparison of the relative pairs of the layouts, the following results can be summarized:

The presence of the crossing aisle in the layouts shows improvement in the system performance: a decrease in the traveling time from 3.6% to 27.9%, a decrease in the waiting time from 12.9% to 49%, and a decrease in the sum of both traveling and waiting time from 4.2% to 30.4%.

When the picking aisles are oriented perpendicular to the dock, it improves the layouts by decreasing the traveling time in three layout pairs from 11.7% to 34% and increasing the traveling time in the fourth layout pair by 0.2%; the perpendicular aisles arrangement shows a decrease in the waiting time from 10.9% to 69%, and a decrease in the sum of the traveling and waiting time from 0.7% to 38.1%.

The effect of dock location is related to the picking aisles orientation. If the picking aisles are perpendicular to the dock,

Legend Of Notation

TVT(M)	Waiting Time (minutes) of Vehicle(M)/Picking Cycle.	$\bar{X}$	Mean Time of Vehicle(M)/Picking Cycle.
TWT(M)	Sum of Traveling and Waiting Time of Vehicle(M)/Picking Cycle.	$\bar{\bar{X}}$	Mean of all Vehicles Mean Time/Picking Cycle.
SVW(M)	Traveling Time (minutes) of Vehicle(M)/Picking Cycle.	ST. D.	Standard Deviation of Vehicle(M) Time.
		N	Sample Size of Order Picking Cycles Processed by Vehicle(M).

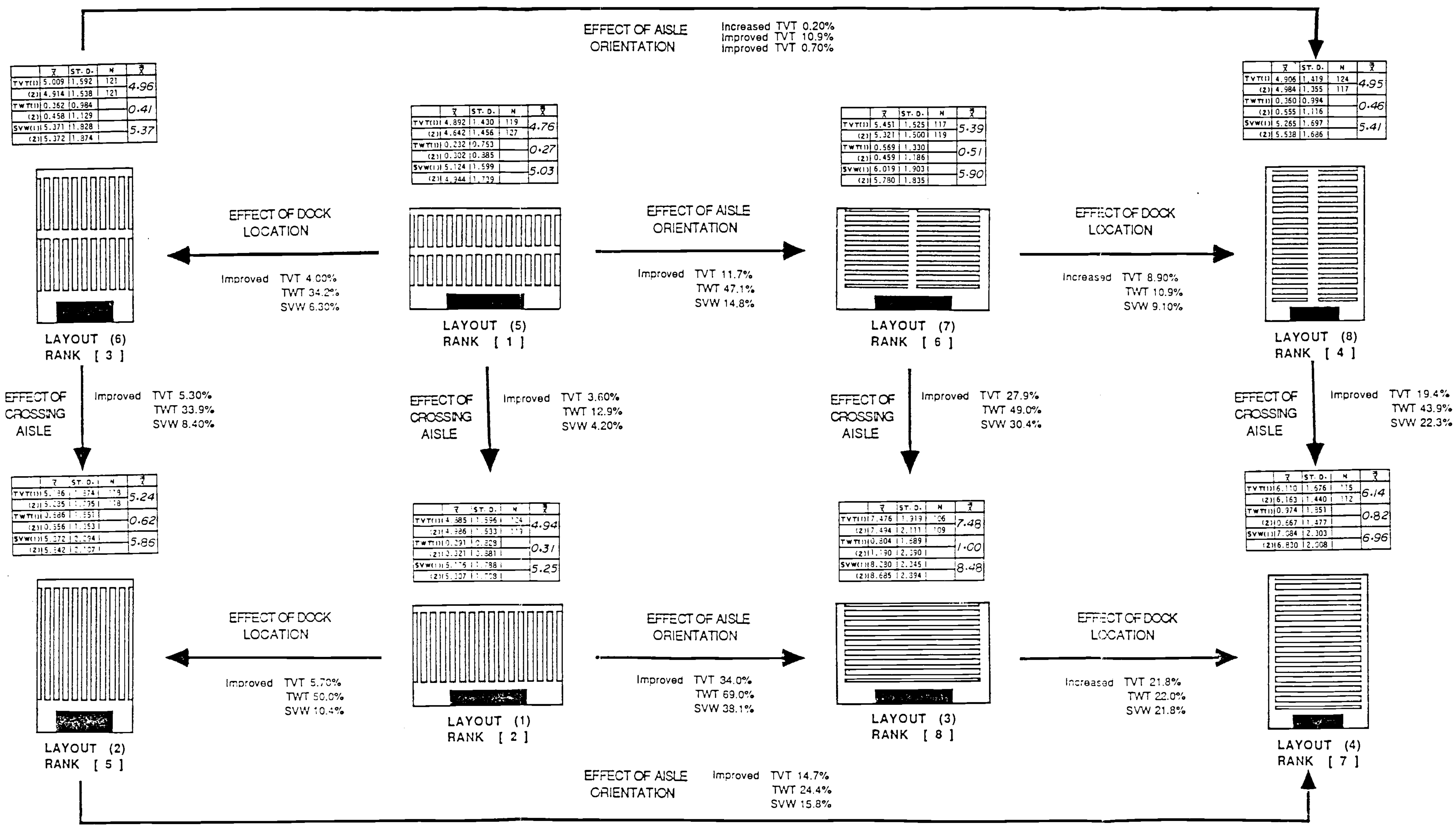


FIGURE V-1 Summary of Results & Conclusions

then locating the dock on the longitudinal side of the warehouse improves the layouts by decreasing traveling time from 4% to 5.7%, and the waiting time from 34.2% to 50%, as well as decreasing the sum of the traveling and waiting time from 6.3% to 10.4%. But if the picking aisles are parallel to the dock, then locating the dock on the longitudinal side of the warehouse will increase the traveling time from 8.9% to 21.8%, increase the waiting time from 10.9% to 22%, and increase the sum of the traveling and waiting time from 9.1% to 21.8%.

General Conclusions

The general trend of the results obtained from this simulation study concludes that the productivity of the warehouse can be substantially improved through decreasing the traveling and waiting time of the order-picking process. This can be achieved when the picking aisles are oriented perpendicular to the dock, when a crossing aisle is placed or located parallel to the dock and when the dock is located on the longitudinal side of the warehouse., The general outlook of the different layout performances indicates that an improvement in the throughput can be achieved by decreasing the traveling time up to 36%, the waiting time up to 73%, and the sum of the traveling and waiting time up to 41%.

Recommendations For Further Research

The possibility of extending this study is positive. An extended study could cover a wide variety of factors effecting the order-picking operation in the warehouse. Some general features of the system mentioned in the assumptions under which the order-picking process operates must be taken into consideration. With these features in mind, the system can be operated to study the interaction effect between several variables such as the number of picking vehicles, the number of items stored in the warehouse, the number of items picked per order, the turnover frequency of the items, the items' location approach, the number of docks, the size and shape of the warehouse, space utilization, the number of picking aisles, and the number of items located per aisle.

One of the interesting areas which is recommended for future research is the study of the effect on the order-picking process by using different approaches to item location. 1 The first approach equally distributes the first 20 items with higher turnover frequency ~~throughout~~ the aisles of the warehouse when the item's closeness to the dock is regarded only within each aisle. 2 The second approach concentrates on the location of the first 20 items with higher turnover frequency within the first 4 or 5 closest aisles to the dock. 3 The third approach locates the items with higher turnover frequency closer to the dock. By applying these three approaches with the increase of the number of vehicles picking each time and the use of the first three best layouts obtained from this study, an interesting relationship might be shown in regard to the reaction of each approach with the increase in the number of picking vehicles. This interaction will be represented by the variation in the traveling and waiting time. The traveling time is expected to increase by using the first approach and to decrease by using the second and third approaches. The waiting time is expected to decrease by using the first approach, to increase moderately by using the third approach, and to increase sharpely by using the second approach.) By increasing the number of picking vehicles, this variation will be seen more clearly. This may lead to an improvement in the system by decreasing the sum of traveling and waiting time.

Another interesting research area can be studied by restricting each picking vehicle to pick just the items located in a particular zone of the warehouse. This can be accomplished by dividing the picking aisles into a number of zones equal to the number of picking vehicles and by scheduling each vehicle to pick just the items located within its zone. That means each picking order which consists of multi-items must be divided into sub-picking orders. Each sub-picking order contains items located in a particular zone. Then each sub-picking order will be assigned to a vehicle to pick. After all the sub-orders of a picking order are picked, it will be consolidated on the dock into one picking order. By comparing this picking approach with the complete order picking approach which is used in this study and by keeping the number of picking vehicles constant, an interesting study can be made, especially if it includes the interaction effect of another factor using the different item location approaches mentioned earlier in this section. The effect of the different combination of the two factors will be reflected in the traveling time only. Obviously, it is expected that there will be no waiting time for each vehicle to pick from its zone. Meanwhile, there will be a considerable variation in the traveling time, especially when the required extra work time to perform the tasks of dividing the picking orders and issuing new sub-orders, and the consolidation-process time of the sub-orders at the dock are included. This study may lead to an improvement in the system by developing a better approach to order-picking and item location.

Comments on the Effect of Some Variables which Change the System Performance

1) Number of Picking Vehicles:

The effect of the increase in the number of picking vehicles is expected primarily to cause a traffic congestion problem in the system which would be reflected mainly on the vehicle's waiting time. This effect will be more intensified, especially when the activity approach is used for item location and a complete order-picking method is applied. The expected increase in number of picking orders processed will reflect the increase in number of order-pickers and is not a result of savings in the vehicles' travel time. On the other hand, by using the random approach for item location, it would help reduce the congestion problem, but it may be expected to increase the travel time. The question would be two-fold: how much saving in waiting time and loss in traveling time will result, and what level of picking-vehicle fleet size would be justifiable to switch from activity to random approach for item location or visa versa. This can be accomplished by utilizing the simulation model used for this study with some changes to adopt the new assumptions.

2) Number of Items Per Order:

It is true that as the number of items per order increases, it is likely that all the picking aisles in the warehouse will be visited. But there is still some room for savings in the travel time, especially with the presence of the crossing aisles and the selection of the shortest path each time the vehicle moves from one item location to the next. By using the random approach for item location, the traveling time is expected to increase moderately, and the waiting time is expected to substantially reduce. But when the activity approach is used for item location, a moderate savings is expected to result in the traveling time and a considerable increase to result in the waiting time. The increase in waiting time is expected to be seen more clearly by leaving the vehicle in a picking aisle until it finishes picking all of the required items located in the same aisle. Then the question becomes a question of item location approach and order-picking method: what order size or number of items per order would be justifiable to trade off the activity approach with the random approach for item location? The next question would regard order-picking method what method is better - to use the complete order picking approach or zone/batch order picking approach at different levels of order size? These questions can also be studied by using the same simulation model with some modification.

3) ABC Curve Ratio:

Changing the ratio of the ABC curve, which is used to determine the item's activity rate and location, is expected to have some impact on the system's performance. For example, the ratio used in this study was 20/80, which means that 20 percent of the items stored in the warehouse represent 80 percent of the activity and are located closer to the dock. By using a lower ratio such as 20/40, the result expected is an increase in traveling time and reduction in waiting time. This result is due to the reduction in order frequency of the same number of items, which is located closer to the dock, which means the vehicle would have to travel to further aisles to pick the other items more frequently. This effect also would lead to a reduction of the vehicle's chances to wait for the less active closer aisles. Suppose a higher ratio is used, such as 10/90. This means fewer items with higher activity rate are located closer to the dock. In this case, the expected result is a considerable reduction in traveling time and a substantial increase in waiting time due to the concentration of a few very high activity items in the closer aisles. This effect can be studied with relation to other factors by using the same simulation model developed for this study.

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APPENDICES

APPENDIX A

Variables, Files, and GASP Function Definitions

Variable	Definition
AISL(I)	Aisle number of location (I).
AISLE,NA	Number of aisles in the warehouse.
AN(M)	Aisle number where vehicle (M) is located.
DX	Distance traveled by vehicle in X-direction.
DY1	Distance traveled by vehicle in Y-direction through aisle after finished picking.
DY2	Distance traveled by vehicle in Y-direction through next aisle to start picking from.
FRQI(I)	Order frequency of item (I).
FX(I)	Cumulative probability to order item (I).
HLV(I)	Level number of location (I).
HMAX	Maximum level in the layout.
HMIN	Minimum level in the layout.
HMED	Middle level in the layout.
HN(M)	Level number where vehicle (M) is located.
I	Location number
ITEM	The item no. which have been ordered to pick.
J	Aisle number
M	Vehicle number
MRL	Middle level of the racks in the layout.
NI,Q(M)	Number of items to be picked by vehicle (M) per order.
OI	The item no. to be ordered.
PCT(M)	Order picking cycle time of vehicle (M).

A-1 Variable Definitions

Variable	Definition
PT(M)	Picking time of vehicle (M) for an item.
RT	The arriving time of the vehicle to the waiting queue.
SVWT(M)	Sum of traveling and waiting time of vehicle (M) per order picking cycle.
SWT(M)	Time vehicle (M) started waiting.
TPT(M)	Total picking time of vehicle (M) per order picking cycle.
TT	Total time.
TUN(M)	Total no. of units picked by vehicle (M).
TVT(M)	Total traveling time of vehicle (M) per order picking cycle.
TWT(M)	Total waiting time of vehicle (M) per order picking cycle.
UNT(I)	Number of units to be picked from item (I).
UT(M)	Unloading time of vehicle (M) per order picking cycle.
VBUZ(M)	= 0 = vehicle (M) idle at the dock. = 1 = vehicle (M) finished picking an item = 2 = vehicle (M) is waiting for aisle
VECS,NV	Number of vehicles used for picking in the warehouse.
VT(M)	Traveling time of vehicle (M).
WT(M)	Waiting time of vehicle (M).
X(I)	X-coordinate of location (I).
XIN(I)	Number of item correspondent to FX(I).
XN(M)	X-coordinate of vehicle (M).
Y(I)	Y-coordinate of location (I).

A-1 (Cotinued)

Variable	Definition
YMAX	Maximum point in Y-direction the vehicle can move to cross aisle.
YMIN	Minimum point in Y-direction the vehicle can move to cross aisle.
YMED	Middle point in Y-direction the vehicle can move to cross aisle.
YN(M)	Y-coordinate of vehicle (M).

A-1 (Cotinued)

File No.	Attributes	Code	Definition
1			Event file.
	ATRIB(1)		Event Time (priority: Least Value First (LVF))
	ATRIB(2)	1	Vehicle assignment
		2	Aisle assignment
	ATRIB(3)		Not used.
	ATRIB(4)		Not used.
	ATRIB(5)		Vehicle number if ATRIB(2) = 1. Not used if ATRIB(2) = 2.
	ATRIB(6)		Aisle number if ATRIB(2) = 2. Not used if ATRIB(2) = 1.
M+1			Each file for a vehicle. M = vehicle no.
	ATRIB(1)		Time of order scheduled.
	ATRIB(2)	1	Vehicle assignment.
	ATRIB(3)		Item number. (Priority: Least Value First (LVF))
	ATRIB(4)		Number of units of ordered items
	ATRIB(5)		Vehicle number the order scheduled to
	ATRIB(6)		Aisle number where ordered item is located.

A-2 Files and Attributes of Entries

File No.	Attributes	Code	Definition
J+NV+1			Each file for an aisle. J = Aisle number NV = Number of vehicles used for picking in the warehouse.
	ATRIB(1)		Not used.
	ATRIB(2)		Not used.
	ATRIB(3)		Item number the vehicle picking.
	ATRIB(4)		Number of units to be picked.
	ATRIB(5)		Vehicle number which is picking from the aisle. (Priority: First in First Out (FIFO))
	ATRIB(6)		Aisle number from which the vehicle is picking.
J+NA+NV+1			Each file for waiting queue of an aisle. J = Aisle number NA = Number of aisles in the warehouse. NV = Number of vehicles in warehouse
	ATRIB(1)		Time vehicle started waiting
	ATRIB(2)		Not used.
	ATRIB(3)		Item number to be picked.
	ATRIB(4)		Number of units to be picked.

A-2 (Continued)

File No.	Attributes	Code	Definition
	ATRIB(5)		Vehicle number which is waiting for the aisle. (Priority: First in First out (FIFO))
	ATRIB(6)		Aisle number for which the vehicle is waiting.

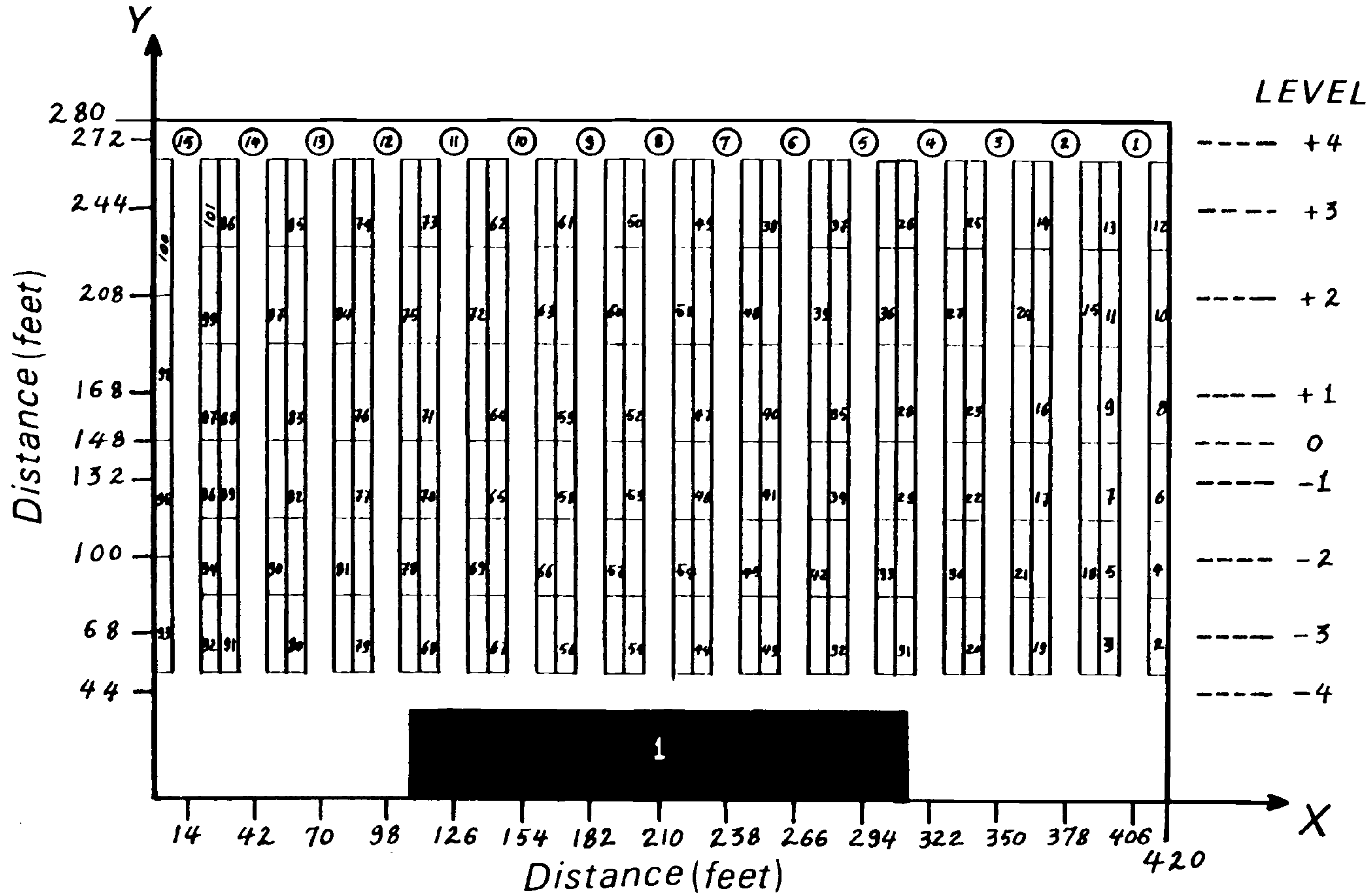
A-2 (Continued)

Subroutines or Function	Description
Subroutine GASP	Executive routine for advancing time and status.
Subroutine DATIN	Initializes GASP variables and calls user written functions INTLC and STATE.
Subroutine FILEM(IFILE)	Files on entry into IFILE.
Subroutine RMOVE(NTRY, IFILE)	Removes entry NTRY from file IFILE.
Subroutine COLCT(XX,ICLCT)	Records value XX as an observation on variable number ICLCT.
Subroutine HISTO(XX,T, ISTAT)	Determines the cell number associated with the value XX for variable IHIST and increases the cell content by one.
Subroutine GPLOT (XX,T, IPLOT)	IPLOT is the plot number and GPLOT stores values of the dependent variables XX for a value of the independent variable T.
Function NPSSN(IPAR, ISTRM)	Poisson deviate generator using stream ISTRM and parameters from parameter set IPAR.
Function DPROB(CPROB, VALUE,NVAL)	A deviate generator for obtaining samples from a probability mass function using stream ISTRM; CPROB is a vector of the cumulative probability values for the probability mass function; VALUE contains the possible deviates that can be obtained from DPROB; NVAL is the number of values in the vectors CPROB and VALUE.

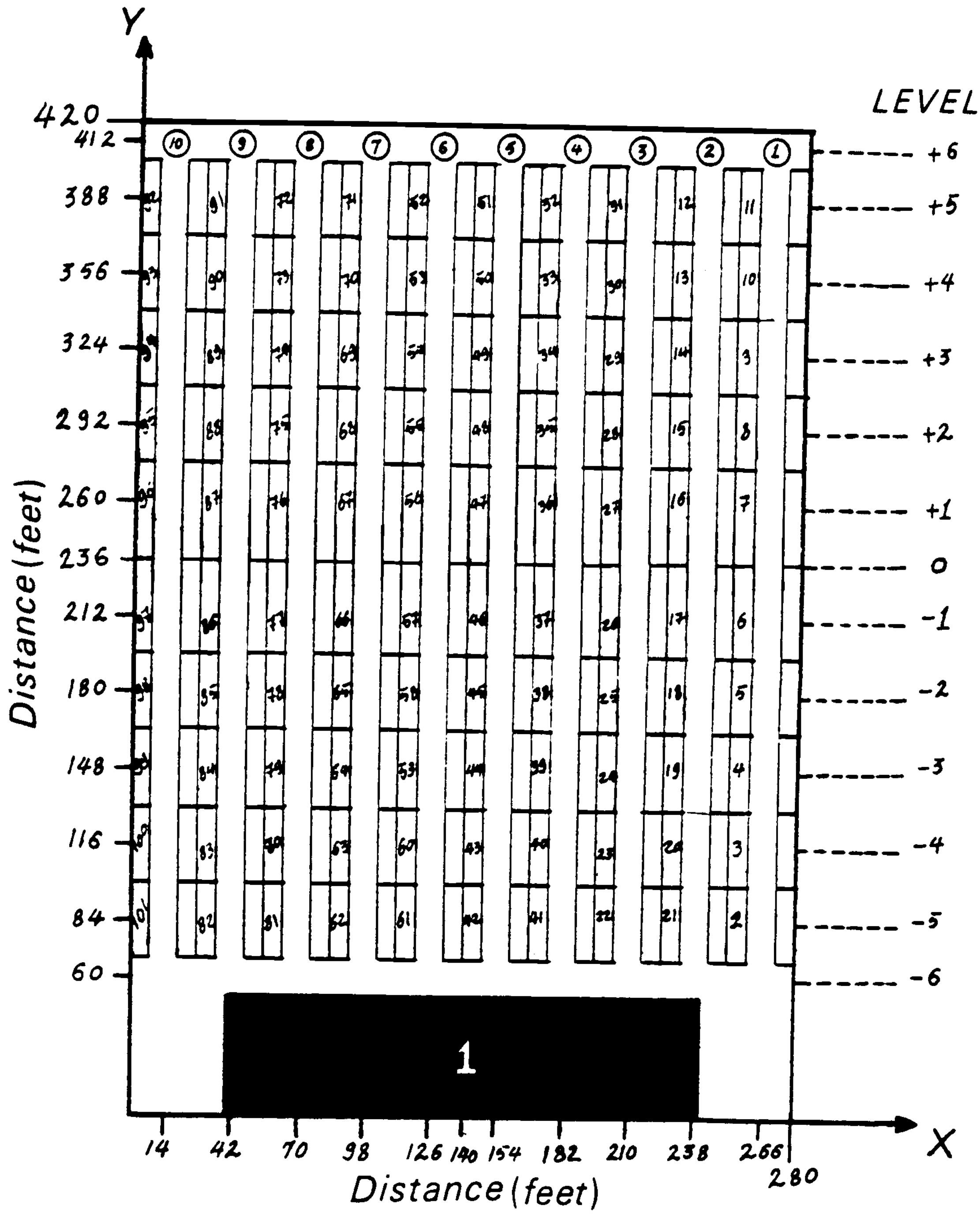
A-3 Description of GASP Subroutines and Functions Used

APPENDIX B

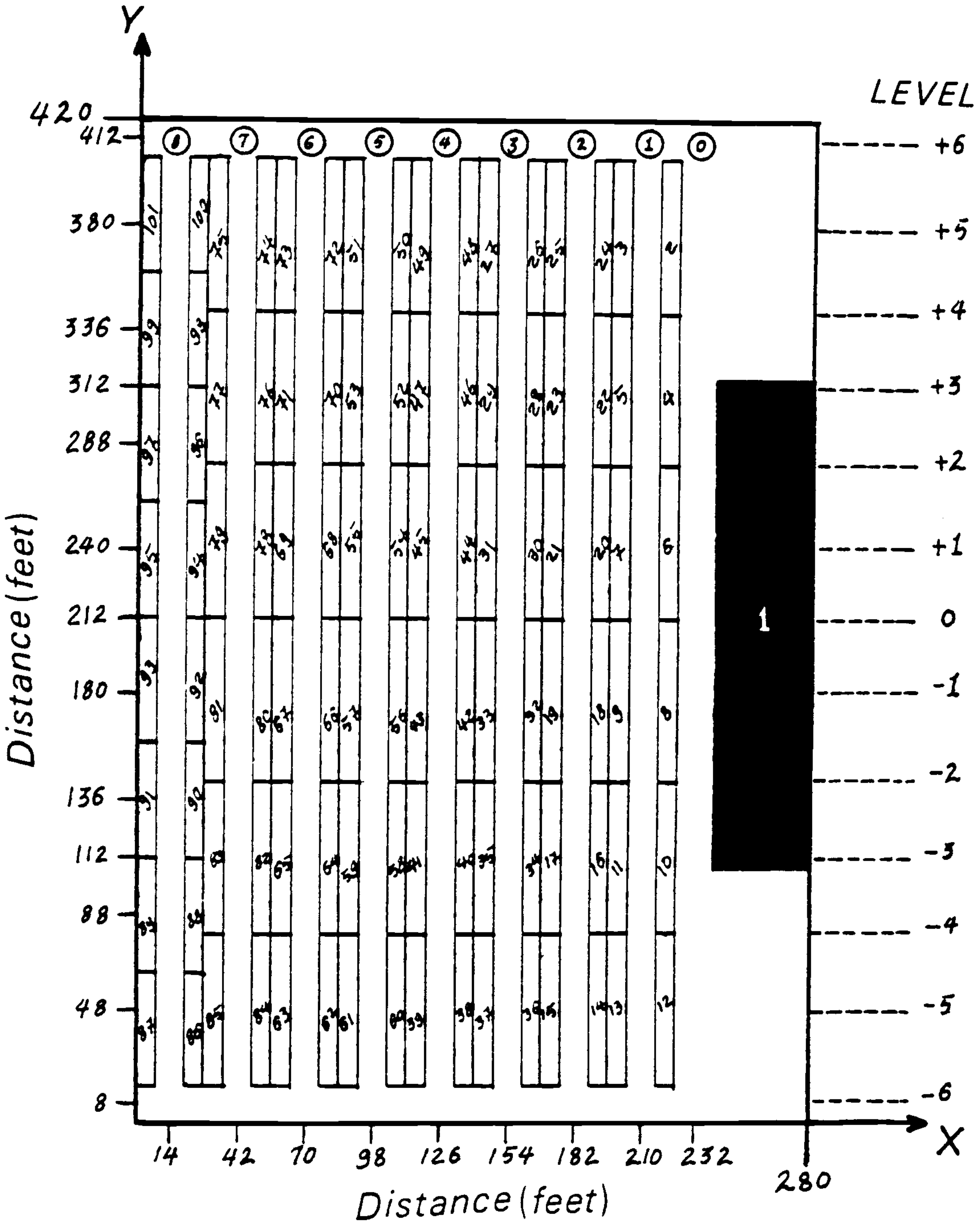
Warehouse Layouts, Flow Charts and Program Listings



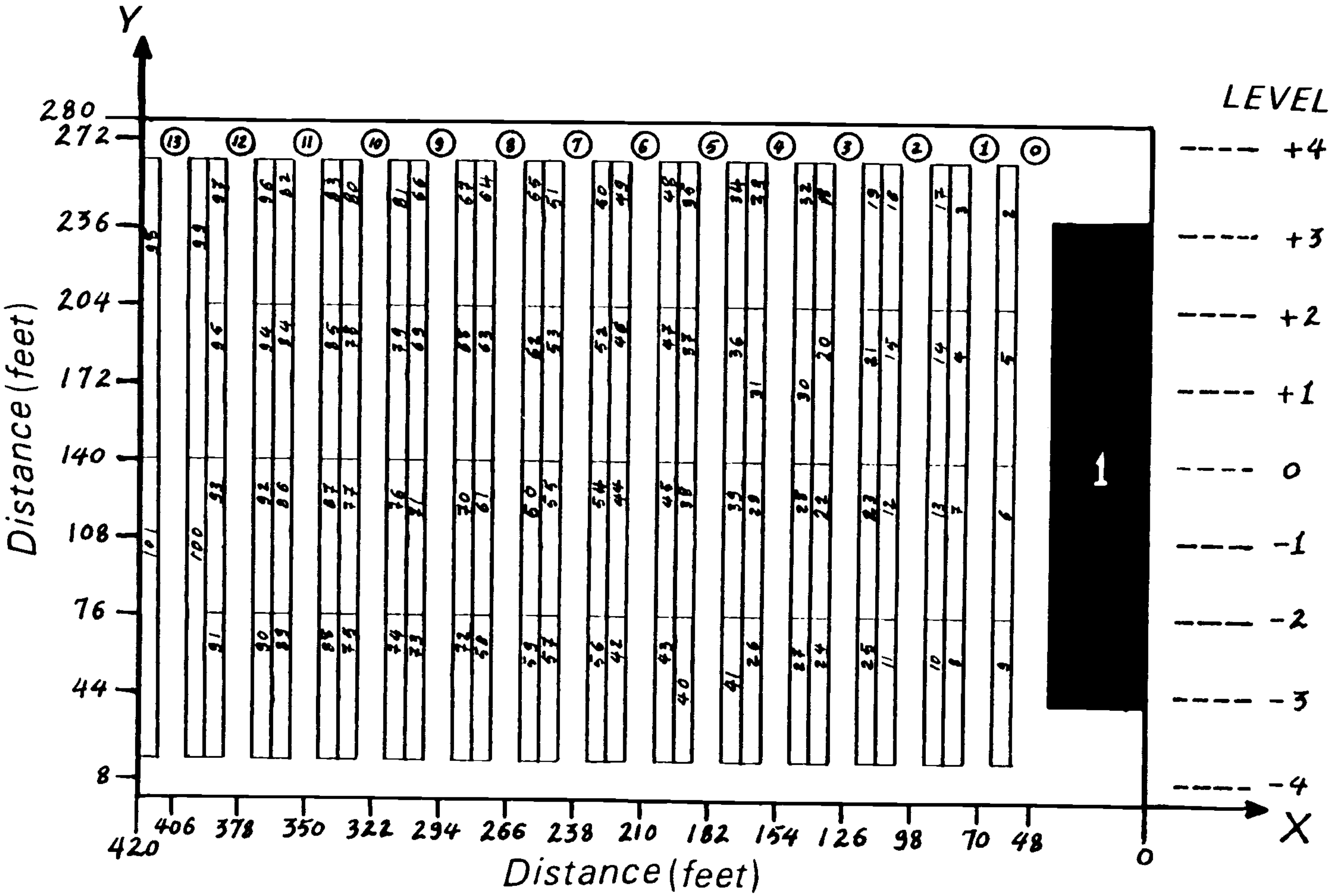
B-1 Layout(1) shows Item Location, Aisle, and Level Numbers, and Distances in X and Y Coordinates



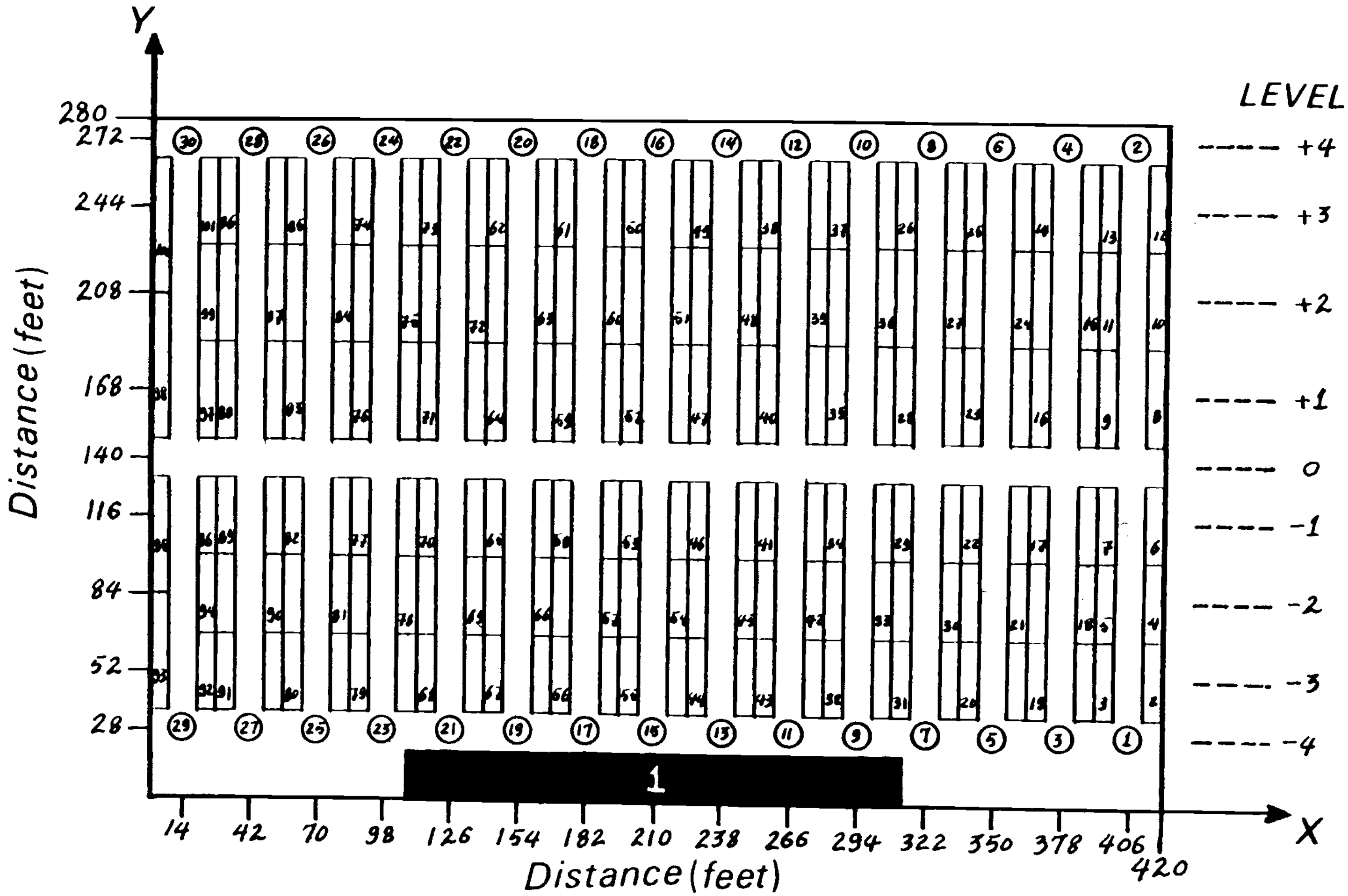
B-2 **Layout(2) shows Item Location, Aisle, and Level Numbers, and Distances in X and Y Coordinates**



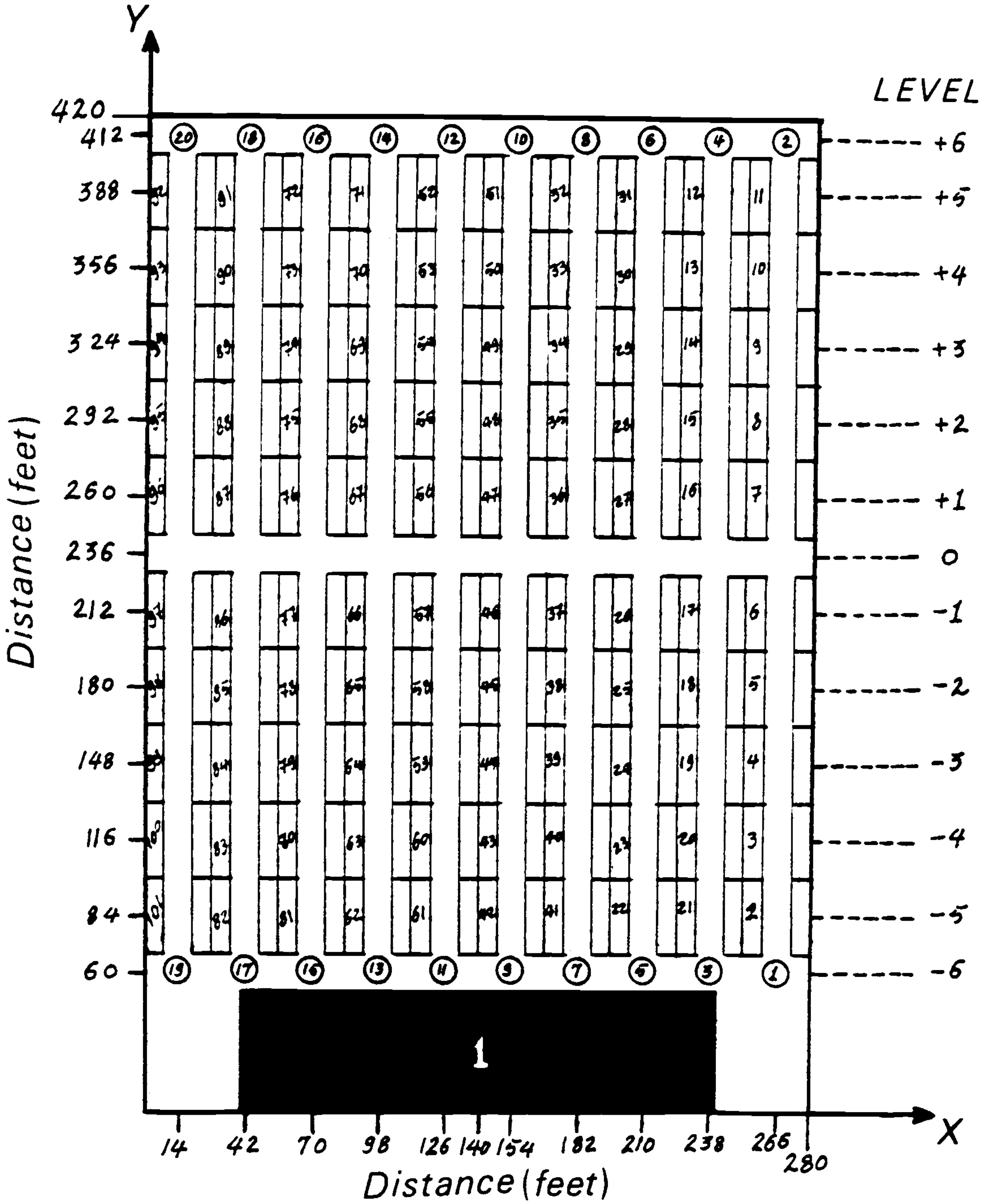
B-3 Layout(3) shows Item Location, Aisle, and Level Numbers, and Distances in X and Y Coordinates



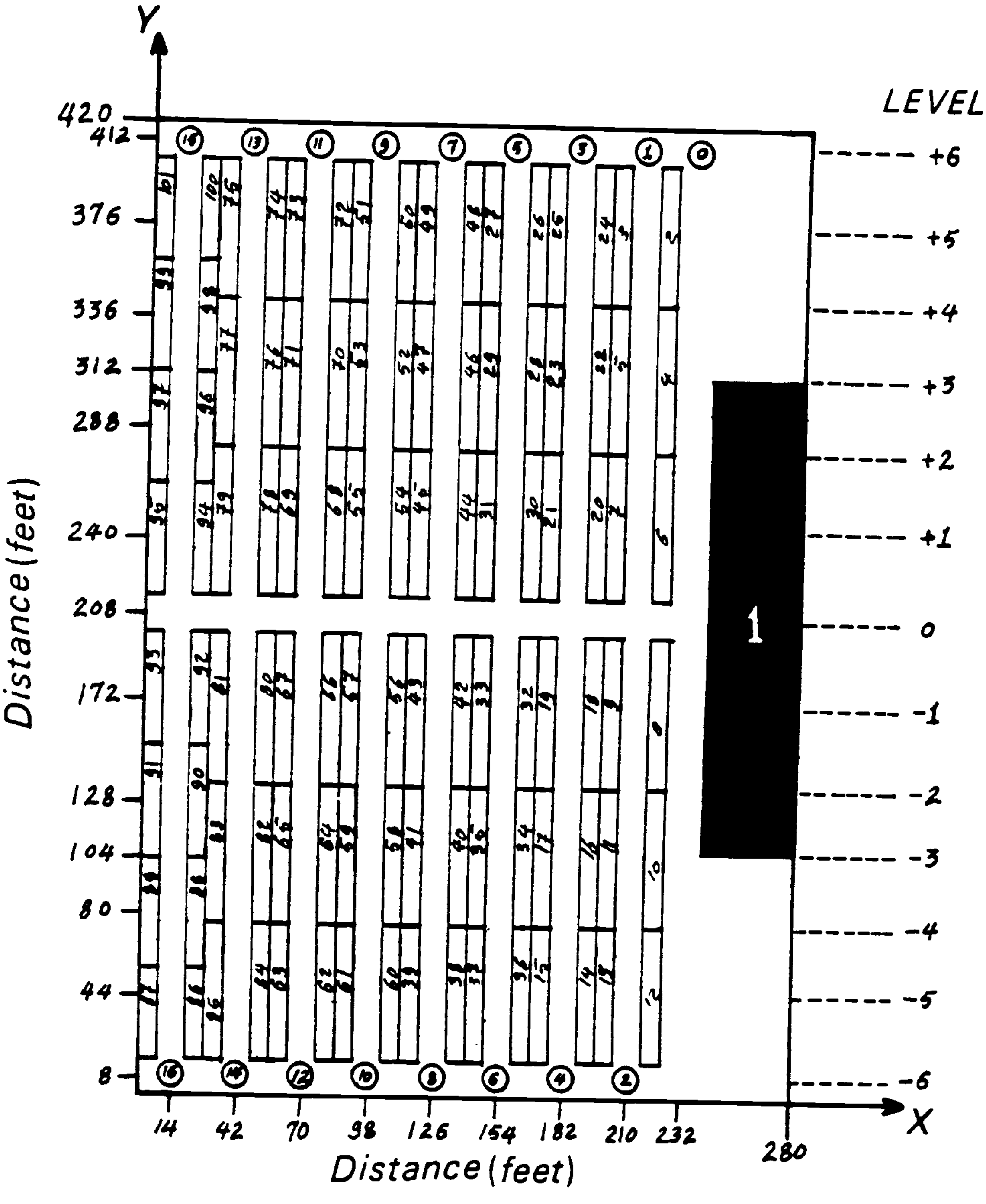
B-4 Layout(4) shows Item Location, Aisle, and Level Numbers, and Distances in X and Y Coordinates



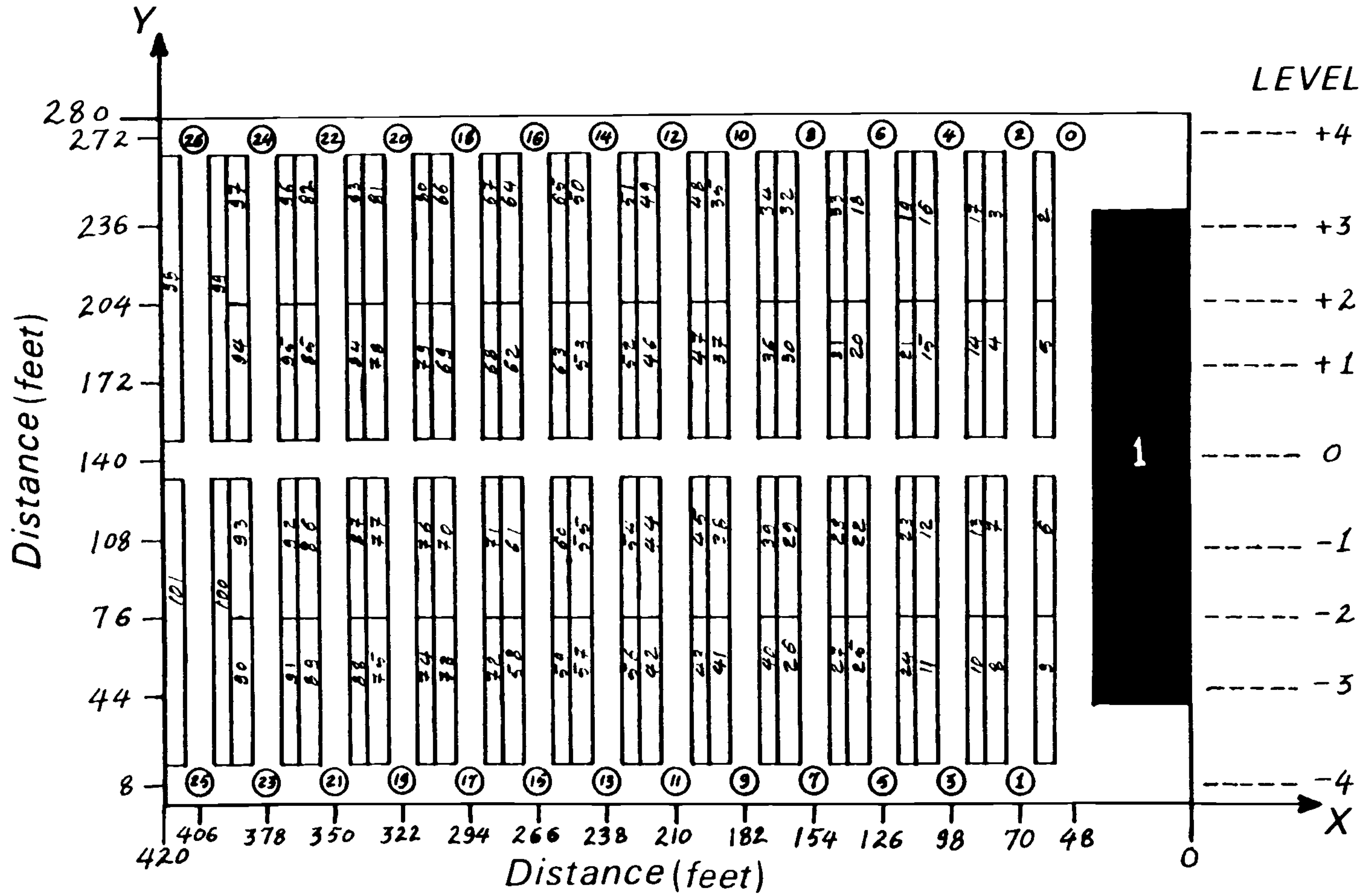
B-5 Layout(5) shows Item Location, Aisle, and Level Numbers, and Distances in X and Y Coordinates



B-6 Layout(6) shows Item Location, Aisle, and Level Numbers, and Distances in X and Y Coordinates



B-7 Layout(7) shows Item Location, Aisle, and Level Numbers, and Distances in X and Y Coordinates



B-8 Layout(8) shows Item Location, Aisle, and Level Numbers, and Distances in X and Y Coordinates

```
      PROGRAM MAIN                                  FTN 4.8+552

      PROGRAM MAIN (INPUT,OUTPUT,TAPE1,TAPE2,TAPE7,TAPE5=INPUT,
     1 TAPE6=OUTPUT)
      DIMENSION NSET(1000)
      COMMON QSET(1000)
      COMMON/GCOM1/ATRIB(25),JEVNT,MFA,MFE(100),MLE(100),MSTOP,NCRDR,
     1NNAPO,NNAPT,NNATR,NNFIL,NNQ(100),NNTRY,NPRNT,PPARM(50,4),TNOW,
     2TTBEG,TTCLR,TTFIN,TTRIB(25),TTSET
       COMMON/UCOM1/Q(10),AN(10),HN(10),XN(10),YN(10),VBUZ(10),
     1 AISL(101),HLV(101),X(101),Y(101),SWT(10),WT(10),TWT(10),
     2 TUN(10),DY1,DX,DY2,VT(10),PT(10),UT(10),TT,XIN(101),NI,
     3 PCT(10),M,J,I,FX(101),K,YMAX,YMIN,YMED,AISLS,SWT(10),
     4 VECS,HMAX,HMIN,HMED,HRL,TVT(10),TPT(10),NV,NA,
     5 ITEM(20),OI(20),FRQI(101),UNT(101),RT,PLOT(5)
C
      EQUIVALENCE(NSET(1),QSET(1))
C
C*****SET VALUES FOR CARD READER AND PFINTER
      NCRDR=5
      NPRNT=6
C
       READ (NCRDR,101) (AISL(I),I=1,101)
       READ (NCRDR,101) (HLV(I),I=1,101)
       READ (NCRDR,101) (X(I),I=1,101)
       READ (NCRDR,101) (Y(I),I=1,101)
       READ (NCRDR,101) (FX(I),I=1,101)
       READ (NCRDR,101) (XIN(I),I=1,101)
       READ (NCRDR,102)YMAX,YMIN,YMED,AISLS,VECS,HMAX,HMIN,HMED,HRL
       WRITE (NPRNT,103) (AISL(I),I=1,101)
       WRITE (NPRNT,103) (HLV(I),I=1,101)
       WRITE (NPRNT,103) (X(I),I=1,101)
       WRITE (NPRNT,103) (Y(I),I=1,101)
       WRITE (NPRNT,103) (FX(I),I=1,101)
       WRITE (NPRNT,103) (XIN(I),I=1,101)
       WRITE(NPRNT,104)YMAX,YMIN,YMED,AISLS,VECS,HMAX,HMIN,HMED,HRL
C
C*****START THE SIMULATION
      CALL GASP
C
  101  FORMAT (10F6.4)
C
  102  FORMAT (9F6.4)
C
  103  FORMAT (1X,10F8.4)
C
  104  FORMAT (1X,9F9.4)
C
      STOP
      END
```

B-9 Listing of Program "MAIN" used for all Layouts

```
SUBROUTINE INTLC                                    FTN 4.8+552

      SUBROUTINE INTLC
      COMMON/GCOM1/ATRIB(25),JEVNT,MFA,MFE(100),MLE(100),MSTOP,NCRDR,
     1NNAPO,NNAPT,NNATR,NNFIL,NNQ(100),NNTRY,NPRNT,PPARM(50,4),TNOW,
     2TTBEG,TTCLR,TTFIN,TTRIB(25),TTSET
       COMMON/UCOM1/Q(10),AN(10),HN(10),XN(10),YN(10),VBUZ(10),
     1 AISL(101),HLV(101),X(101),Y(101),SWT(10),WT(10),TWT(10),
     2 TUN(10),DY1,DX,DY2,VT(10),PT(10),UT(10),TT,XIN(101),NI,
     3 PCT(10),M,J,I,FX(101),K,YMAX,YMIN,YMED,AISLS,SVWT(10),
     4 VECS,HMAX,HMIN,HMED,MRL,TVT(10),TPT(10),NV,NA,
     5 ITEM(20),OI(20),FRQI(101),UNT(101),RT,PLOT(5)
C
C
       DO 10  M=1,10
       AN(M)=8.
       HN(M)=-4.
       XN(M)=210.
       YN(M)=44.
       VBUZ(M)=0.
       Q(M)=0.
       TUN(M)=0.
       SWT(M)=0.
       WT(M)=0.
       TWT(M)=0.
       VT(M)=0.
       PT(M)=0.
       UT(M)=0.
       TVT(M)=0.
       TPT(M)=0.
       SVWT(M)=0.
       PCT(M)=0.
 10    CONTINUE
       DO 20  K=1,20
       ITEM(K)=0.
       OI(K)=0.
 20    CONTINUE
       DO 30  I=1,101
       FRQI(I)=0.
       UNT(I)=0.
 30    CONTINUE
       DY1=0.
       DX=0.
       DY2=0.
       TT=0.
       NI=0
       NV=0.
       NA=0.
       RT=0.
       PLOT(1)=0.
       PLOT(2)=0.
       PLOT(3)=0.
       PLOT(4)=0.
      RETURN
      END
```

Change for each Layout

B-10 **Listing of Subroutine "INTLC" used for all Layouts with the necessary chages**

```
      SUBROUTINE  EVNTS(IX)
      COMMON/GCOM1/ATRIB(25),JEVNT,MFA,MFE(100),MLE(100),MSTOP,NCRDR,
     1NNAPO,NNAPT,NNATR,NNFIL,NNQ(100),NNTRY,NPRNT,PPARM(50,4),TNOW,
     2TTBEG,TTCLR,TTFIN,TTRIB(25),TTSET
       COMMON/UCOM1/Q(10),AN(10),HN(10),XN(10),YN(10),VBUZ(10),
     1 AISL(101),HLV(101),X(101),Y(101),SWT(10),WT(10),TWT(10),
     2 TUN(10),DY1,DX,DY2,VT(10),PT(10),UT(10),TT,XIN(101),NI,
     3 PCT(10),M,J,I,FK(101),K,YMAX,YMIN,YMED,AISLS,SVWT(10),
     4 VECS,HMAX,HMIN,HMED,HRL,TVT(10),TPT(10),NV,NA,
     5 ITEM(20),OI(20),FRQI(101),UNT(101),RT,PLOT(5)
C
C
      GO TO (101,102),IX
C
 101  M=ATRIB(5)
      NV=VECS
      NA=AISLS
      IF (VBUZ(M).GT.0.0) GO TO 45
      DO 5 L=1,20
      ITEM(L)=0.
      OI(L)=0.
   5  CONTINUE
      NI=NPSSN(1,1)
      DO 20 K=1,NI
      ATRIB(1)=TNOW
      ATRIB(2)=1.
  10  OI(K)=DPROB(FK,XIN,101,3)
      DO 15 N=1,20
      IF (ITEM(N).EQ.OI(K)) GO TO 10
  15  CONTINUE
      ITEM(K)=OI(K)
      ATRIB(3)=ITEM(K)
      I=ATRIB(3)
      FRQI(I)=I
      CALL HISTO (FRQI(I),1)
      ATRIB(4)=NPSSN(2,2)
      UNT(I)=ATRIB(4)
      CALL HISTO (UNT(I),2)
      ATRIB(5)=M
      ATRIB(6)=AISL(I)
      CALL FILEM(M+1)
  20  CONTINUE
C
      Q(M)=NI
      CALL COLCT(Q(M),M)
      CALL HISTO (Q(M),3)
      GO TO 50
C
  45  K=AN(M)
      CALL RMOVE(MFE(K+NV+1),(K+NV+1))
  50  IF (Q(M).EQ.0.0) GO TO 70
      CALL RMOVE(MFE(M+1),(M+1))
      I=ATRIB(3)
      J=AISL(I)
      IF (NNQ(J+NV+1).GT.0.0) GO TO 60
      IF (AN(M).EQ.AISL(I)) GO TO 55
      IF (NNQ(J+NA+NV+1).GT.0.0) GO TO 50
  55  TUN(M)=TUN(M)+ATRIB(4)
C
      CALL PICK
      CALL FILEM (J+NV+1)
      VBUZ(M)=1.
      Q(M)=Q(M)-1.
      TVT(M)=TVT(M)+VT(M)
      TPT(M)=TPT(M)+PT(M)
      ATRIB(1)=TNOW+TT
      ATRIB(2)=1.
      ATRIB(5)=M
      CALL FILEM (1)
      GO TO 104
C
  60  CALL PICK
      SWT(M)=TNOW+VT(M)
      ATRIB(1)=SWT(M)
      CALL FILEM (J+NA+NV+1)
      VBUZ(M)=2.
      TVT(M)=TVT(M)+VT(M)
```

B-11 Listing of Subroutine "EVENTS" used for all Layouts

```
      SUBROUTINE EVNTS                       FTN 4.8+552
      GO TO 104
C
   70 I=1.
      CALL COLCT (TUN(M),M+NV)
C
      CALL PICK
      TVT(M)=TVT(M)+VT(M)
      CALL COLCT (TVT(M),M+(2)*(NV))
      PLOT(1)=TVT(M)
      TPT(M)=TPT(M)+UT(M)
      CALL COLCT (TPT(M),M+(3)*(NV))
      PLOT(2)=TPT(M)
      CALL COLCT (TWT(M),M+(4)*(NV))
      PLOT(3)=TWT(M)
      SVWT(M)=TVT(M)+TWT(M)
      CALL COLCT (SVWT(M),M+(5)*(NV))
      PLOT(4)=SVWT(M)
      PCT(M)=TVT(M)+TPT(M)+TWT(M)
      CALL COLCT (PCT(M),M+(6)*(NV))
      PLOT(5)=PCT(M)
      CALL GPLOT (PLOT,TNOW,M)
      VBUZ(M)=0.
      TUN(M)=0.
      TVT(M)=0.
      TPT(M)=0.
      TWT(M)=0.
      SVWT(M)=0.
      PCT(M)=0.
      ATRIB(1)=TNOW+TT
      ATRIB(2)=1.
      ATRIB(5)=M
      CALL FILEM (1)
      GO TO 104
C
C
  102 J=ATRIB(6)
      NV=VECS
      NA=AISLS
      IF (NNQ(J+NA+NV+1).EQ.0.0) GO TO 104
      CALL RMOVE(MFE(J+NA+NV+1),(J+NA+NV+1))
      RT=ATRIB(1)
      I=ATRIB(3)
      M=ATRIB(5)
      IF (RT.GT.TNOW) GO TO 103
      TUN(M)=TUN(M)+ATRIB(4)
C
      CALL PICK
      CALL FILEM (J+NV+1)
      VBUZ(M)=1.
      Q(M)=Q(M)-1.
      WT(M)=TNOW-SWT(M)
      TWT(M)=TWT(M)+WT(M)
      ATRIB(1)=TNOW+TT
      ATRIB(2)=1.
      ATRIB(5)=M
      CALL FILEM (1)
      GO TO 104
C
  103 CALL FILEM (J+NA+NV+1)
      ATRIB(1)=RT
      ATRIB(2)=2.
      ATRIB(6)=J
      CALL FILEM (1)
C
  104 RETURN
      END
```

B-11 "EVENTS" (Continued)

SUBROUTINE PICK FTN 4.8+552

```
      SUBROUTINE PICK
      COMMON/GCOM1/ATRIB(25),JEVNT,MFA,MFE(100),MLE(100),MSTOP,NCRDR,
     1NNAPO,NNAPT,NNATR,NNFIL,NNQ(100),NNTRY,NPRNT,PPARM(50,4),TNOW,
     2TTBEG,TTCLR,TTFIN,TTRIB(25),TTSET
      COMMON/UCOM1/Q(10),AN(10),HN(10),XN(10),YN(10),VBUZ(10),
     1 AISL(101),HLV(101),X(101),Y(101),SWT(10),WT(10),TWT(10),
     2 TUN(10),DY1,DX,DY2,VT(10),PT(10),UT(10),TT,XIN(101),NI,
     3 PCT(10),M,J,I,FX(101),K,YMAX,YMIN,YMED,AISLS,SVWT(10),
     4 VECS,HMAX,HMIN,HMED,MRL,TVT(10),TPT(10),NV,NA,
     5 ITEM(20),OI(20),FRQI(101),UNT(101),RT,PLOT(5)
C
      IF (VBUZ(M)-1.0) 10,50,180
C
   10 NV=VECS
      NA=AISLS
      IF (NNQ(J+NV+1).GT.0.0) GO TO 30
      IF (NNQ(J+NA+NV+1).GT.0.0) GO TC 20
      DY1=0.
      DX=ABS(X(I)-XN(M))
      DY2=ABS(Y(I)-YN(M))
      HN(M)=HLV(I)
      YN(M)=Y(I)
      VT(M)=(DY1+DX+DY2)/264.
      PT(M)=(ATRIB(4))*(0.2)
      TT=VT(M)+PT(M)
      GO TO 200
C
   20 ATRIB(1)=TNOW
      ATRIB(2)=2.
      ATRIB(6)=J
      CALL FILEM (1)
   30 DY1=0.
      DX=ABS(X(I)-XN(M))
      DY2=0.
      HN(M)=HMIN
      YN(M)=YMIN
      VT(M)=(DY1+DX+DY2)/264.
      GO TO 200
C
   50 NV=VECS
      NA=AISLS
      IF (Q(M).GT.0.0) GO TO 60
      DY1=ABS(YMIN-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=0.
      HN(M)=HLV(I)
      YN(M)=Y(I)
      VT(M)=(DY1+DX+DY2)/264.
      UT(M)=(TUN(M))*(0.2)
      TT=VT(M)+UT(M)
      ATRIB(1)=TNOW+(DY1/264.)
      ATRIB(2)=2.
      ATRIB(6)=AN(M)
      CALL FILEM(1)
      GO TO 200
C
   60 IF (NNQ(J+NV+1).GT.0.0) GO TO 100
      IF (AN(M).EQ.AISL(I)) GO TO 180
      IF (NNQ(J+NA+NV+1).GT.0.0) GO TC 90
      IF (HN(M)+HLV(I).GT.0.0) GO TO 70
      DY1=ABS(YMIN-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=ABS(YMIN-Y(I))
      GO TO 80
C
   70 DY1=ABS(YMAX-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=ABS(YMAX-Y(I))
   80 ATRIB(1)=TNOW+(DY1/264.)
      ATRIB(2)=2.
      ATRIB(6)=AN(M)
      CALL FILEM(1)
      HN(M)=HLV(I)
      YN(M)=Y(I)
      VT(M)=(DY1+DX+DY2)/264.
      PT(M)=(ATRIB(4))*(0.2)
      TT=VT(M)+PT(M)
```

B-12 Listing of Subroutine "PICK" used for Layouts(1) and (2)

```
          SUBROUTINE PICK                          FTN 4.8+552
          GO TO 200
C
   90     ATRIB(1)=TNOW
          ATRIB(2)=2.
          ATRIB(6)=J
          CALL FILEM (1)
  100     IF (HN(M)+HLV(I).GT.0.0) GO TO 110
          DY1=ABS(YMIN-YN(M))
          DX=ABS(X(I)-XN(M))
          DY2=0.
          HN(M)=HMIN
          YN(M)=YMIN
          GO TO 120
C
  110     DY1=ABS(YMAX-YN(M))
          DX=ABS(X(I)-XN(M))
          DY2=0.
          HN(M)=HMAX
          YN(M)=YMAX
  120     VT(M)=(DY1+DX+DY2)/264.
          ATRIB(1)=TNOW+(DY1/264.)
          ATRIB(2)=2.
          ATRIB(6)=AN(M)
          CALL FILEM (1)
          GO TO 200
C
  180     DY1=ABS(YN(M)-Y(I))
          DX=0.
          DY2=0.
          HN(M)=HLV(I)
          YN(M)=Y(I)
          VT(M)=(DY1+DX+DY2)/264.
          PT(M)=(ATRIB(4))*(0.2)
          TT=VT(M)+PT(M)
  200     AN(M)=AISL(I)
          XN(M)=X(I)
C
          RETURN
          END
```

B-12 "PICK" (Continued)

```
      SUBROUTINE PICK                                              FTN 4.8+552

      SUBROUTINE PICK
      COMMON/GCOM1/ATRIB(25),JEVNT,MFA,MFE(100),MLE(100),MSTOP,NCRDF,
     1NNAPO,NNAPT,NNATP,NNFIL,NNQ(100),NNTRY,NPRNT,PPARM(50,4),TNOW,
     2TTBEG,TTCLR,TTFIN,TTRIB(25),TTSET
      COMMON/UCOM1/Q(10),AN(10),HN(10),XN(10),YN(10),VBUZ(10),
     1 AISL(101),HLV(101),X(101),Y(101),SWT(10),WT(10),TWT(10),
     2 TUN(10),DY1,DX,DY2,VT(10),PT(10),UT(10),TT,XIN(101),NT,
     3 PCT(10),M,J,I,FX(101),K,YMAX,YMIN,YMED,AISLS,SVWT(10),
     4 VECS,HMAX,HMIN,HMED,MPL,TVT(10),TPT(10),NV,NA,
     5 ITEM(20),OI(20),FROI(101),UNT(101),RT,PLOT(5)
C
C
      IF (VBUZ(M)-1.0) 10,50,100
C
 10   NV=VECS
      NA=AISLS
      IF (NNQ(J+NV+1).GT.0.0) GO TO 30
      IF (NNQ(J+NA+NV+1).GT.0.0) GO TO 20
      IF (HLV(I).GT.0.0) GO TO 12
      DY1=ABS(YMIN-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=ABS(YMIN-Y(I))
      GO TO 15
 12   DY1=ABS(YMAX-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=ABS(YMAX-Y(I))
 15   HN(M)=HLV(I)
      YN(M)=Y(I)
      VT(M)=(DY1+DX+DY2)/264.
      PT(M)=(ATRIB(4))*(0.2)
      TT=VT(M)+PT(M)
      GO TO 200
C
 20   ATRIB(1)=TNOW
      ATRIB(2)=2.
      ATRIB(6)=J
      CALL FILEM (1)
 30   IF (HLV(I).GT.0.0) GO TO 35
      DY1=ABS(YMIN-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=0.
      HN(M)=HMIN
      YN(M)=YMIN
      GO TO 40
 35   DY1=ABS(YMAX-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=0.
      HN(M)=HMAX
      YN(M)=YMAX
 40   VT(M)=(DY1+DX+DY2)/264.
      GO TO 200
C
 50   NV=VECS
      NA=AISLS
      IF (Q(M).GT.0.0) GO TO 60
      IF (HN(M).GT.0.0) GO TO 52
      DY1=ABS(YMIN-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=0.
      GO TO 55
 52   DY1=ABS(YMAX-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=ABS(YMAX-Y(I))
 55   HN(M)=HLV(I)
      YN(M)=Y(I)
      VT(M)=(DY1+DX+DY2)/264.
      UT(M)=(TUN(M))*(0.2)
      TT=VT(M)+UT(M)
      ATRIB(1)=TNOW+(DY1/264.)
      ATRIB(2)=2.
      ATRIB(5)=AN(M)
      CALL FILEM(1)
      GO TO 200
C
 60   IF (NNQ(J+NV+1).GT.0.0) GO TO 100
      IF (AN(M).EQ.AISL(I)) GO TO 190
      IF (NNQ(J+NA+NV+1).GT.0.0) GO TO 90
```

B-13 Listing of Subroutine "PICK" used for Layouts(3) and (4)

```
          SUBROUTINE PICK                              FTN 4.8+552

      IF (HN(M)+HLV(I).GT.0.0) GO TO 70
      DY1=ABS(YMIN-YN(M))
      DX=ABS (X(I)-XN(M))
      DY2=ABS(YMIN-Y(I))
      GO TO 80
C
 70   DY1=ABS(YMAX-YN(M))
      DX=ABS (X(I)-XN(M))
      DY2=ABS(YMAX-Y(I))
 80   ATRIB(1)=TNOW+(DY1/264.)
      ATRIB(2)=2.
      ATRIB(6)=AN(M)
      CALL FILEM(1)
      HN(M)=HLV(I)
      YN(M)=Y(I)
      VT(M)=(DY1+DX+DY2)/264.
      PT(M)=(ATRIB(4))*(0.2)
      TT=VT(M)+PT(M)
      GO TO 200
C
 90   ATRIB(1)=TNOW
      ATRIB(2)=2.
      ATRIB(6)=J
      CALL FILEM (1)
 100  IF (HN(M)+HLV(I).GT.0.0) GO TO 110
      DY1=ABS(YMIN-YN(M))
      DX=ABS (X(I)-XN(M))
      DY2=0.
      HN(M)=HMIN
      YN(M)=YMIN
      GO TO 120
C
 110  DY1=ABS(YMAX-YN(M))
      DX=ABS (X(I)-XN(M))
      DY2=0.
      HN(M)=HMAX
      YN(M)=YMAX
 120  VT(M)=(DY1+DX+DY2)/264.
      ATRIB(1)=TNOW+(DY1/264.)
      ATRIB(2)=2.
      ATRIB(6)=AN(M)
      CALL FILEM (1)
      GO TO 200
C
 180  DY1=ABS(YN(M)-Y(I))
      DX=0.
      DY2=0.
      HN(M)=HLV(I)
      YN(M)=Y(I)
      VT(M)=(DY1+DX+DY2)/264.
      PT(M)=(ATRIB(4))*(0.2)
      TT=VT(M)+PT(M)
 200  AN(M)=AISL(I)
      XN(M)=X(I)
C
      RETURN
      END
```

B-13 "PICK" (Continued)

```
      SUBROUTINE PICK                                     FTN 4.8+552

      SUBROUTINE PICK
      COMMON/GCOM1/ATRIB(25),JEVNT,MFA,MFE(100),MLE(100),MSTOP,NCROR,
     1NNAPO,NNAPT,NNATR,NNFIL,NNQ(100),NNTRY,NPRNT,PPARM(50,4),TNOW,
     2TTBEG,TTCLR,TTFIN,TTRIB(25),TTSET
      COMMON/UCOM1/Q(10),AN(10),HN(10),XN(10),YN(10),VBUZ(10),
     1 AISL(101),HLV(101),X(101),Y(101),SWT(10),WT(10),TWT(10),
     2 TUN(10),DY1,DX,DY2,VT(10),PT(10),UT(10),TT,XIN(101),NI,
     3 PCT(10),M,J,I,FX(101),K,YMAX,YMIN,YMED,AISLS,SVWT(10),
     4 VECS,HMAX,HMIN,HMED,MRL,TVT(10),TPT(10),NV,NA,
     5 ITEM(20),OI(20),FROI(101),UNT(101),RT,PLOT(5)
C
C
      IF (VBUZ(M)-1.0) 10,50,180
C
 10   NV=VECS
      NA=AISLS
      IF (NNQ(J+NV+1).GT.0.0) GO TO 30
      IF (NNQ(J+NA+NV+1).GT.0.0) GO TO 20
      DY1=0.
      DX=ABS(X(I)-XN(M))
      DY2=ABS(Y(I)-YN(M))
      HN(M)=HLV(I)
      YN(M)=Y(I)
      VT(M)=(DY1+DX+DY2)/264.
      PT(M)=(ATRIB(4))*(0.2)
      TT=VT(M)+PT(M)
      GO TO 200
C
 20   ATRIB(1)=TNOW
      ATRIB(2)=2.
      ATRIB(6)=J
      CALL FILEM (1)
 30   IF (HLV(I).GT.0.0) GO TO 35
      DY1=0.
      DX=ABS(X(I)-XN(M))
      DY2=0.
      HN(M)=HMIN
      YN(M)=YMIN
      GO TO 40
 35   DY1=ABS(YMED-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=0.
      HN(M)=HMED
      YN(M)=YMED
 40   VT(M)=(DY1+DX+DY2)/264.
      GO TO 200
C
 50   NV=VECS
      NA=AISLS
      IF (Q(M).GT.0.0) GO TO 60
      DY1=ABS(YMIN-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=0.
      HN(M)=HLV(I)
      YN(M)=Y(I)
      VT(M)=(DY1+DX+DY2)/264.
      UT(M)=(TUN(M))*(0.2)
      TT=VT(M)+UT(M)
      ATRIB(1)=TNOW+(DY1/264.)
      ATRIB(2)=2.
      ATRIB(6)=AN(M)
      CALL FILEM(1)
      GO TO 200
C
 60   IF (NNQ(J+NV+1).GT.0.0) GO TO 100
      IF (AN(M).EQ.AISL(I)) GO TO 180
      IF (NNQ(J+NA+NV+1).GT.0.0) GO TO 90
      IF (HN(M).GT.0.0) GO TO 75
      IF (HLV(I).GT.0.0) GO TO 70
      IF (HN(M)+HLV(I).GE.(-2)*(MRL)) GO TO 65
      DY1=ABS(YMIN-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=ABS(YMIN-Y(I))
      GO TO 80
 65   DY1=ABS(YMED-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=ABS(YMED-Y(I))
```

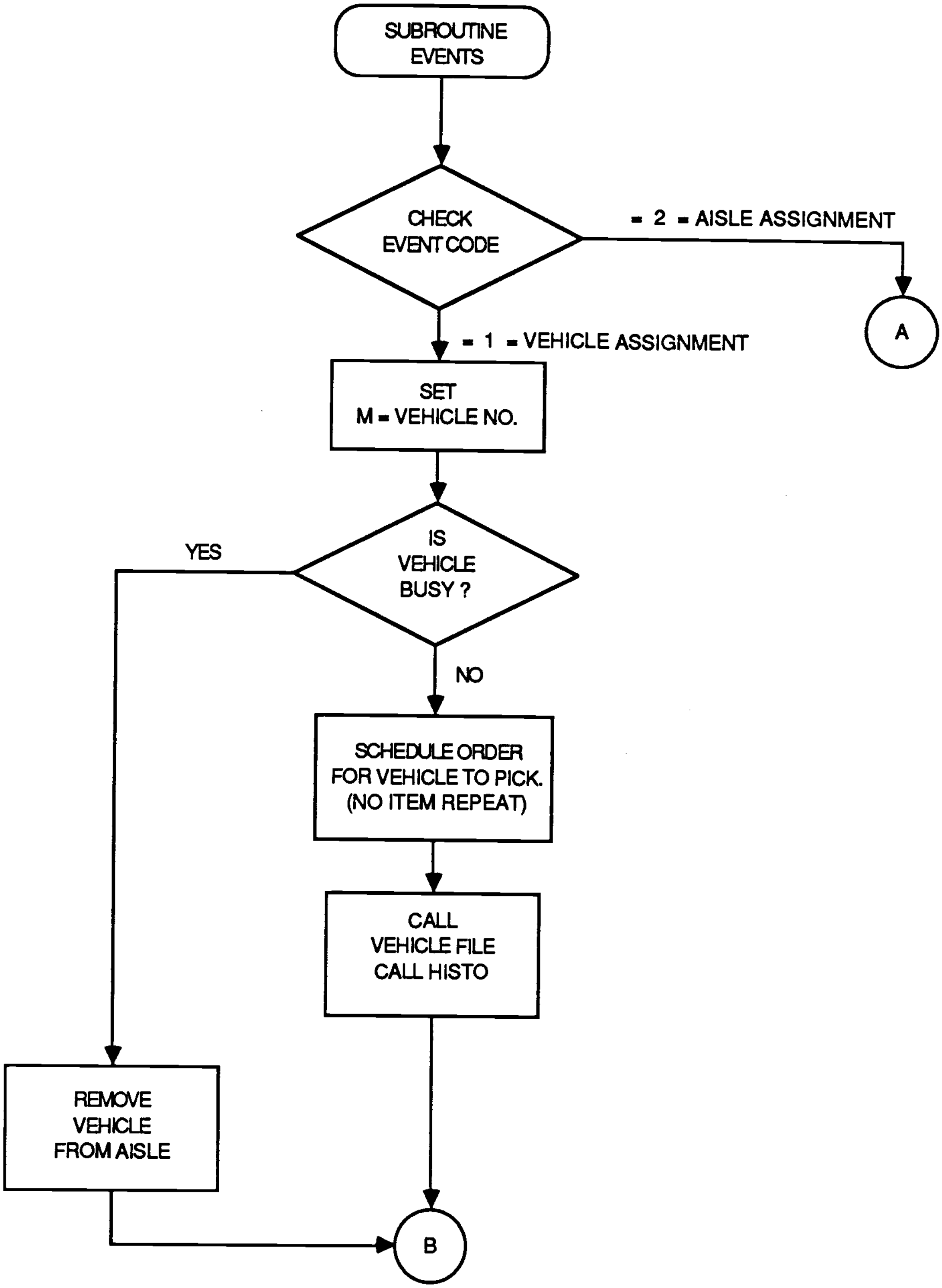
Change for Layouts (7)&(8)

```
      HN(M)=HMED
      YN(M)=YMED
      GO TO 40
 35   DY1=0.
```

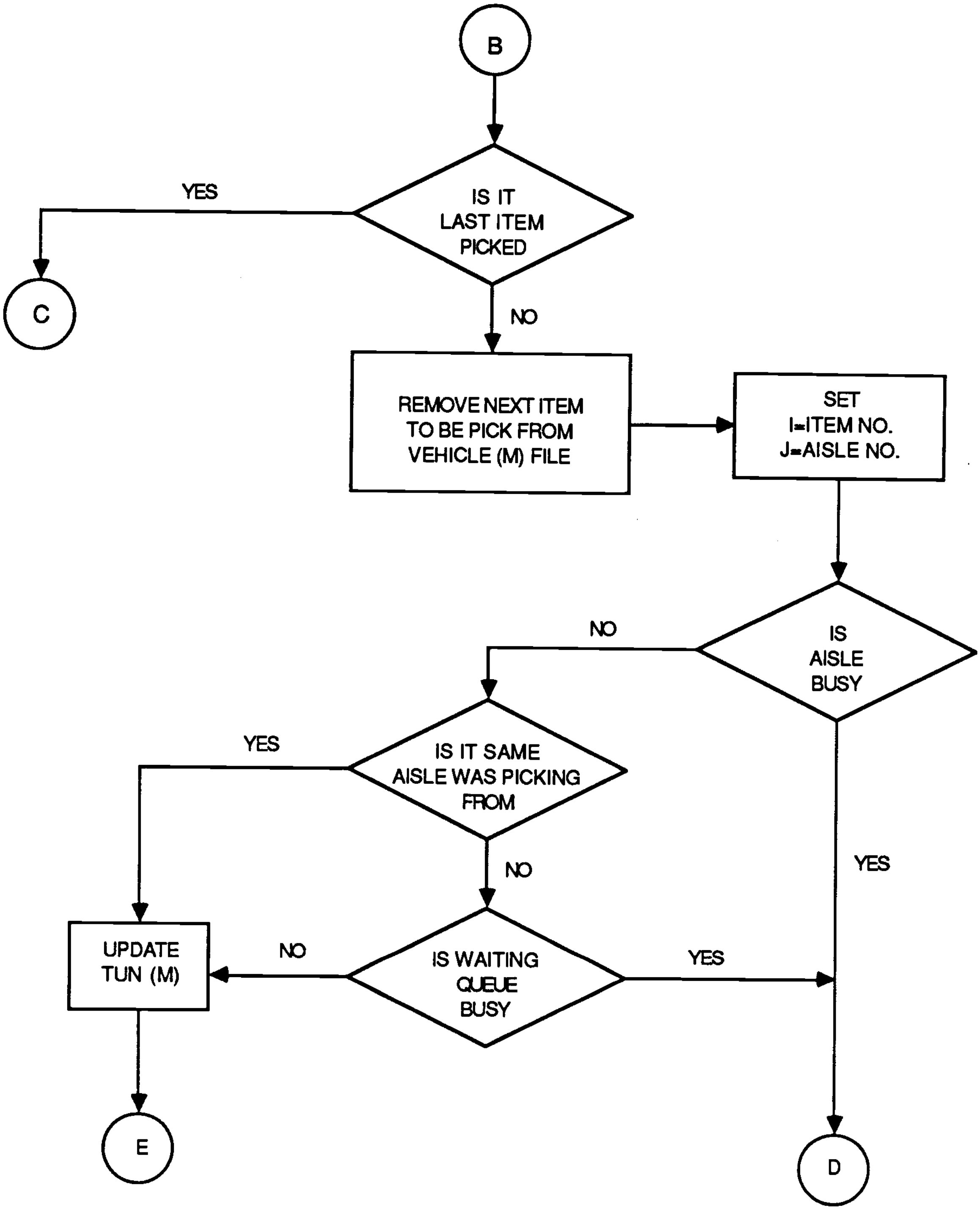
B-14 Listing of Subroutin "PICK" used for Layouts (5)&(6), and with the necessary changes for Layouts (7)&(8)

```
      GO TO 90
   70 DY1=ABS(Y(I)-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=0.
      GO TO 80
   75 IF (HLV(I).GT.0.0) GO TO 77
      DY1=ABS(Y(I)-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=0.
      GO TO 80
   77 IF (HN(M)+HLV(I).GE.(2)*(MRL)) GO TO 79
      DY1=ABS(YMED-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=ABS(YMED-Y(I))
      GO TO 80
C
   79 DY1=ABS(YMAX-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=ABS(YMAX-Y(I))
   80 ATRIB(1)=TNOW+(DY1/264.)
      ATRIB(2)=2.
      ATRIB(6)=AN(M)
      CALL FILEM(1)
      HN(M)=HLV(I)
      YN(M)=Y(I)
      VT(M)=(DY1+DX+DY2)/264.
      PT(M)=(ATRIB(4))*(0.2)
      TT=VT(M)+PT(M)
      GO TO 200
C
   90 ATRIB(1)=TNOW
      ATRIB(2)=2.
      ATRIB(6)=J
      CALL FILEM (1)
  100 IF (HN(M).GT.0.0) GO TO 110
      IF (HLV(I).GT.0.0) GO TO 105
      IF (HN(M)+HLV(I).GE.(-2)*(MRL)) GO TO 105
      DY1=ABS(YMIN-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=0.
      HN(M)=HMIN
      YN(M)=YMIN
      GO TO 120
C
  105 DY1=ABS(YMED-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=0.
      HN(M)=HMED
      YN(M)=YMED
      GO TO 120
  110 IF (HLV(I).LT.0.0) GO TO 115
      IF (HN(M)+HLV(I).LE.(2)*(MRL)) GO TO 115
      DY1=ABS(YMAX-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=0.
      HN(M)=HMAX
      YN(M)=YMAX
      GO TO 120
  115 DY1=ABS(YMED-YN(M))
      DX=ABS(X(I)-XN(M))
      DY2=0.
      HN(M)=HMED
      YN(M)=YMED
  120 VT(M)=(DY1+DX+DY2)/264.
      ATRIB(1)=TNOW+(DY1/264.)
      ATRIB(2)=2.
      ATRIB(6)=AN(M)
      CALL FILEM (1)
      GO TO 200
C
  180 DY1=ABS(YN(M)-Y(I))
      DX=0.
      DY2=0.
      HN(M)=HLV(I)
      YN(M)=Y(I)
      VT(M)=(DY1+DX+DY2)/264.
      PT(M)=(ATRIB(4))*(0.2)
      TT=VT(M)+PT(M)
  200 AN(M)=AISL(I)
      XN(M)=X(I)
C
      RETURN
      END
```

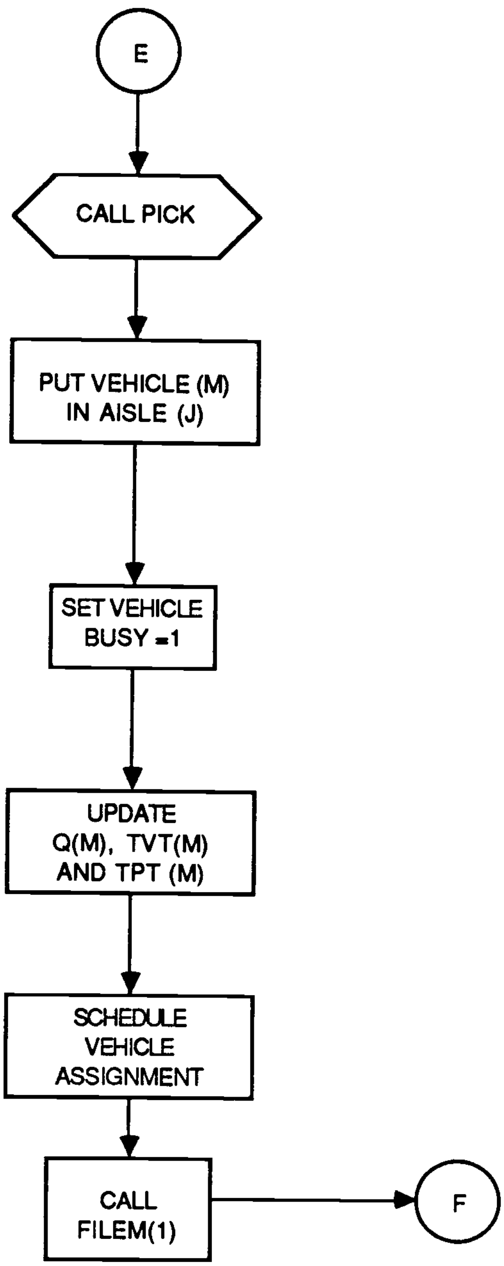
B-14 "PICK" (Continued)



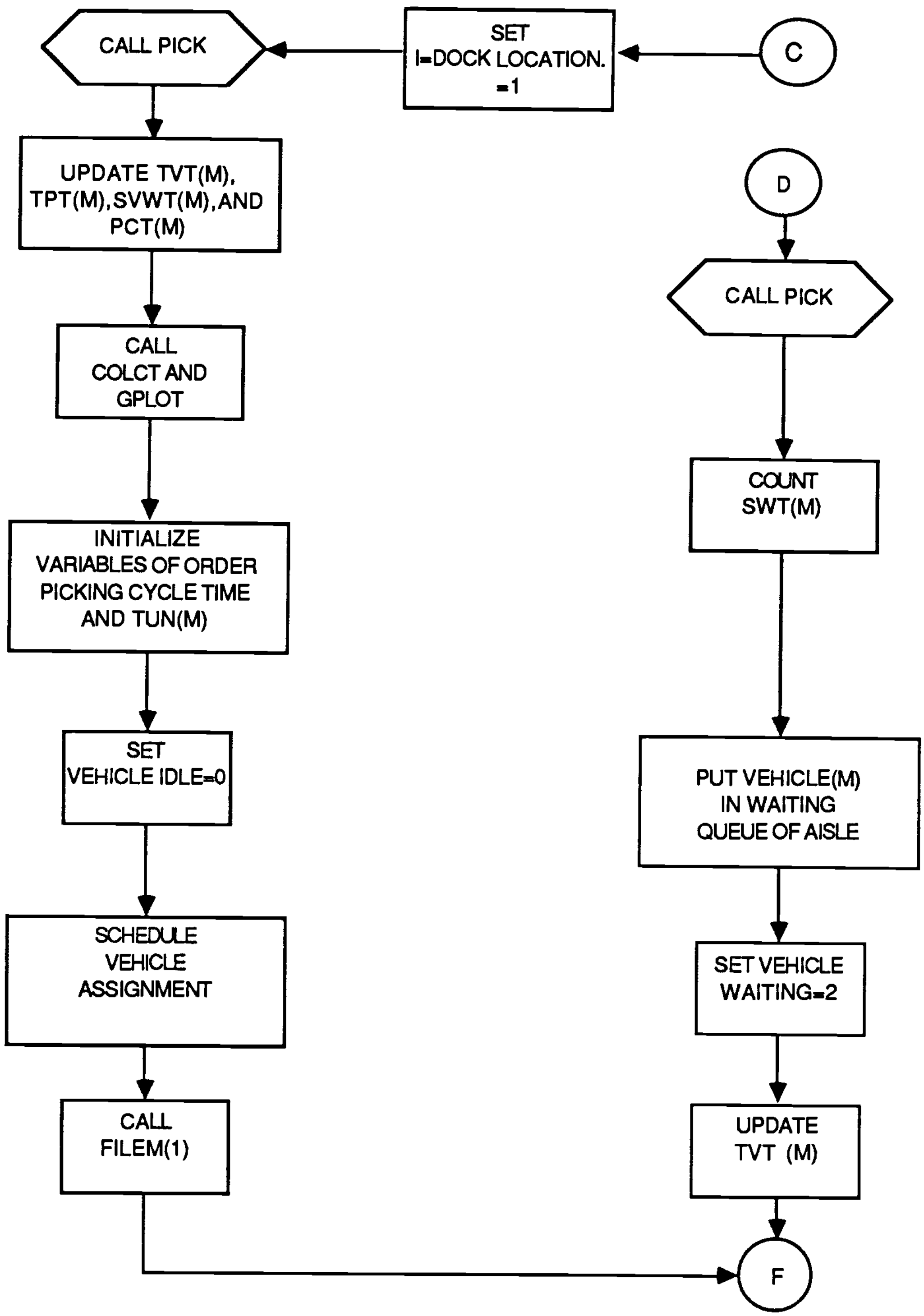
B - 15 Flow chart of subroutine " EVENTS" used for all layouts



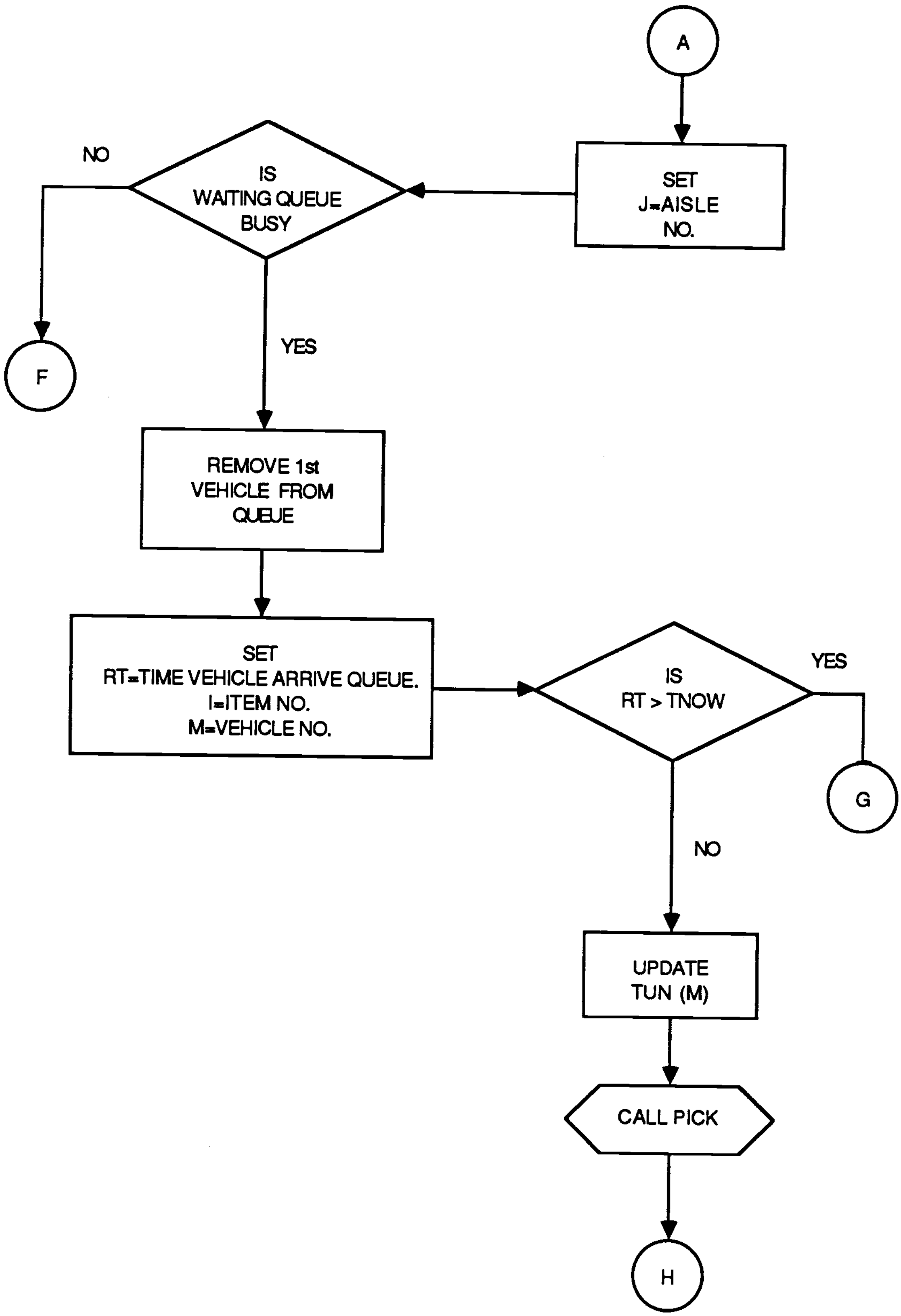
B-15 "EVENTS" (Continued)



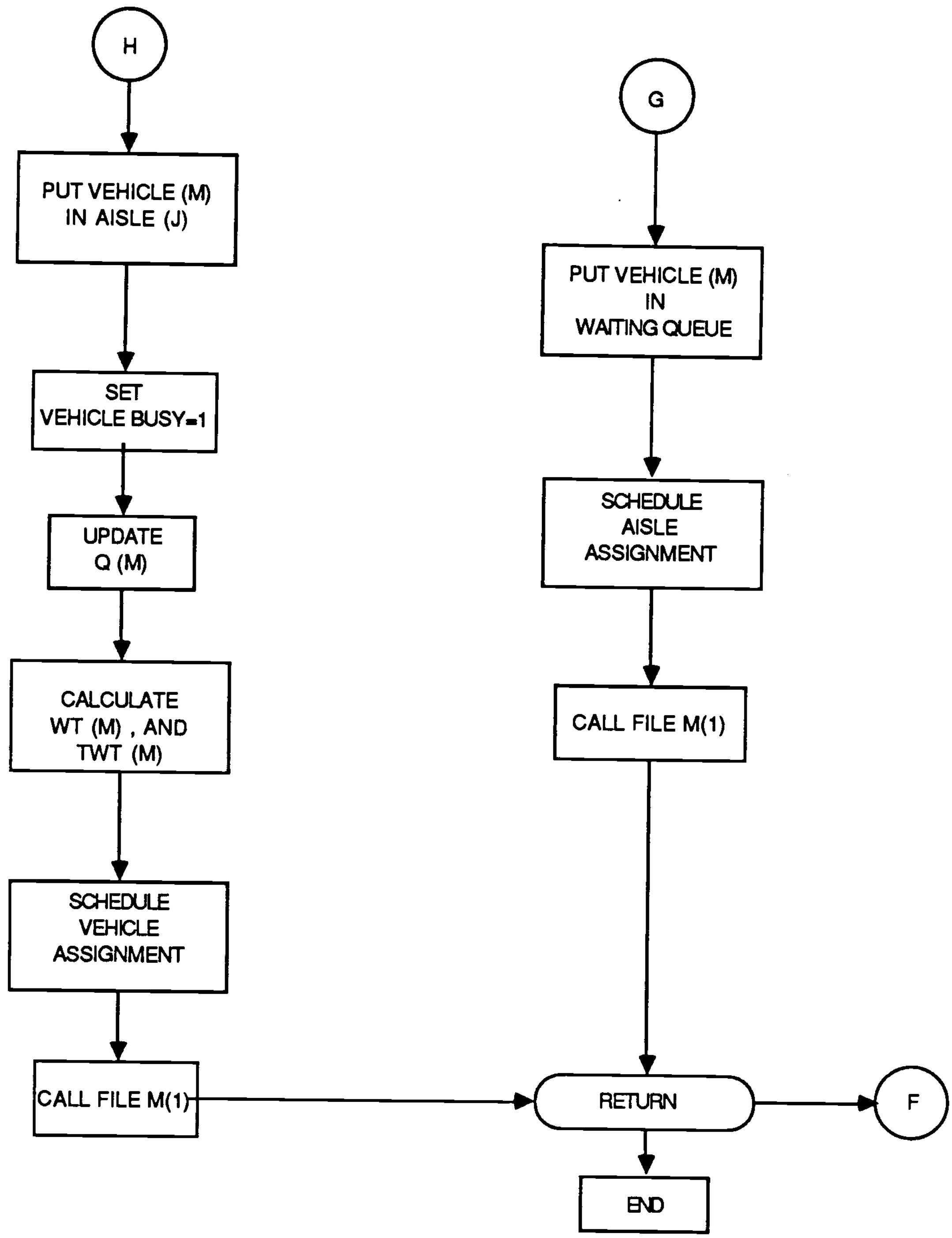
B-15 "EVENTS" (Continued)



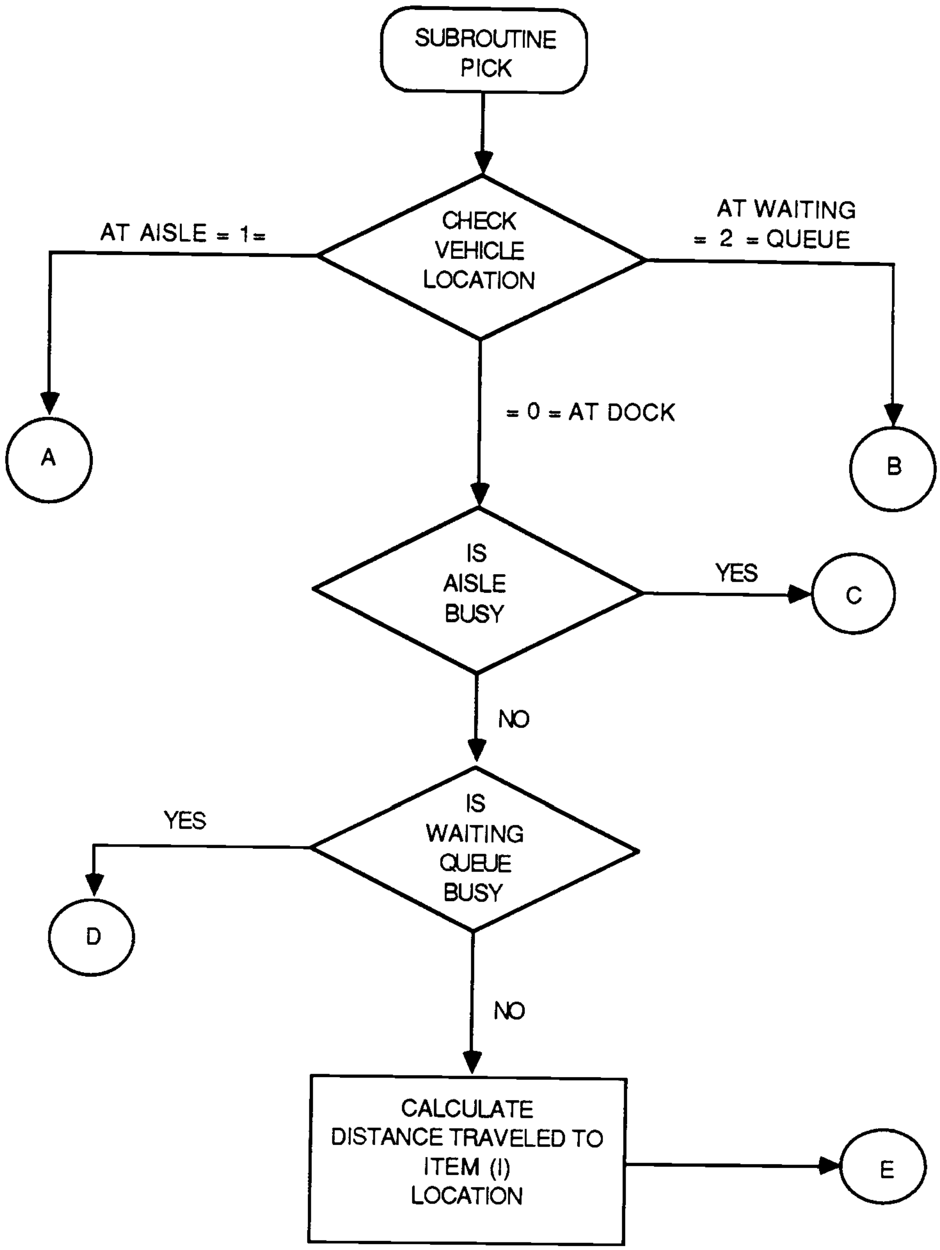
B-15 "EVENTS" (Continued)



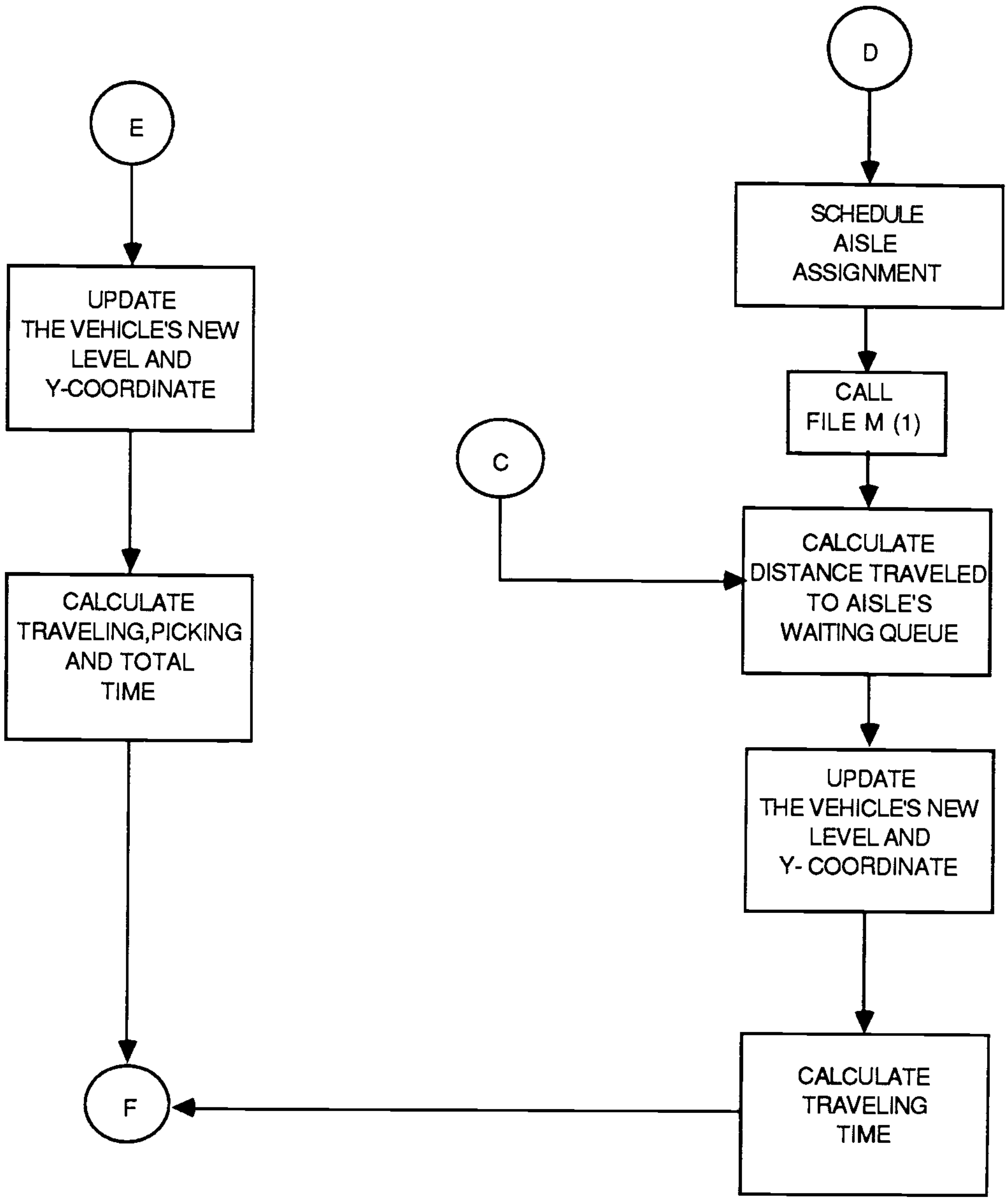
B-15 "EVENTS" (Continued)



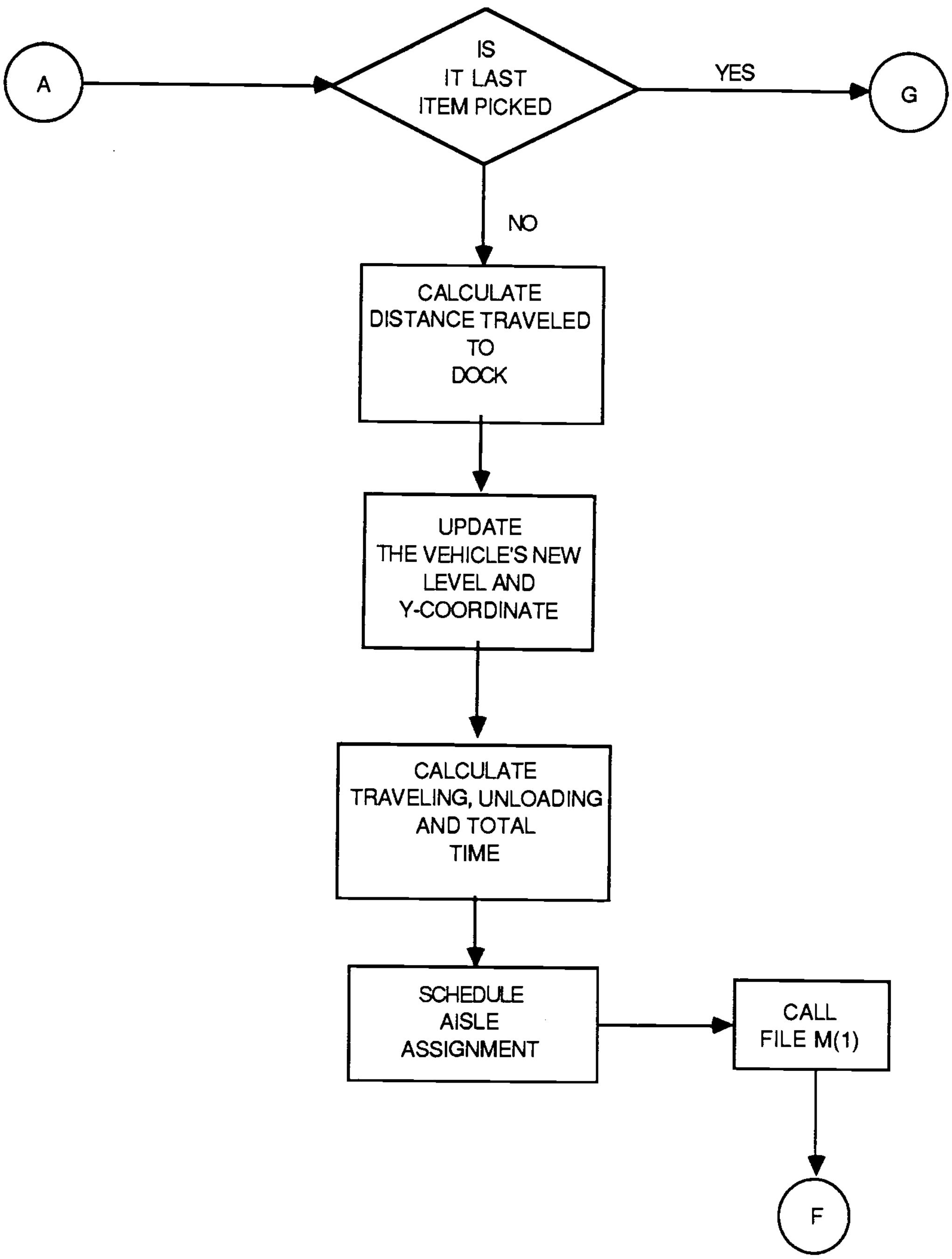
B-15 "EVENTS" (Continued)



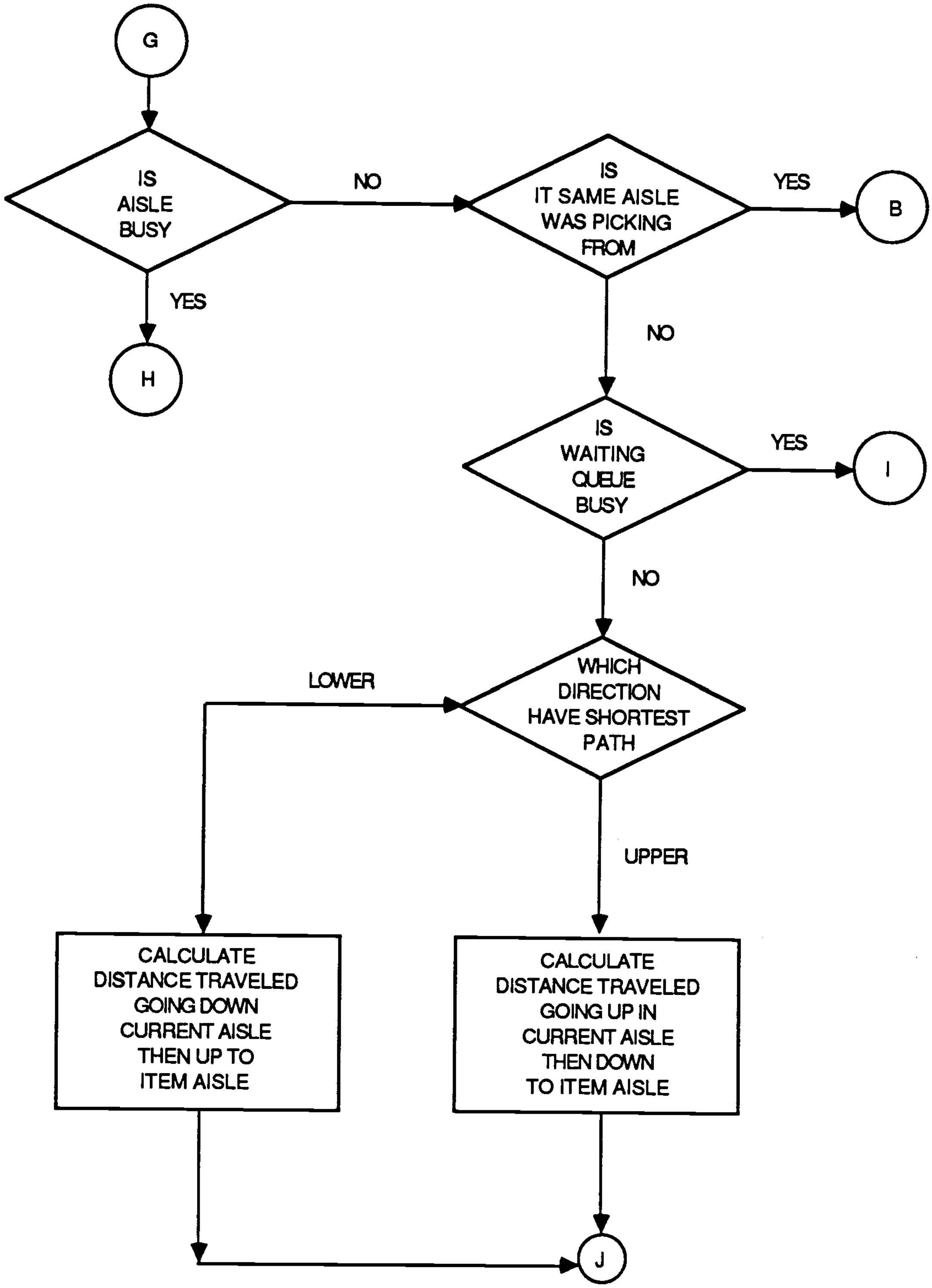
B -16 Flow Chart of Subroutine " PICK" used for Layouts 1and 2



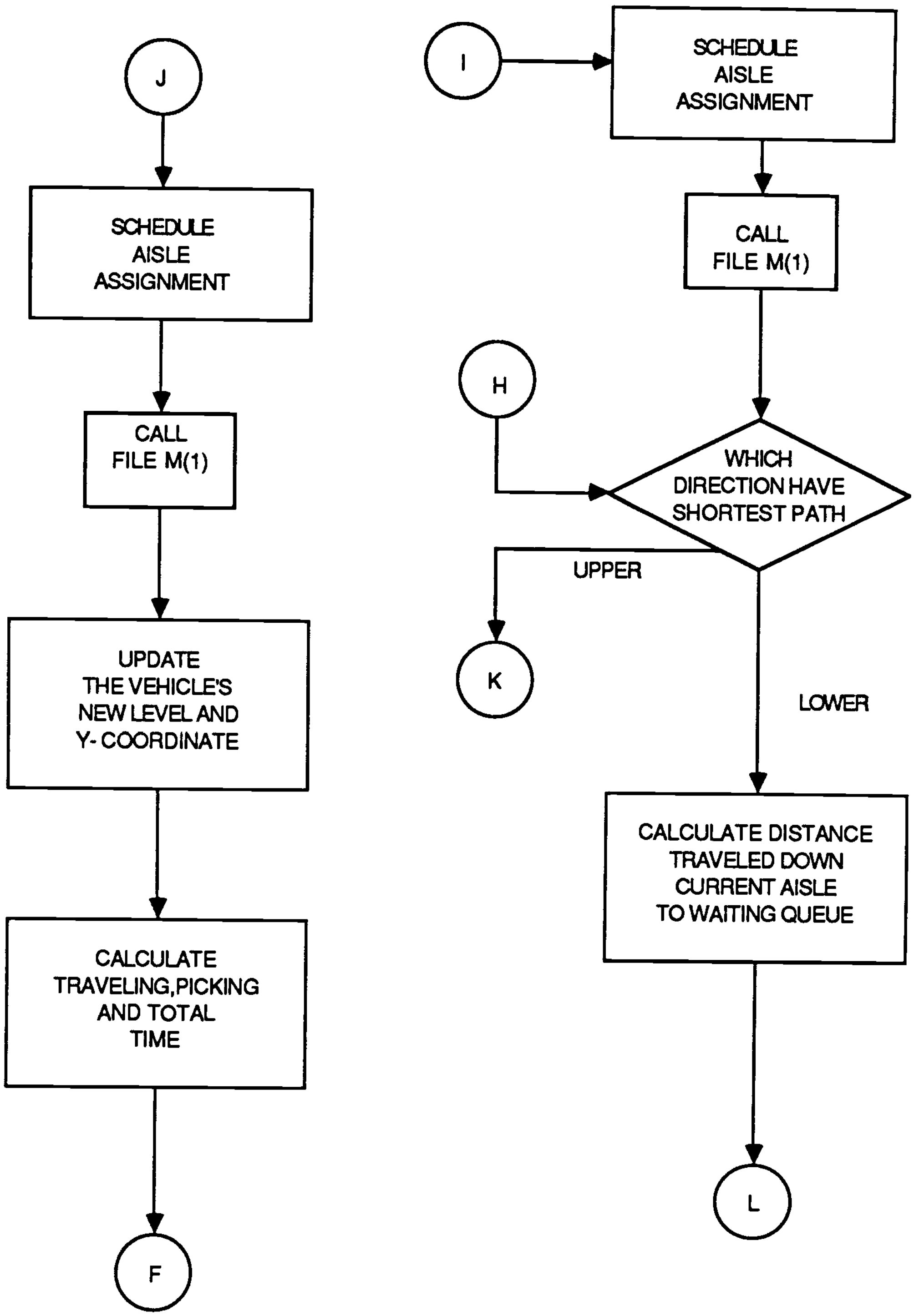
B - 16 "PICK " (Continued)



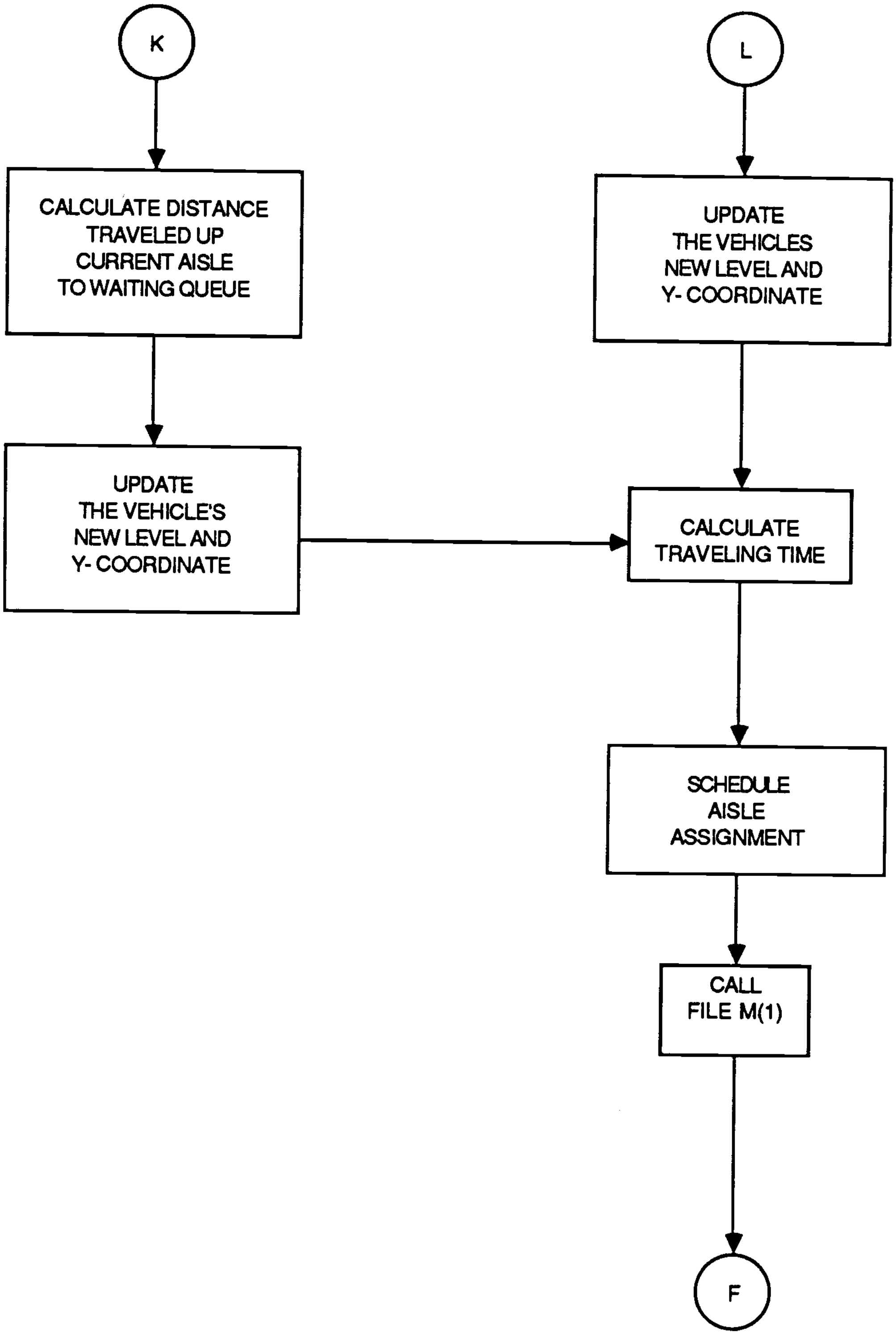
B - 16 "PICK " (Continued)



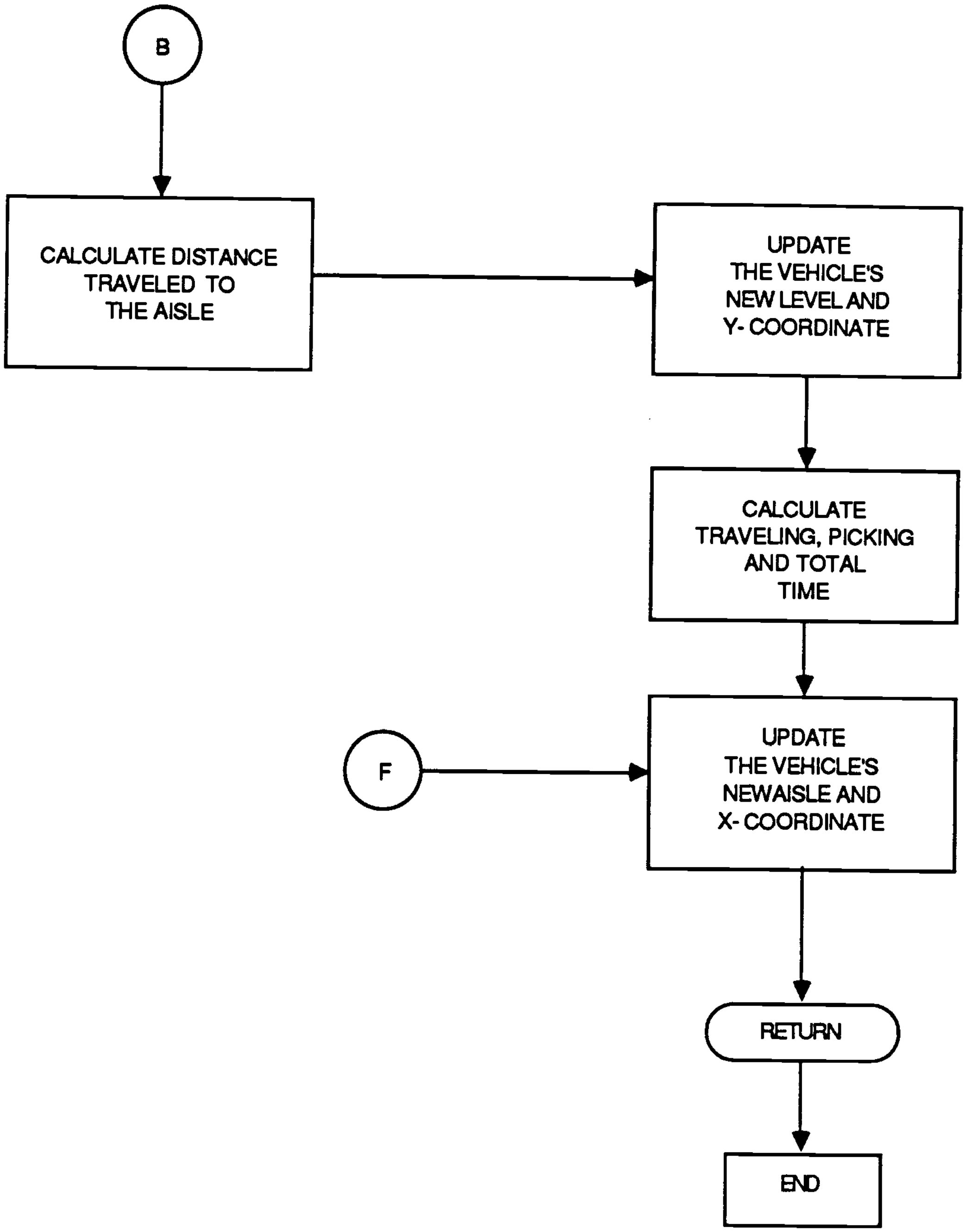
B - 16 "PICK " (Continued)



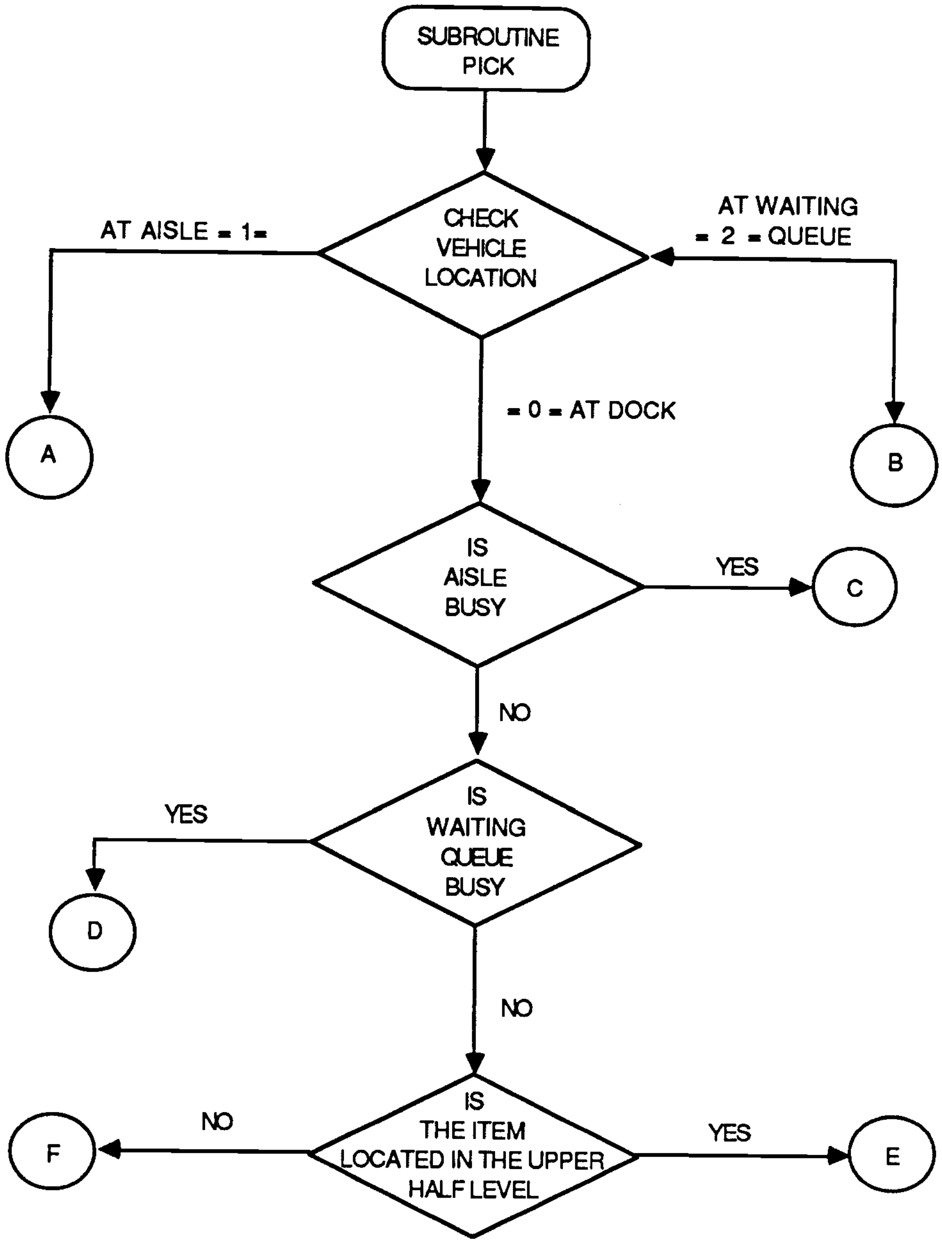
B - 16 "PICK " (Continued)



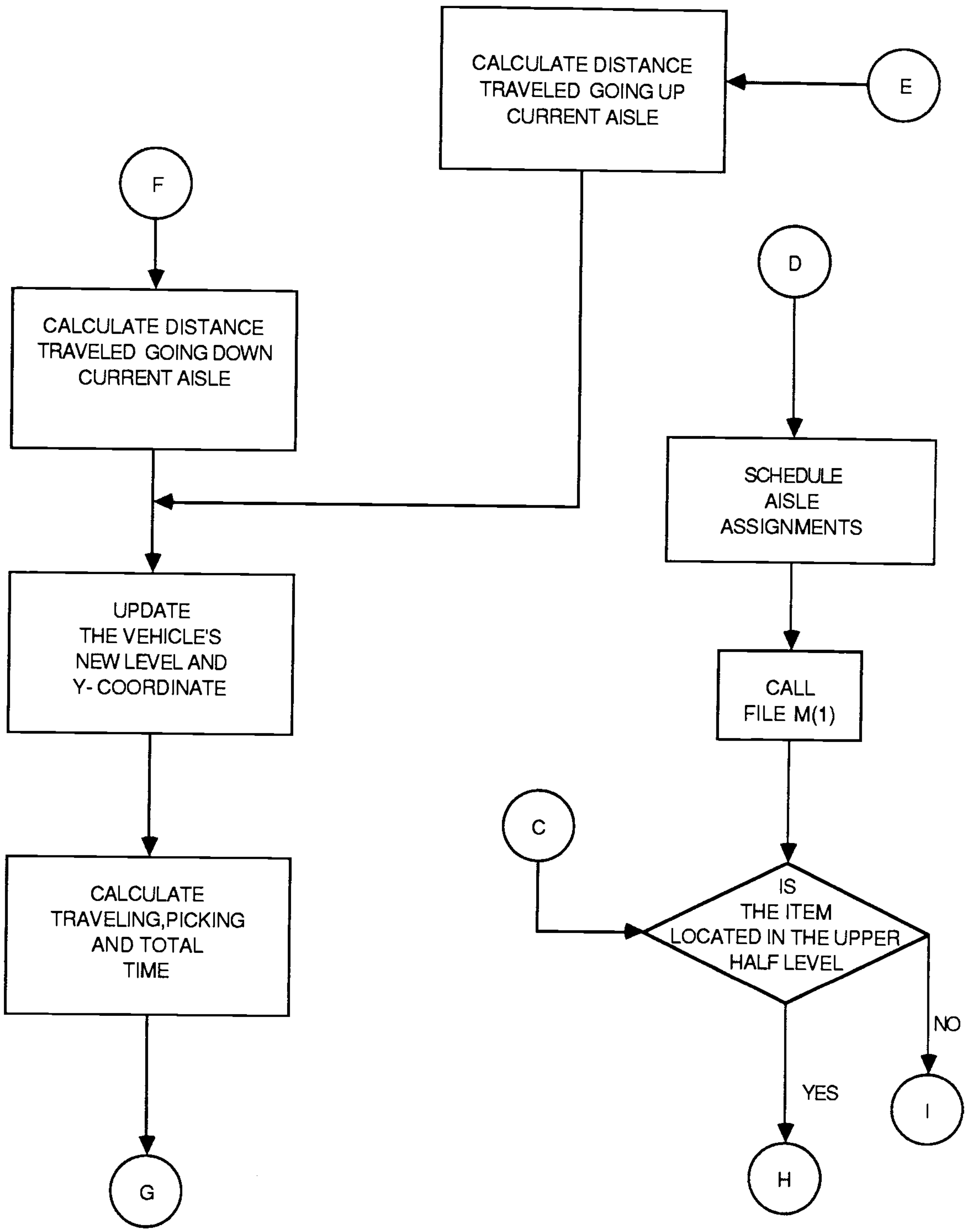
B - 16 "PICK " (Continued)



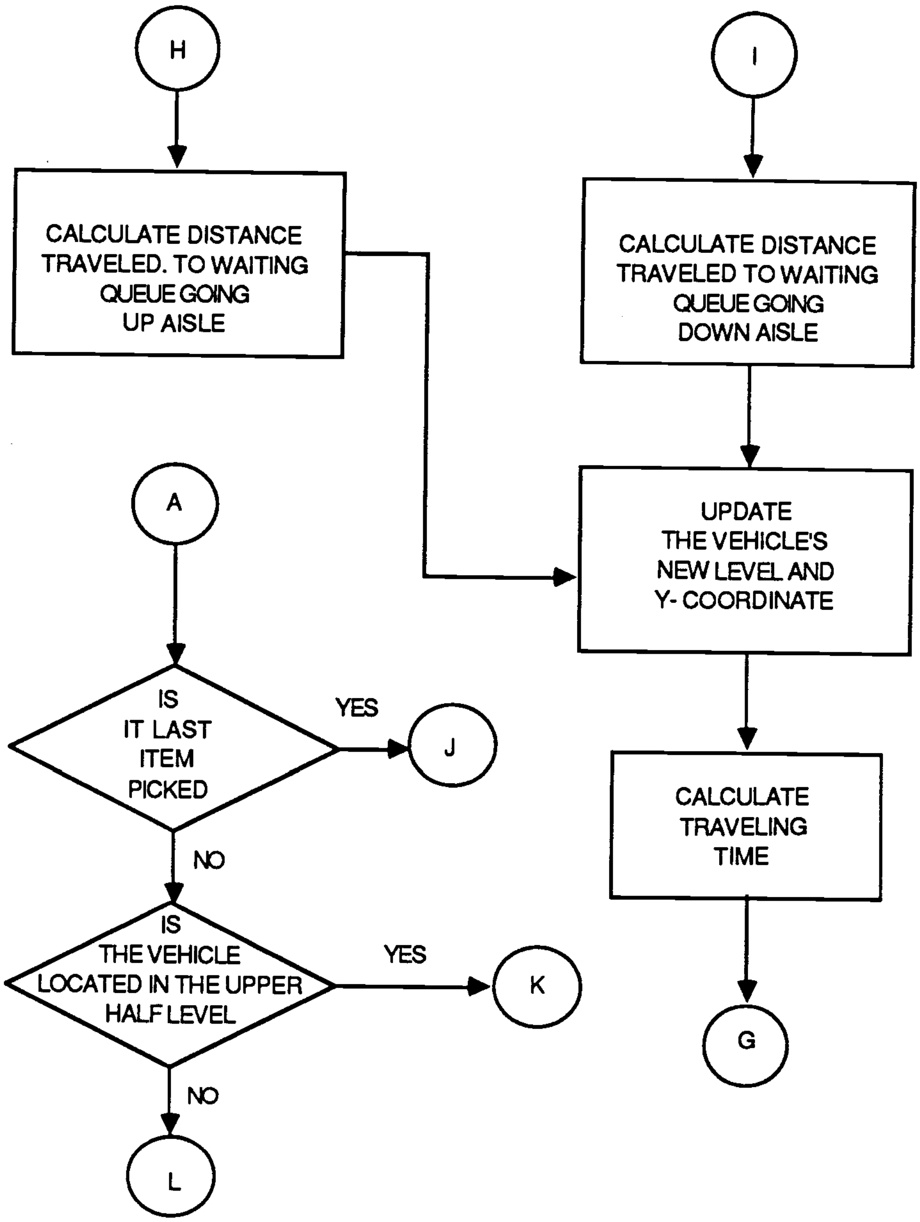
B - 16 "PICK " (Continued)



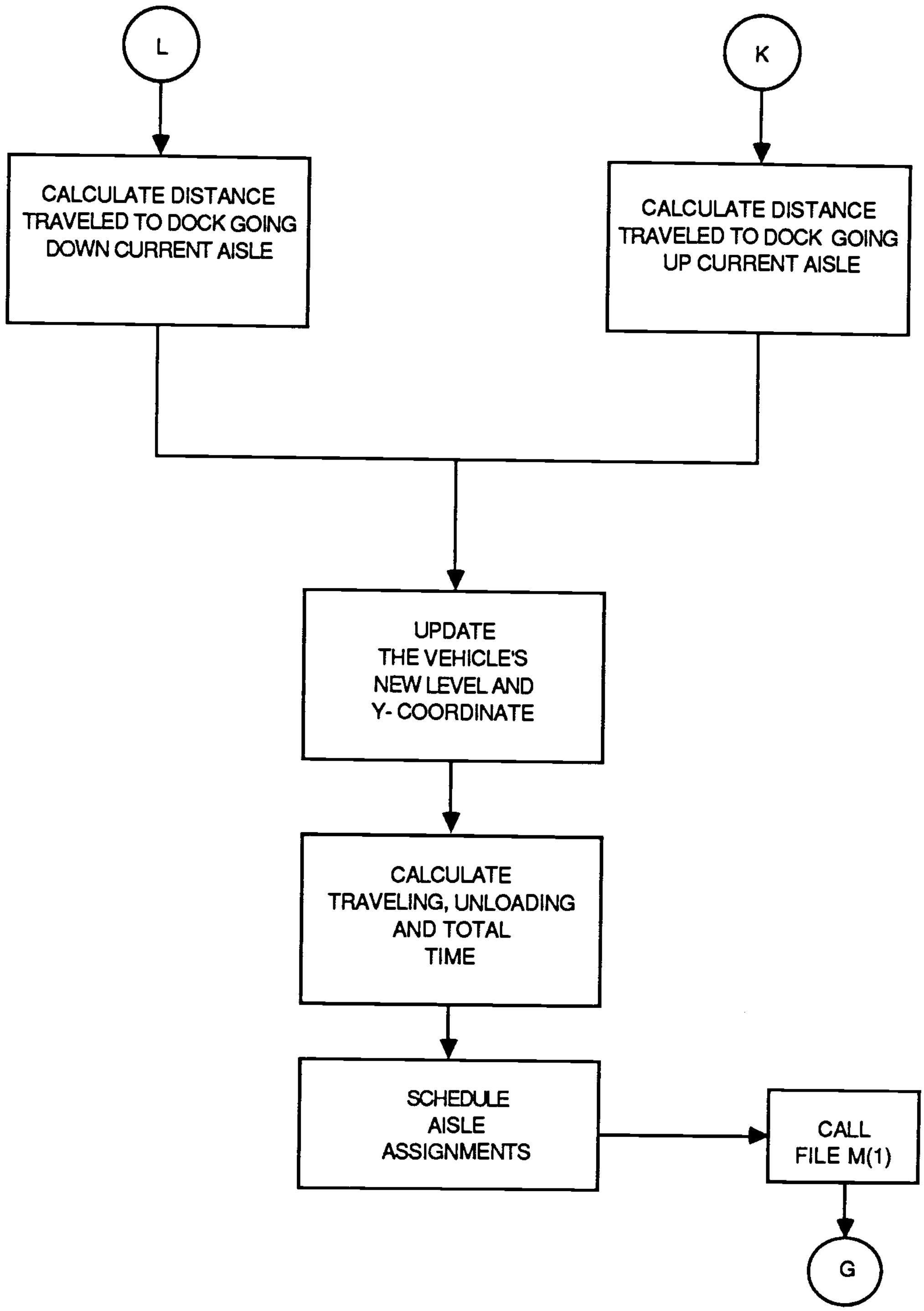
B -17 Flow Chart of Subroutine " PICK" used for Layouts 3and 4



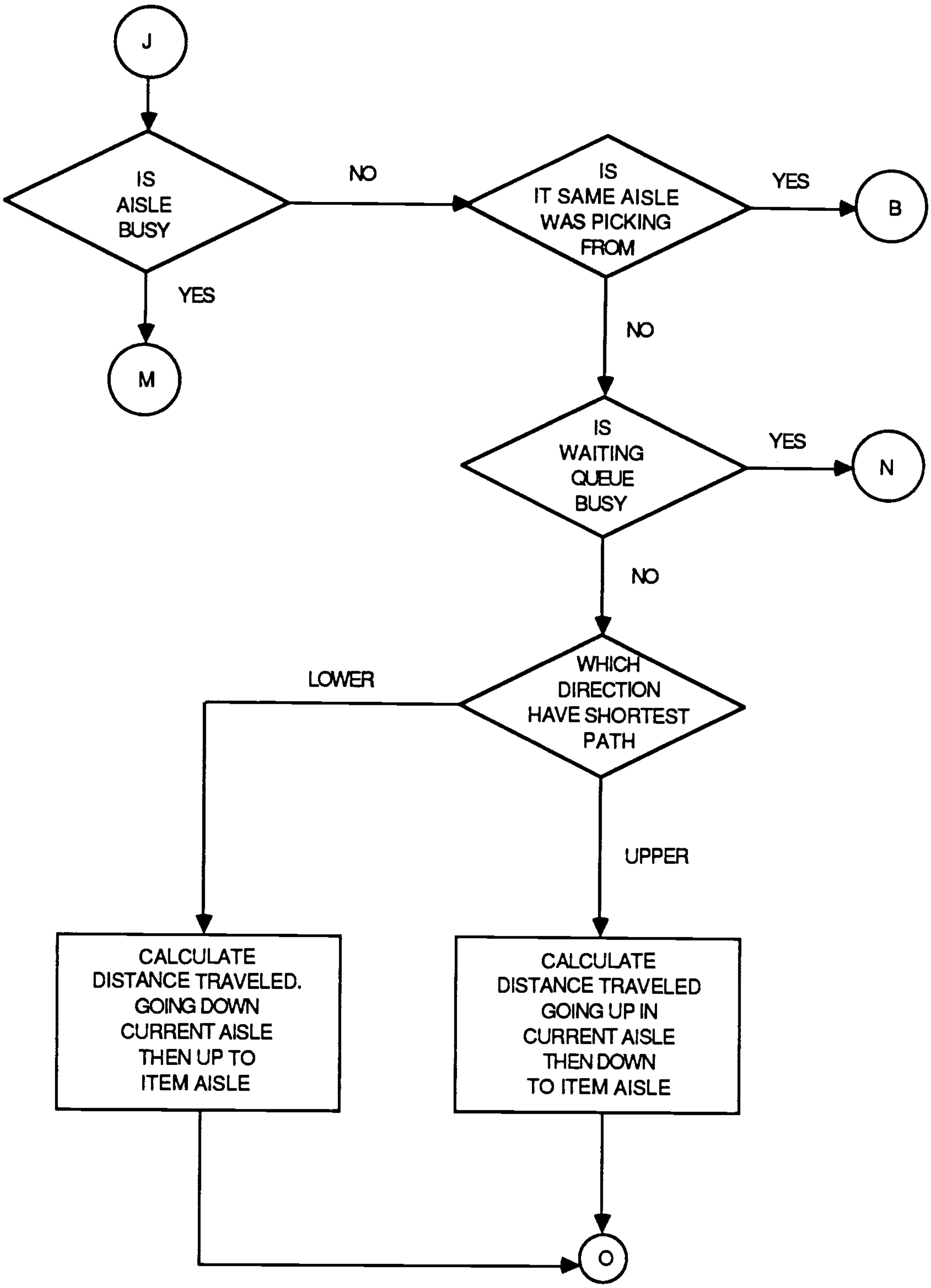
B - 17 "PICK " (Continued)



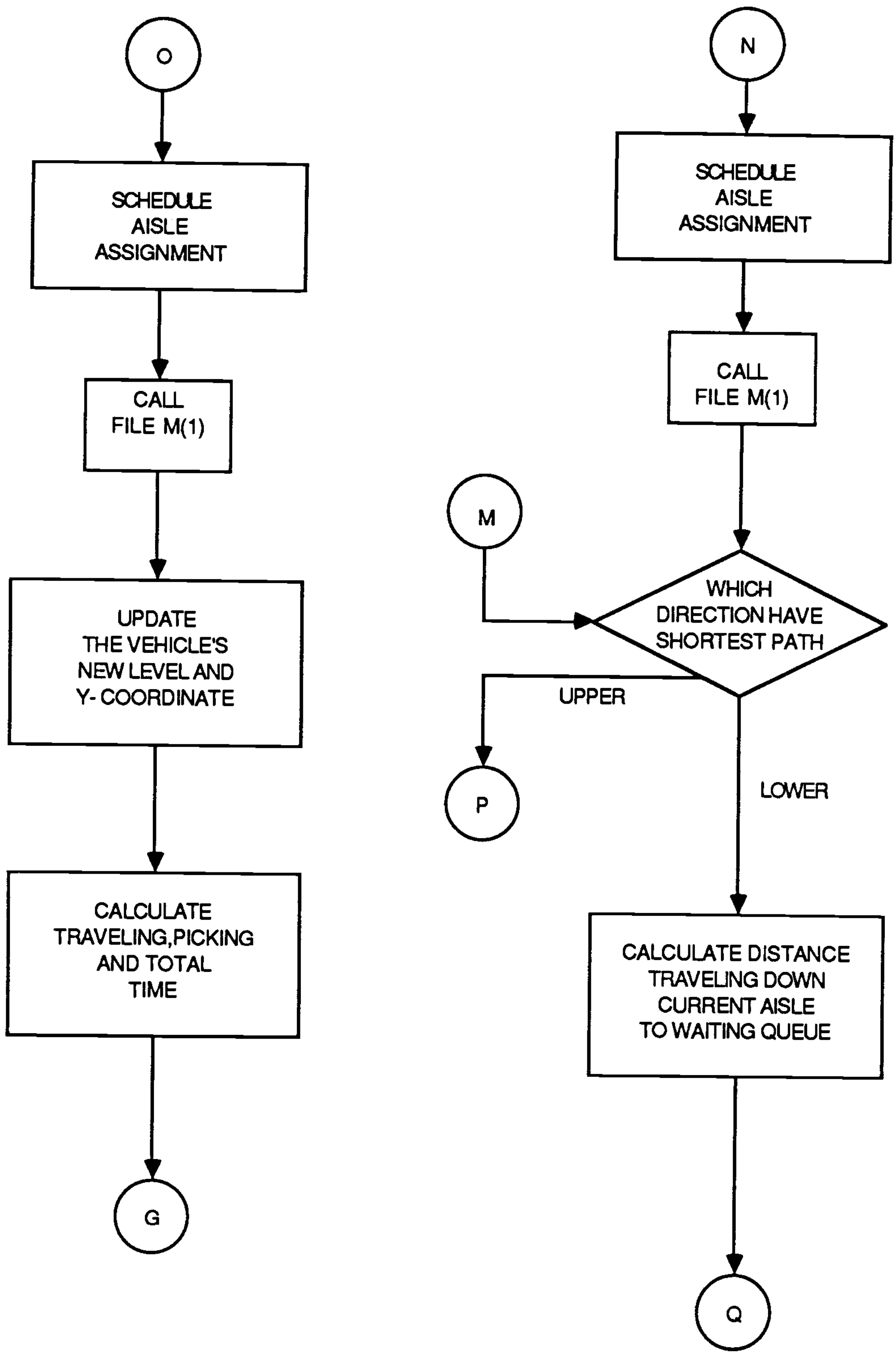
B - 17 "PICK " (Continued)



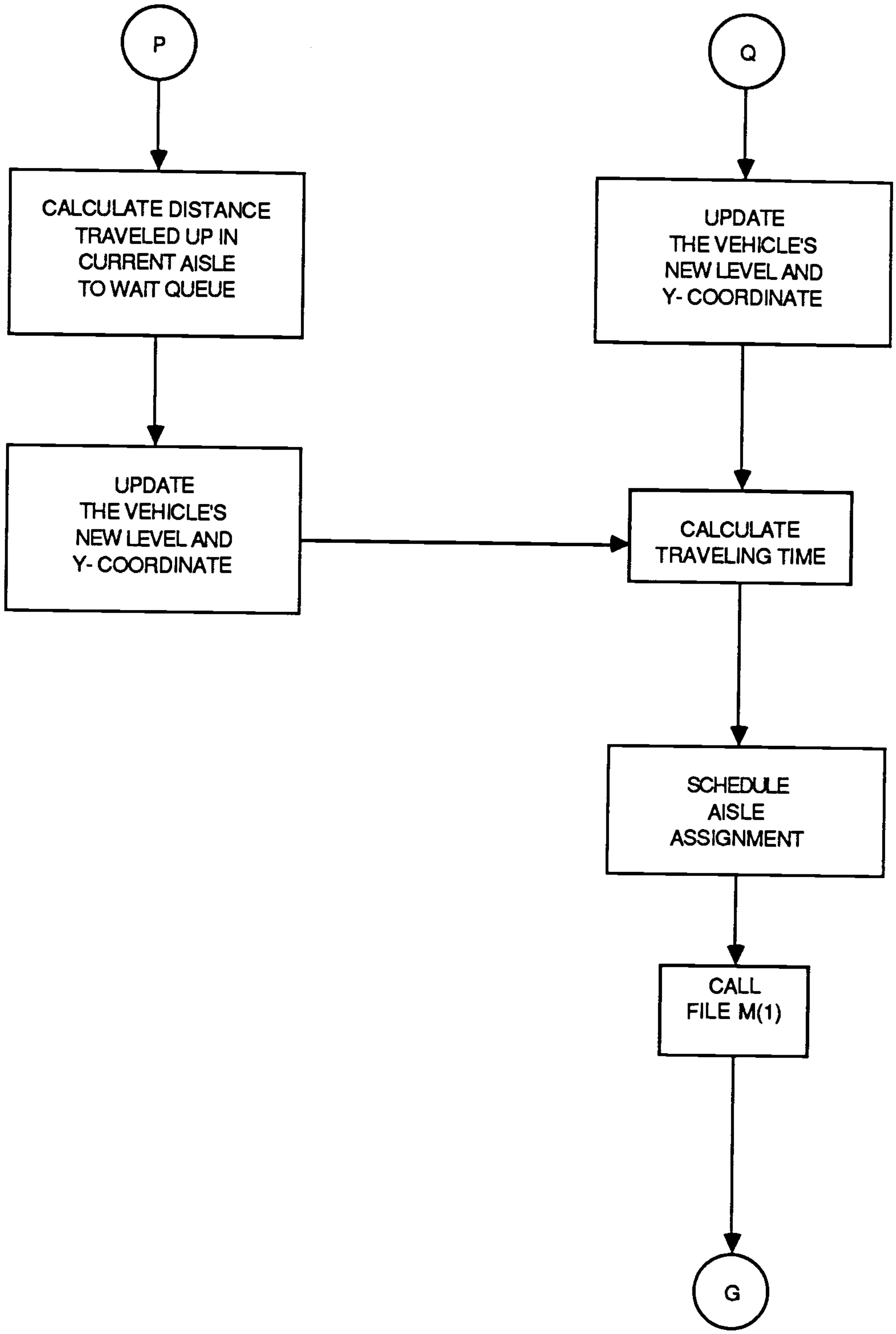
B - 17 "PICK " (Continued)



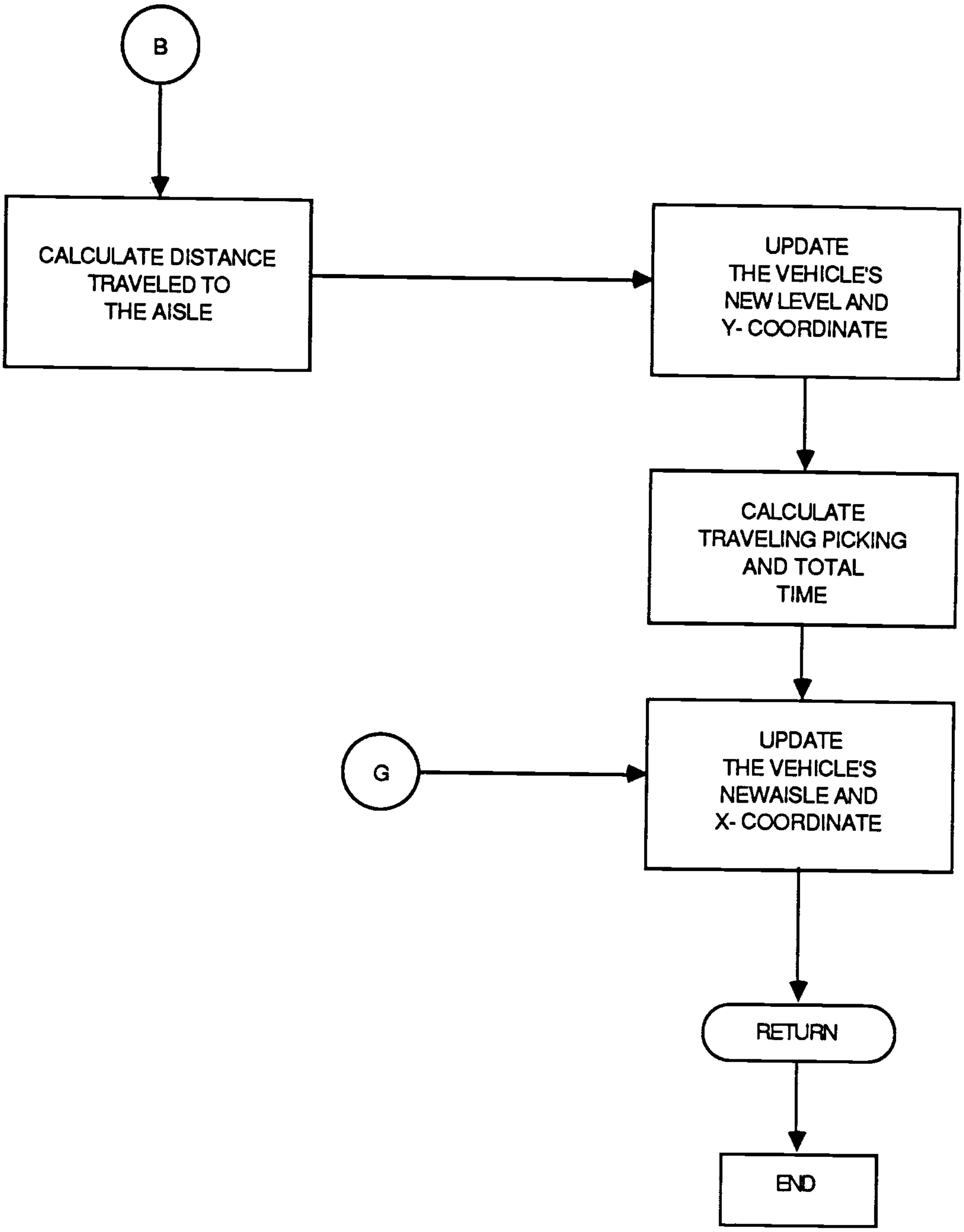
B - 17 "PICK " (Continued)



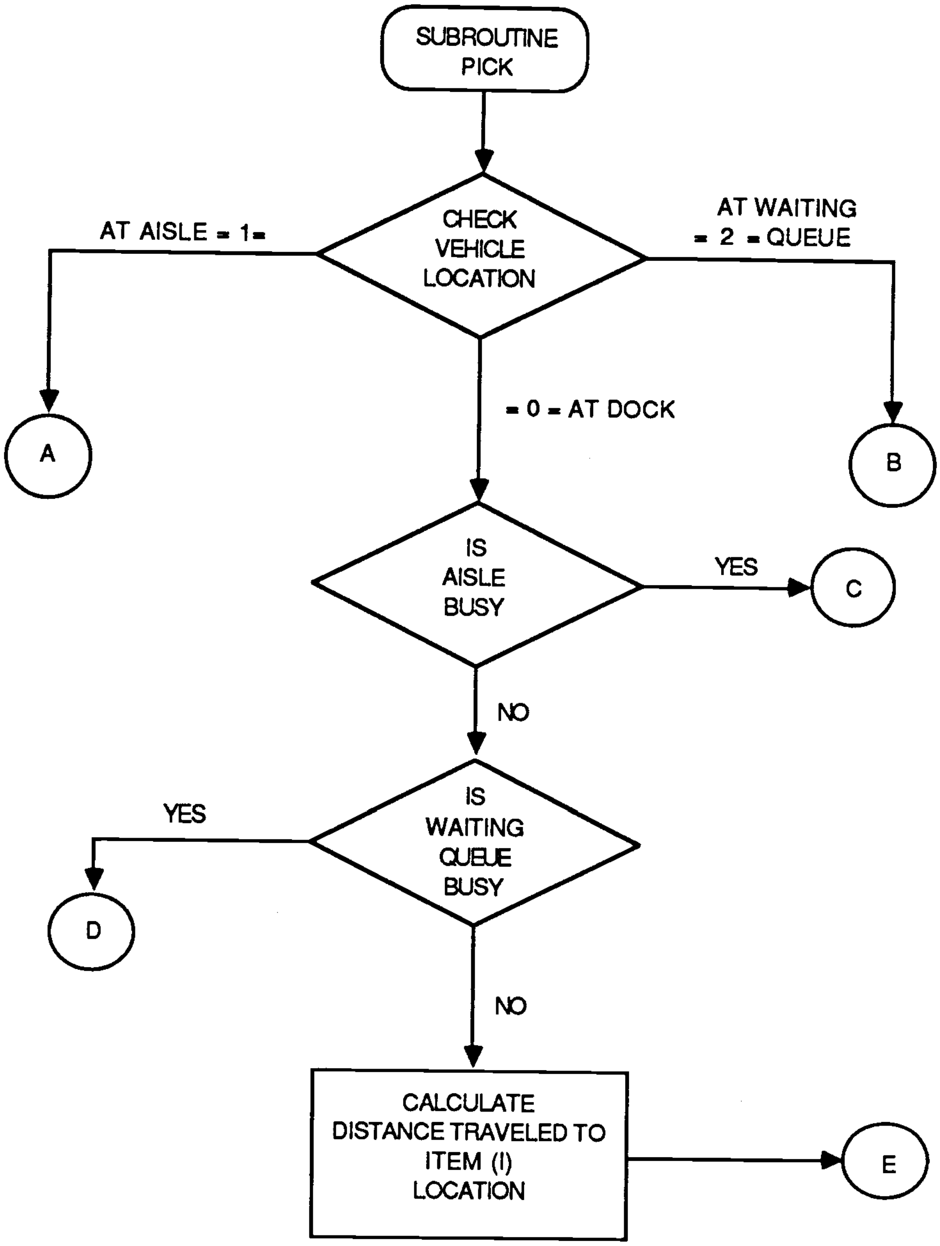
B - 17 "PICK " (Continued)



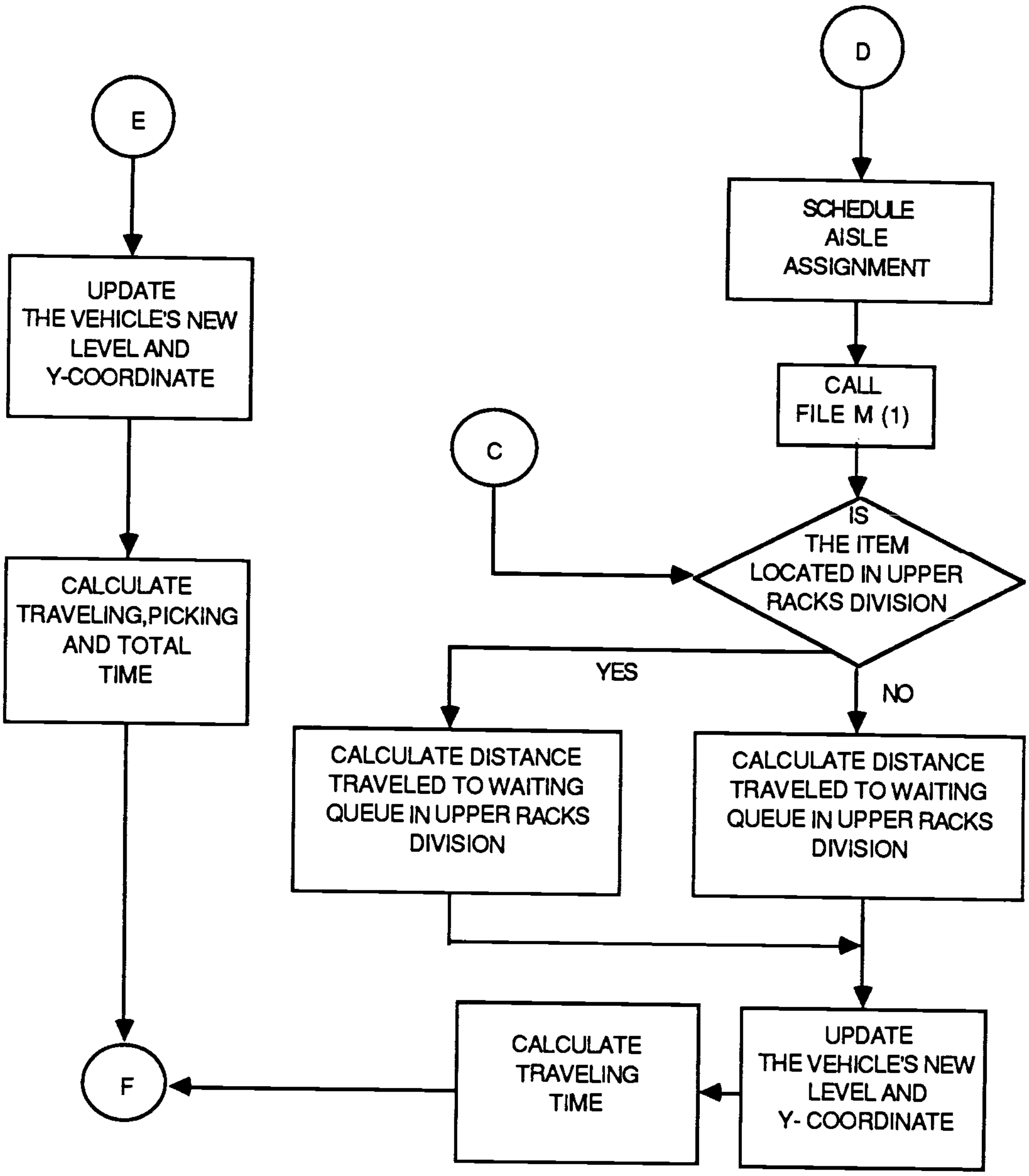
B - 17 "PICK " (Continued)



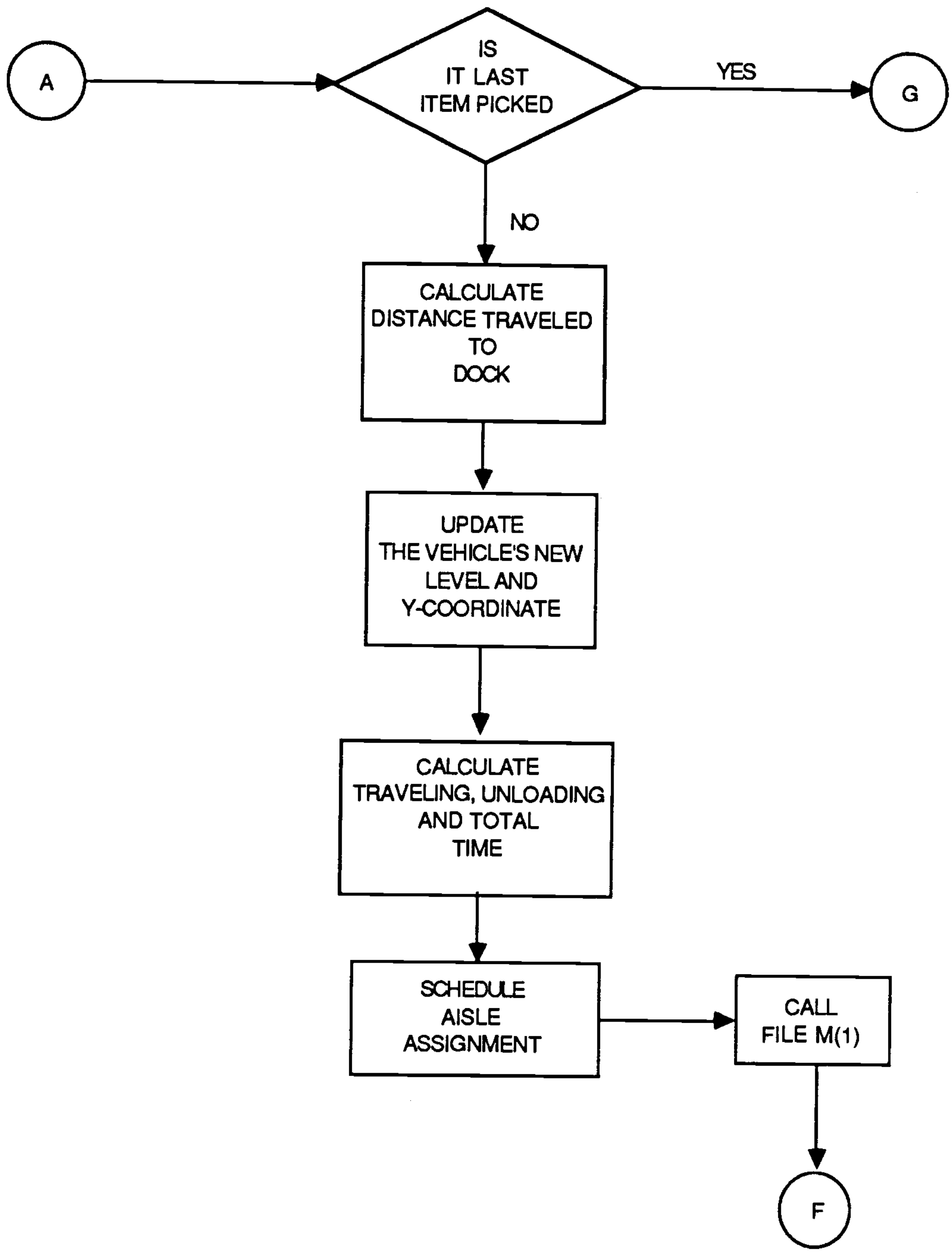
B - 17 "PICK " (Continued)



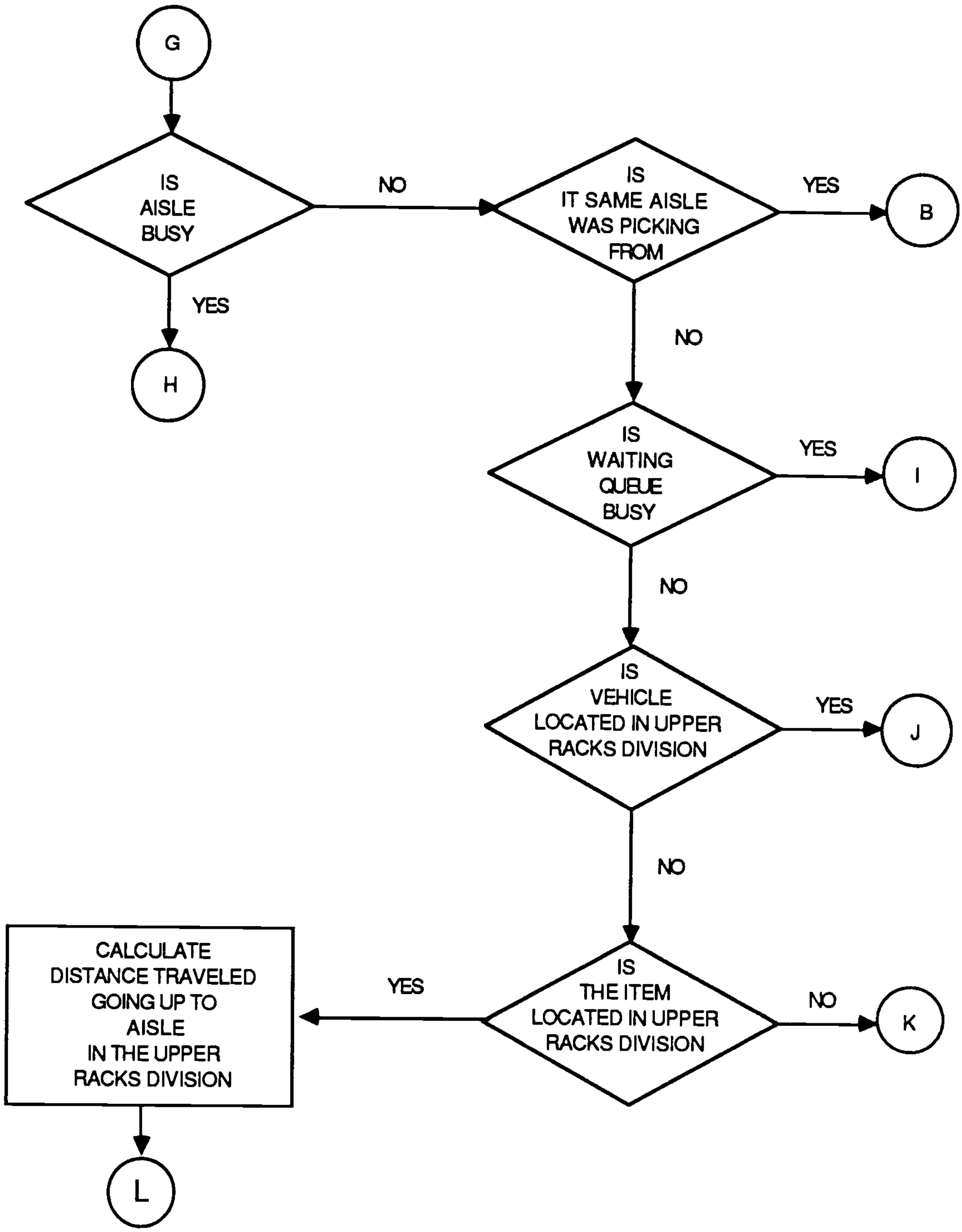
B -18 Flow Chart of Subroutine " PICK" used for Layouts 5,6,7 and 8



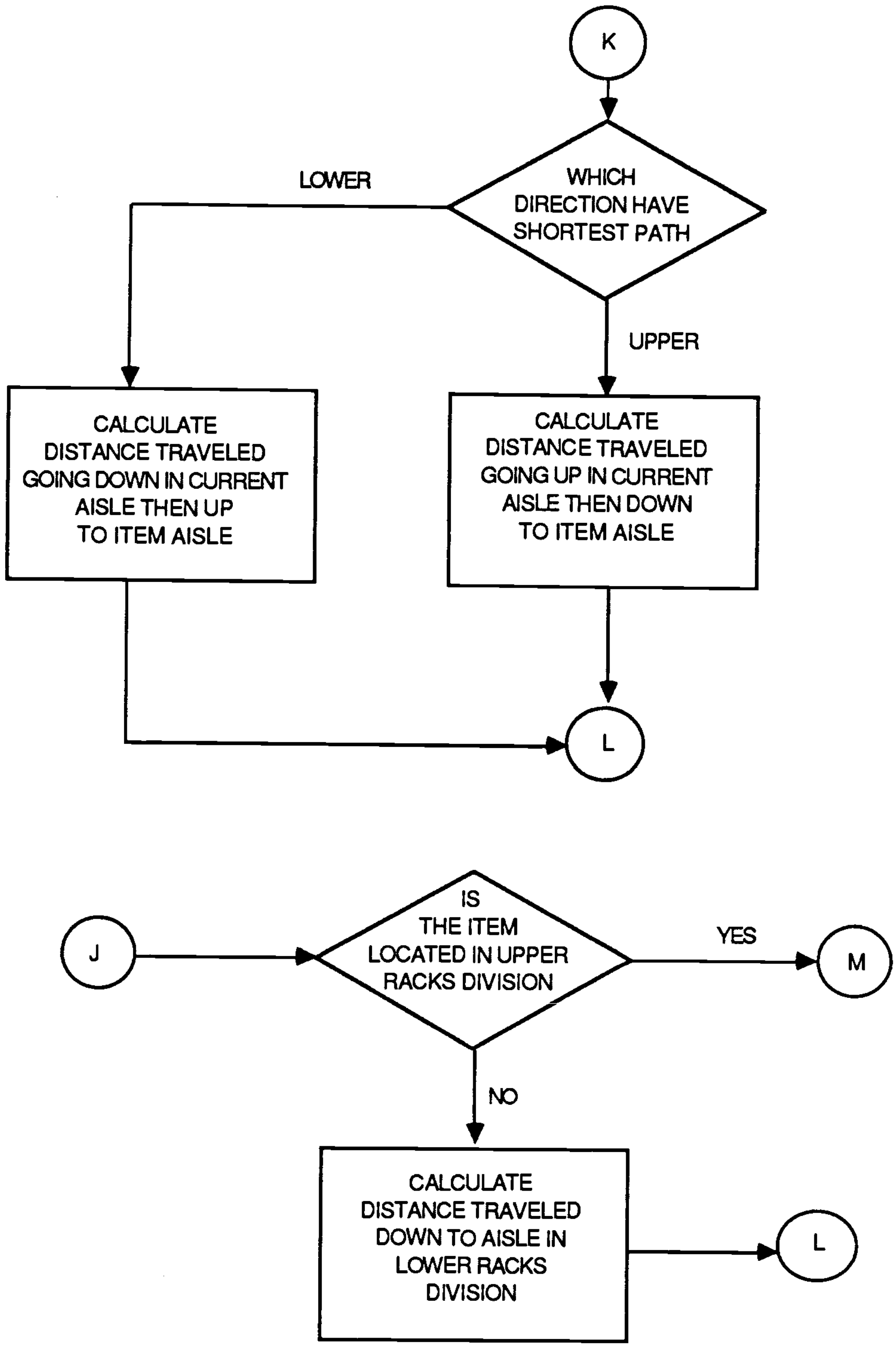
B - 18 "PICK " (Continued)



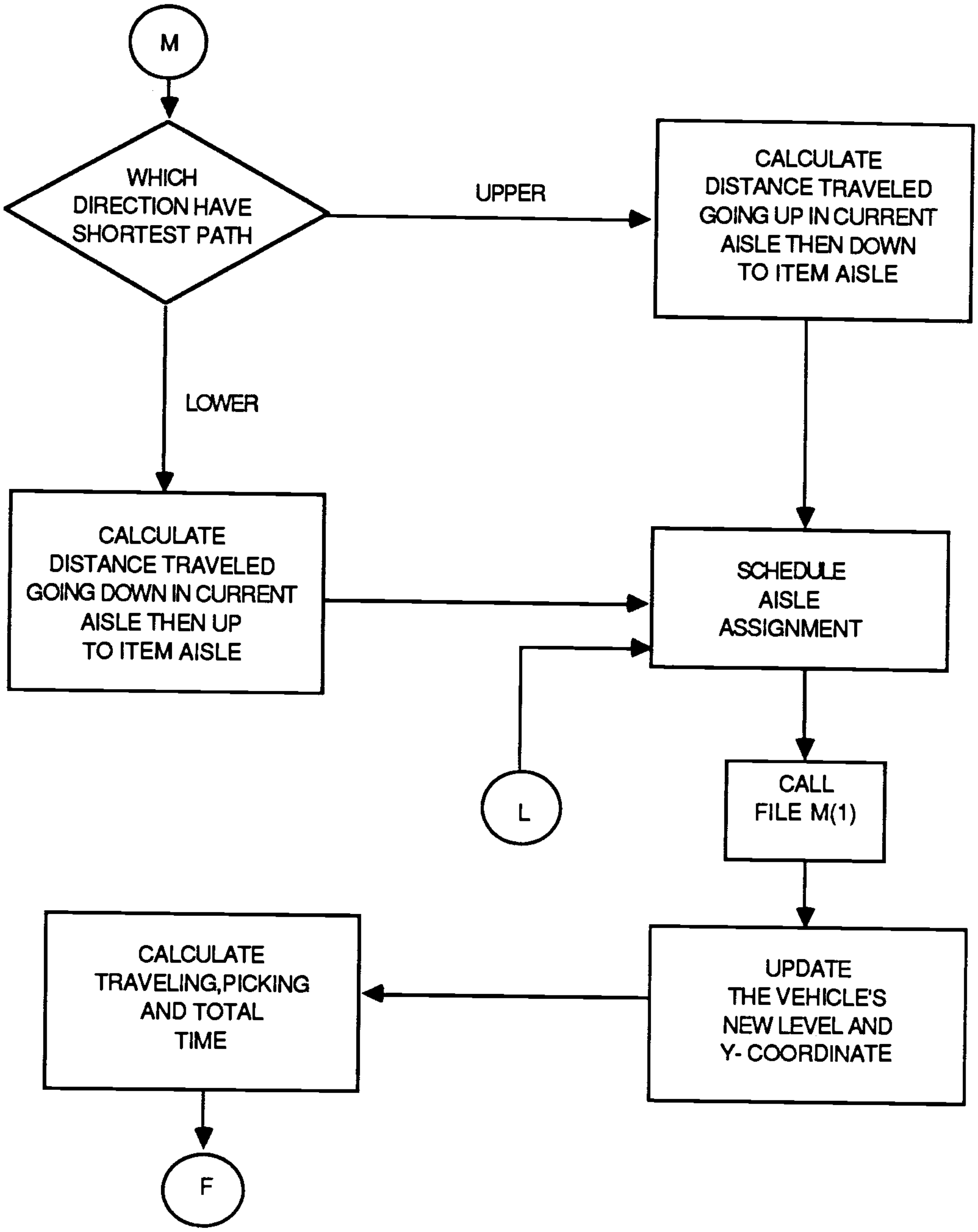
B - 18 "PICK " (Continued)



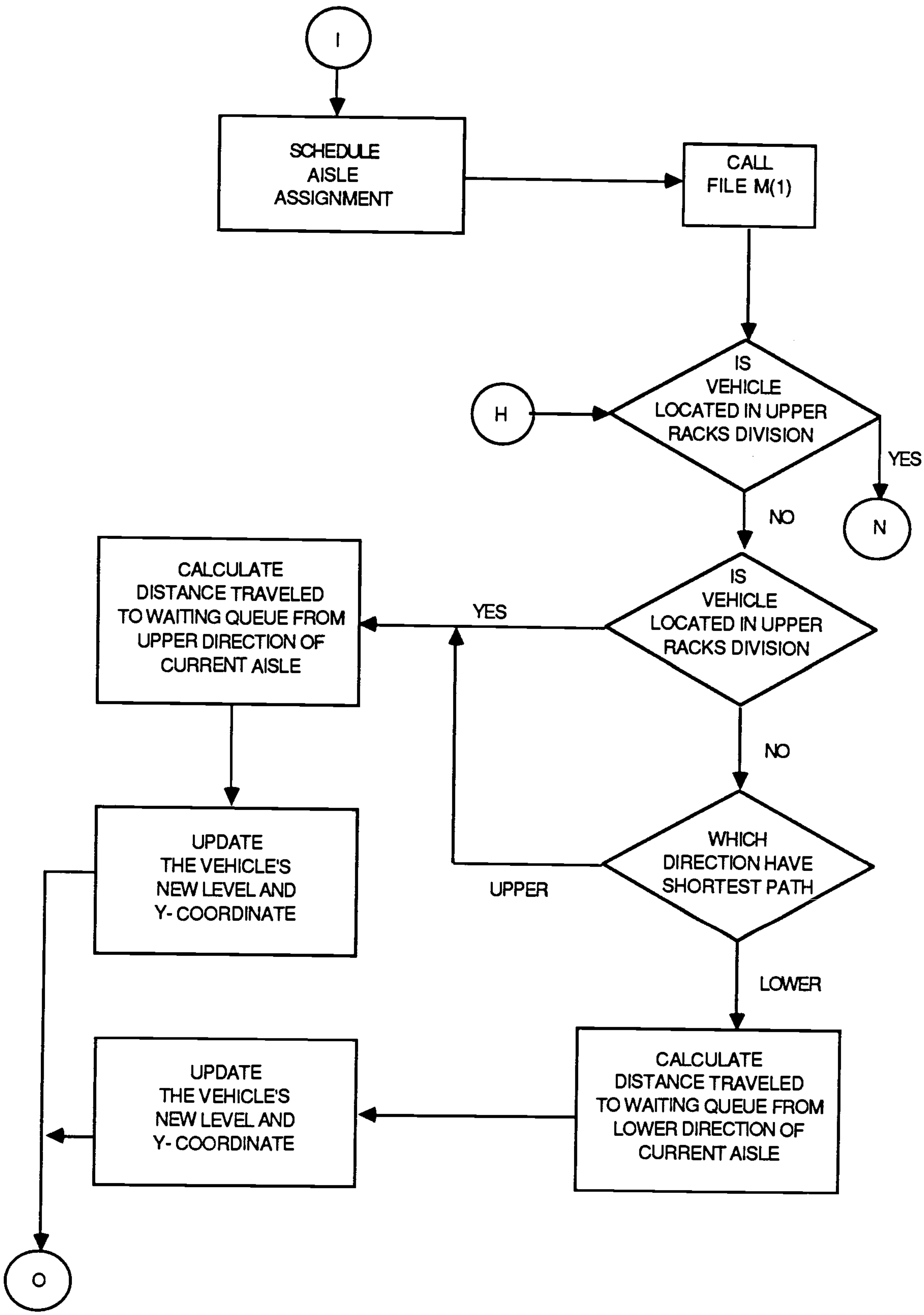
B - 18 "PICK " (Continued)



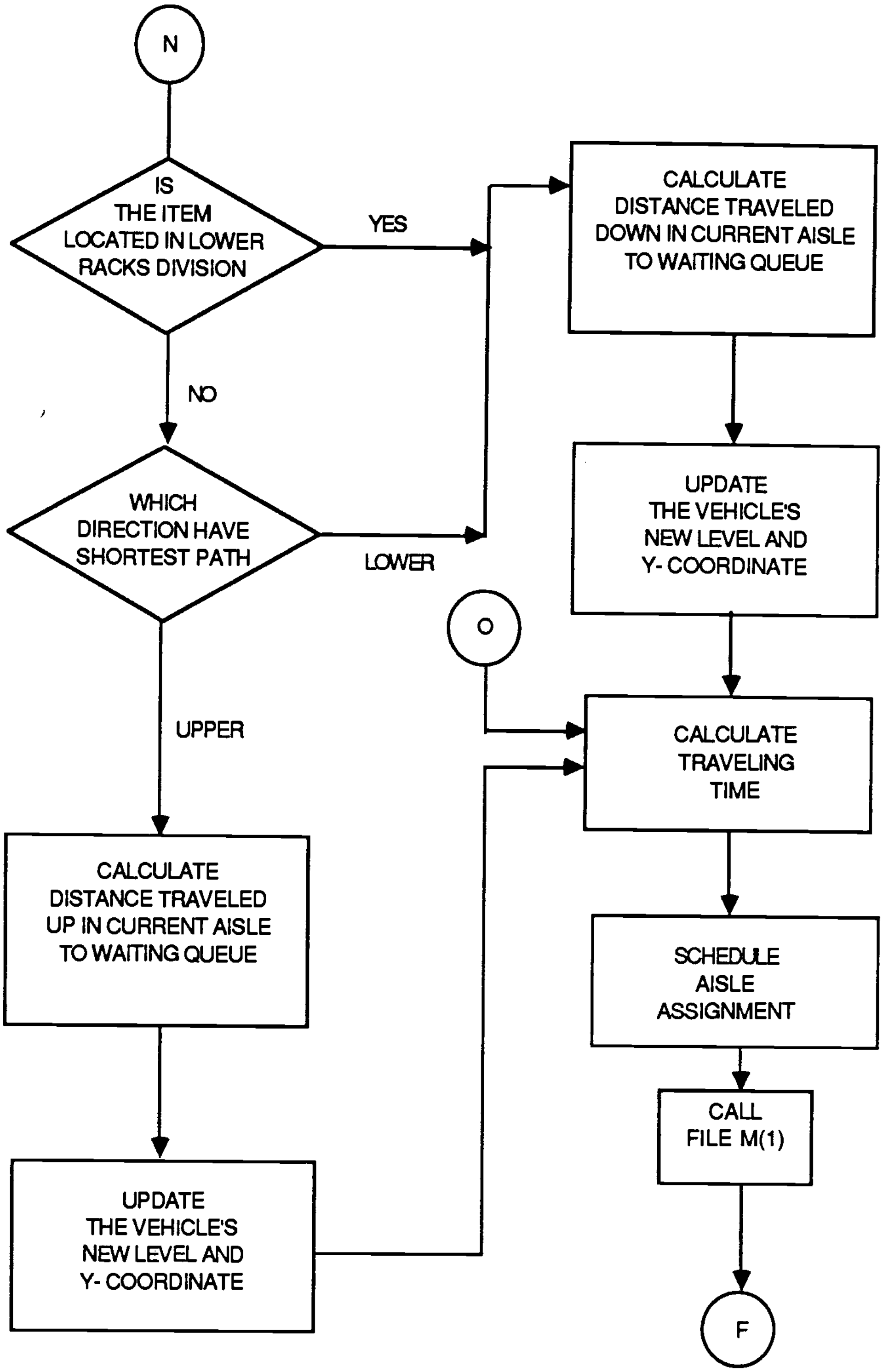
B-18 "PICK" (Continued)



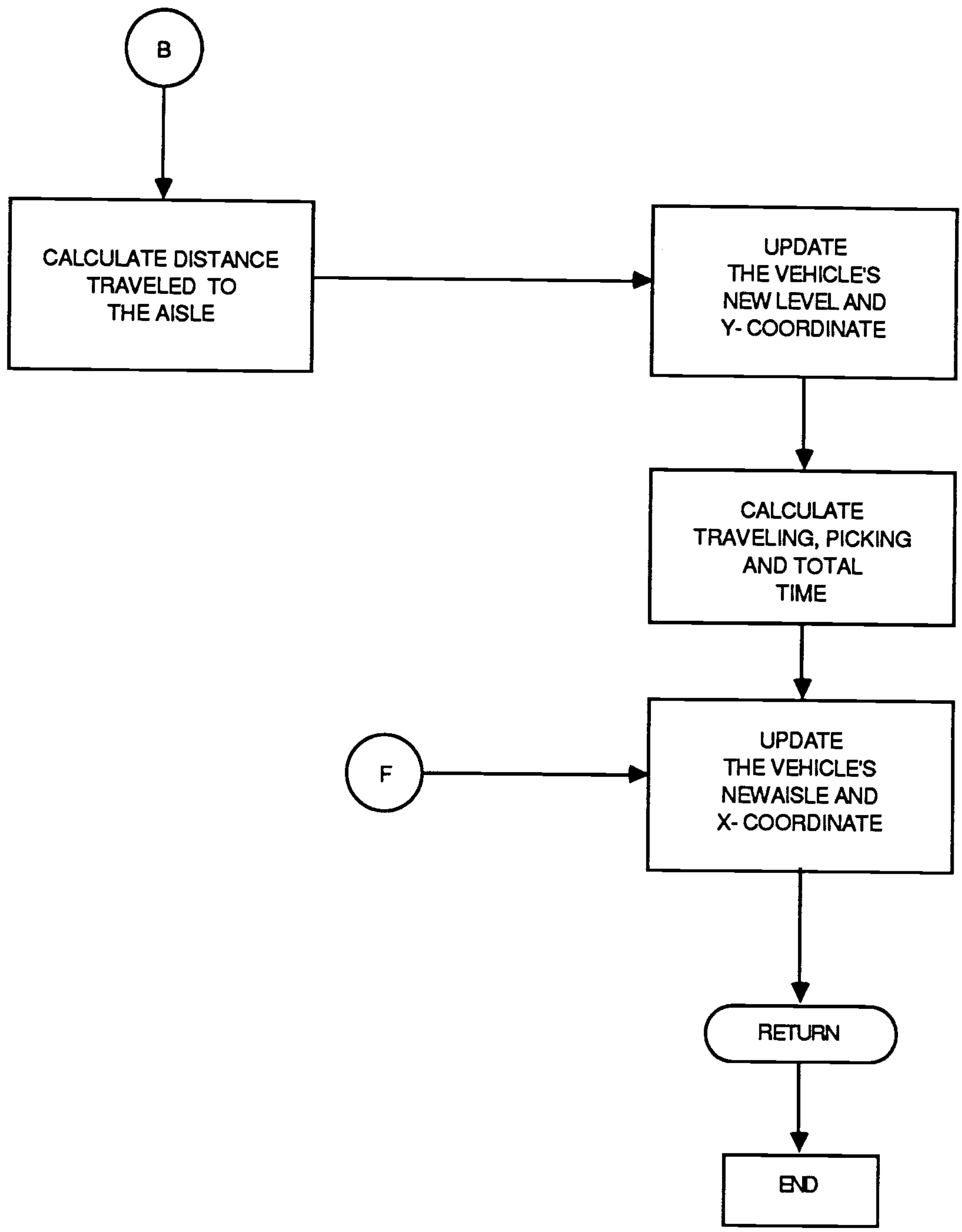
B-18 "PICK" (Continued)



B-18 "PICK" (Continued)



B-18 "PICK" (Continued)



B - 18 "PICK " (Continued)

APPENDIX C

Input Data and File Storage

```
GEN,Y. BENMAHMUD,1,4,20,1982,1,7,Y,Y, ,Y,Y*
STA,14,0,3,2*
LIM,2,3,50,6,33,1000*
COL,1,Q(1),2,Q(2)*
COL,3,TUN(1),4,TUN(2)*
COL,5,TVT(1),6,TVT(2)*
COL,7,TPT(1),8,TPT(2)*
COL,9,TWT(1),10,TWT(2)*
COL,11,SWT(1),12,SWT(2)*
COL,13,PCT(1),14,PCT(2)*
HIS,1,ITEM-FRQ,101,1.0,1.0*
HIS,2,UNITS,10,1.0,1.0*
HIS,3,ITEMS,20,1.0,1.0*
PLO,1,TIME,1,5,0,10*
VAR,1,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,1,2,P,PICK-TM,1,1,0.0,90.*
VAR,1,3,W,WAIT-TM,1,1,0.0,90.*
VAR,1,4,S,TRVL+WT,1,1,0.0,90.*
VAR,1,5,C,CYCLE-TM,1,1,0.0,90.*
PLO,2,TIME,2,5,0,10*
VAR,2,1,V,TRAVL-TM,1,1,0,0,90.*
VAR,2,2,P,PICK-TM,1,1,0.0,90.*
VAR,2,3,W,WAIT-TM,1,1,0.0,90.*
VAR,2,4,S,TRVL+WT,1,1,0.0,90.*
VAR,2,5,C,CYCLE-TM,1,1,0.0,90.*
PRI,1,LVF,1,2,LVF,3,3,LVF,3*
PRI,4,FIFO,5,5,FIFO,5,6,FIFO,5*
PRI,7,FIFO,5,8,FIFO,5,9,FIFO,5*
PRI,10,FIFO,5,11,FIFO,5,12,FIFO,5*
PRI,13,FIFO,5,14,FIFO,5,15,FIFO,5*
PRI,16,FIFO,5,17,FIFO,5,18,FIFO,5*
PRI,19,FIFO,5,20,FIFO,5,21,FIFO,5*
PRI,22,FIFO,5,23,FIFO,5,24,FIFO,5*
PRI,25,FIFO,5,26,FIFO,5,27,FIFO,5*
PRI,28,FIFO,5,29,FIFO,5,30,FIFO,5*
PRI,31,FIFO,5,32,FIFO,5,33,FIFO,5*
PAR,1,9.,1.,20.*
PAR,2,4.,1.,10.*
INI,1,Y,Y,0,0,3000,,Y*
SEE,41981,11854,97339*
ENT,1,0.0,1.,0.0,0.0,1.,0.0,1,0.0,1.,0.0,0.0,2.,0.0*
FIN*
```

C-1 General Input for Layout (1)

```
GEN,Y. BENMAHMUD,2.4,20,1982,1.7,Y,Y, ,Y,Y*
STA,14,0.3,2*
LIM,2,3,50,6,23,1000*
COL,1,Q(1),2,Q(2)*
COL,3,TUN(1),4,TUN(2)*
COL,5,TVT(1),6,TVT(2)*
COL,7,TPT(1),8,TPT(2)*
COL,9,TWT(1),10,TWT(2)*
COL,11,SVWT(1),12,SVWT(2)*
COL,13,PCT(1),14,PCT(2)*
HIS,1,ITEM-FRQ,101,1.0,1.0*
HIS,2,UNITS,10,1.0,1.0*
HIS,3,ITEMS,20,1.0,1.0*
PLO,1,TIME,1,5,0,10*
VAR,1,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,1,2,P,PICK-TM,1,1,0.0,90.*
VAR,1,3,W,WAIT-TM,1,1,0.0,90.*
VAR,1,4,S,TRVL+WT,1,1,0.0,90.*
VAR,1,5,C,CYCLE-TM,1,1,0.0,90.*
PLO,2,TIME,2,5,0,10*
VAR,2,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,2,2,P,PICK-TM,1,1,0.0,90.*
VAR,2,3,W,WAIT-TM,1,1,0.0,90.*
VAR,2,4,S,TRVL+WT,1,1,0.0,90.*
VAR,2,5,C,CYCLE-TM,1,1,0.0,90.*
PRI,1,LVF,1,2,LVF,3,3,LVF,3*
PRI,4,FIFO,5,5,FIFO,5,6,FIFO,5*
PRI,7,FIFO,5,8,FIFO,5,9,FIFO,5*
PRI,10,FIFO,5,11,FIFO,5,12,FIFO,5*
PRI,13,FIFO,5,14,FIFO,5,15,FIFO,5*
PRI,16,FIFO,5,17,FIFO,5,18,FIFO,5*
PRI,19,FIFO,5,20,FIFO,5,21,FIFO,5*
PRI,22,FIFO,5,23,FIFO,5*
PAR,1,3.,1.,20.*
PAR,2,4.,1.,10.*
INI,1,Y,Y,0.0,3000.,Y*
SEE,41981,11854,97339*
ENT,1,0.0,1.,0.0,0.0,1.,0.0,1,0.0,1.,0.0.0.0,2.,0.0*
FIN*
```

C-2 General Input for Layout (2)

```
GEN,Y. BENMAHMUD,3,4,20,1982,1,7,Y,Y, ,Y,Y*
STA,14,0,3,2*
LIM,2,3,50,6,19,1000*
COL,1,Q(1),2,Q(2)*
COL,3,TUN(1),4,TUN(2)*
COL,5,TVT(1),6,TVT(2)*
COL,7,TPT(1),8,TPT(2)*
COL,9,TWT(1),10,TWT(2)*
COL,11,SVWT(1),12,SVWT(2)*
COL,13,PCT(1),14,PCT(2)*
HIS,1,ITEM-FRQ,101,1.0,1.0*
HIS,2,UNITS,10,1.0,1.0*
HIS,3,ITEMS,20,1.0,1.0*
PLO,1,TIME,1,5,0,10*
VAR,1,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,1,2,P,PICK-TM,1,1,0.0,90.*
VAR,1,3,W,WAIT-TM,1,1,0.0,90.*
VAR,1,4,S,TRVL+WT,1,1,0.0,90.*
VAR,1,5,C,CYCLE-TM,1,1,0.0,90.*
PLO,2,TIME,2,5,0,10*
VAR,2,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,2,2,P,PICK-TM,1,1,0.0,90.*
VAR,2,3,W,WAIT-TM,1,1,0.0,90.*
VAR,2,4,S,TRVL+WT,1,1,0.0,90.*
VAR,2,5,C,CYCLE-TM,1,1,0.0,90.*
PRI,1,LVF,1,2,LVF,3,3,LVF,3*
PRI,4,FIFO,5,5,FIFO,5,6,FIFO,5*
PRI,7,FIFO,5,8,FIFO,5,9,FIFO,5*
PRI,10,FIFO,5,11,FIFO,5,12,FIFO,5*
PRI,13,FIFO,5,14,FIFO,5,15,FIFO,5*
PRI,16,FIFO,5,17,FIFO,5,18,FIFO,5*
PRI,19,FIFO,5*
PAR,1,9.,1.,20.*
PAR,2,4.,1.,10.*
INI,1,Y,Y,0.0,3000.,Y*
SEE,41981.11854.97339*
ENT,1,0.0,1.,0.0,0.0,1.,0.0,1,0.0,1.,0.0,0.0,2.,0.0*
FIN*
```

C-3 General Input for Layout (3)

```
GEN,Y. BENMAHMUD,4,4,20,1982,1,7,Y,Y, ,Y,Y*
STA,14,0,3,2*
LIM,2,3,50,6,29,1000*
COL,1,Q(1),2,Q(2)*
COL,3,TUN(1),4,TUN(2)*
COL,5,TVT(1),6,TVT(2)*
COL,7,TPT(1),8,TPT(2)*
COL,9,TWT(1),10,TWT(2)*
COL,11,SVWT(1),12,SVWT(2)*
COL,13,PCT(1),14,PCT(2)*
HIS,1,ITEM-FRQ,101,1.0,1.0*
HIS,2,UNITS,10,1.0,1.0*
HIS,3,ITEMS,20,1.0,1.0*
PLO,1,TIME,1,5,0,10*
VAR,1,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,1,2,P,PICK-TM,1,1,0.0,90.*
VAR,1,3,W,WAIT-TM,1,1,0.0,90.*
VAR,1,4,S,TRVL+WT,1,1,0.0,90.*
VAR,1,5,C,CYCLE-TM,1,1,0.0,90.*
PLO,2,TIME,2,5,0,10*
VAR,2,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,2,2,P,PICK-TM,1,1,0.0,90.*
VAR,2,3,W,WAIT-TM,1,1,0.0,90.*
VAR,2,4,S,TRVL+WT,1,1,0.0,90.*
VAR,2,5,C,CYCLE-TM,1,1,0.0,90.*
PRI,1,LVF,1,2,LVF,3,3,LVF,3*
PRI,4,FIFO,5,5,FIFO,5,6,FIFO,5*
PRI,7,FIFO,5,8,FIFO,5,9,FIFO,5*
PRI,10,FIFO,5,11,FIFO,5,12,FIFO,5*
PRI,13,FIFO,5,14,FIFO,5,15,FIFO,5*
PRI,16,FIFO,5,17,FIFO,5,18,FIFO,5*
PRI,19,FIFO,5,20,FIFO,5,21,FIFO,5*
PRI,22,FIFO,5,23,FIFO,5,24,FIFO,5*
PRI,25,FIFO,5,26,FIFO,5,27,FIFO,5*
PRI,28,FIFO,5,29,FIFO,5*
PAR,1,9.,1.,20.*
PAR,2,4.,1.,10.*
INI,1,Y,Y,0.0,3000.,Y*
SEE,41981,11854,97339*
ENT,1,0.0,1.,0.0,0.0,1.,0.0,1,0.0,1.,0.0,0.0,2.,0.0*
FIN*
```

C-4 General Input for Layout (4)

```
GEN,Y. BENMAHMUD,5,4,20,1982,1,7,Y,Y, ,Y,Y*
STA,14,0,3,2*
LIM,2,3,50,6,66,1000*
COL,1,Q(1),2,Q(2)*
COL,3,TUN(1),4,TUN(2)*
COL,5,TVT(1),6,TVT(2)*
COL,7,TPT(1),8,TPT(2)*
COL,9,TWT(1),10,TWT(2)*
COL,11,SVWI(1),12,SVWI(2)*
COL,13,PCT(1),14,PCT(2)*
HIS,1,ITEM-FRQ,101,1.0,1.0*
HIS,2,UNITS,10,1.0,1.0*
HIS,3,ITEMS,20,1.0,1.0*
PLO,1,TIME,1,5,0,10*
VAR,1,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,1,2,P,PICK-TM,1,1,0.0,90.*
VAR,1,3,W,WAIT-TM,1,1,0.0,90.*
VAR,1,4,S,TRVL+WT,1,1,0.0,90.*
VAR,1,5,C,CYCLE-TM,1,1,0.0,90.*
PLO,2,TIME,2,5,0,10*
VAR,2,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,2,2,P,PICK-TM,1,1,0.0,90.*
VAR,2,3,W,WAIT-TM,1,1,0.0,90.*
VAR,2,4,S,TRVL+WT,1,1,0.0,90.*
VAR,2,5,C,CYCLE-TM,1,1,0.0,90.*
PRI,1,LVF,1,2,LVF,3,3,LVF,3*
PRI,4,FIFO,5,5,FIFO,5,6,FIFO,5*
PRI,7,FIFO,5,8,FIFO,5,9,FIFO,5*
PRI,10,FIFO,5,11,FIFO,5,12,FIFO,5*
PRI,13,FIFO,5,14,FIFO,5,15,FIFO,5*
PRI,16,FIFO,5,17,FIFO,5,18,FIFO,5*
PRI,19,FIFO,5,20,FIFO,5,21,FIFO,5*
PRI,22,FIFO,5,23,FIFO,5,24,FIFO,5*
PRI,25,FIFO,5,26,FIFO,5,27,FIFO,5*
PRI,28,FIFO,5,29,FIFO,5,30,FIFO,5*
PRI,31,FIFO,5,32,FIFO,5,33,FIFO,5*
PRI,34,FIFO,5,35,FIFO,5,36,FIFO,5*
PRI,37,FIFO,5,38,FIFO,5,39,FIFO,5*
PRI,40,FIFO,5,41,FIFO,5,42,FIFO,5*
PRI,43,FIFO,5,44,FIFO,5,45,FIFO,5*
PRI,46,FIFO,5,47,FIFO,5,48,FIFO,5*
PRI,49,FIFO,5,50,FIFO,5,51,FIFO,5*
PRI,52,FIFO,5,53,FIFO,5,54,FIFO,5*
PRI,55,FIFO,5,56,FIFO,5,57,FIFO,5*
PRI,58,FIFO,5,59,FIFO,5,60,FIFO,5*
PRI,61,FIFO,5,62,FIFO,5,63,FIFO,5*
PAR,1,9.,1.,20.*
PAR,2,4.,1.,10.*
INI,1,Y,Y,0.0,3000.,Y*
SEE,41981,11854,97339*
ENT,1,0.0,1.,0.0,0.0,1.,0.0,1,0.0,1.,0.0,0.0,2.,0.0*
FIN*
```

C-5 General Input for Layout (5)

```
GEN,Y. BENMAHMUD,6,4,20,1982,1,7,Y,Y, ,Y,Y*
STA,14,0,3,2*
LIM,2,3,50,6,43,1000*
COL,1,Q(1),2,Q(2)*
COL,3,TUN(1),4,TUN(2)*
COL,5,TVT(1),6,TVT(2)*
COL,7,TPT(1),8,TPT(2)*
COL,9,TWT(1),10,TWT(2)*
COL,11,SVWT(1),12,SVWT(2)*
COL,13,PCT(1),14,PCT(2)*
HIS,1,ITEM-FRQ,101,1.0,1.0*
HIS,2,UNITS,10,1.0,1.0*
HIS,3,ITEMS,20,1.0,1.0*
PLO,1,TIME,1,5,0,10*
VAR,1,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,1,2,P,PICK-TM,1,1,0.0,90.*
VAR,1,3,W,WAIT-TM,1,1,0.0,90.*
VAR,1,4,S,TRVL+WT,1,1,0.0,90.*
VAR,1,5,C,CYCLE-TM,1,1,0.0,90.*
PLO,2,TIME,2,5,0,10*
VAR,2,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,2,2,P,PICK-TM,1,1,0.0,90.*
VAR,2,3,W,WAIT-TM,1,1,0.0,90.*
VAR,2,4,S,TRVL+WT,1,1,0.0,90.*
VAR,2,5,C,CYCLE-TM,1,1,0.0,90.*
PRI,1,LVF,1,2,LVF,3,3,LVF,3*
PRI,4,FIFO,5,5,FIFO,5,6,FIFO,5*
PRI,7,FIFO,5,8,FIFO,5,9,FIFO,5*
PRI,10,FIFO,5,11,FIFO,5,12,FIFO,5*
PRI,13,FIFO,5,14,FIFO,5,15,FIFO,5*
PRI,16,FIFO,5,17,FIFO,5,18,FIFO,5*
PRI,19,FIFO,5,20,FIFO,5,21,FIFO,5*
PRI,22,FIFO,5,23,FIFO,5,24,FIFO,5*
PRI,25,FIFO,5,26,FIFO,5,27,FIFO,5*
PRI,28,FIFO,5,29,FIFO,5,30,FIFO,5*
PRI,31,FIFO,5,32,FIFO,5,33,FIFO,5*
PRI,34,FIFO,5,35,FIFO,5,36,FIFO,5*
PRI,37,FIFO,5,38,FIFO,5,39,FIFO,5*
PRI,40,FIFO,5,41,FIFO,5,42,FIFO,5*
PRI,43,FIFO,5*
PAR,1,9.,1.,20.*
PAR,2,4.,1.,10.*
INI,1,Y,Y,0.0,3000.,Y*
SEE,41981,11854,97339*
ENT,1,0.0,1.,0.0,0.0,1.,0.0,1,0.0,1.,0.0,0.0,2.,0.0*
FIN*
```

C-6 General Input for Layout (6)

```
GEN,Y. BENHAHMUD,7,4,20,1982,1,7,Y,Y, ,Y,Y*
STA,14,0,3,2*
LIM,2,3,50,6,16,1000*
COL,1,Q(1),2,Q(2)*
COL,3,TUN(1),4,TUN(2)*
COL,5,TVT(1),6,TVT(2)*
COL,7,TPT(1),8,TPT(2)*
COL,9,TWT(1),10,TWT(2)*
COL,11,SVWT(1),12,SVWT(2)*
COL,13,PCT(1),14,PCT(2)*
HIS,1,ITEM-FRQ,101,1,0,1.0*
HIS,2,UNITS,10,1.0,1.0*
HIS,3,ITEMS,20,1.0,1.0*
PLO,1,TIME,1,5,0,10*
VAR,1,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,1,2,P,PICK-TM,1,1,0.0,90.*
VAR,1,3,W,WAIT-TM,1,1,0.0,90.*
VAR,1,4,S,TRVL+WT,1,1,0.0,90.*
VAR,1,5,C,CYCLE-TM,1,1,0.0,90.*
PLO,2,TIME,2,5,0,10*
VAR,2,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,2,2,P,PICK-TM,1,1,0.0,90.*
VAR,2,3,W,WAIT-TM,1,1,0.0,90.*
VAR,2,4,S,TRVL+WT,1,1,0.0,90.*
VAR,2,5,C,CYCLE-TM,1,1,0.0,90.*
PRI,1,LVF,1,2,LVF,3,3,LVF,3*
PRI,4,FIFO,5,5,FIFO,5,6,FIFO,5*
PRI,7,FIFO,5,8,FIFO,5,9,FIFO,5*
PRI,10,FIFO,5,11,FIFO,5,12,FIFO,5*
PRI,13,FIFO,5,14,FIFO,5,15,FIFO,5*
PRI,16,FIFO,5,17,FIFO,5,18,FIFO,5*
PRI,19,FIFO,5,20,FIFO,5,21,FIFO,5*
PRI,22,FIFO,5,23,FIFO,5,24,FIFO,5*
PRI,25,FIFO,5,26,FIFO,5,27,FIFO,5*
PRI,28,FIFO,5,29,FIFO,5,30,FIFO,5*
PRI,31,FIFO,5,32,FIFO,5,33,FIFO,5*
PRI,34,FIFO,5,35,FIFO,5*
PAR,1,9.,1.,20.*
PAR,2,4.,1.,10.*
INI,1,Y,Y,0.0,3000.,Y*
SEE,41981,11854,97339*
ENT,1,0.0,1.,0.0,0.0,1.,0.0,1,0.0,1.,0.0,0.0,2.,0.0*
FIN*
```

C-7 General Input for Layout (7)

```
GEN,Y. BENMAHMUD,8,4,20,1982,1,7,Y,Y, ,Y,Y*
STA,14,0,3,2*
LIM,2,3,50,6,26,1000*
COL,1,Q(1),2,Q(2)*
COL,3,TUN(1),4,TUN(2)*
COL,5,TVT(1),6,TVT(2)*
COL,7,TPT(1),8,TPT(2)*
COL,9,TWT(1),10,TWT(2)*
COL,11,SVWT(1),12,SVWT(2)*
COL,13,PCT(1),14,FCT(2)*
HIS,1,ITEM-FRQ,101,1.0,1.0*
HIS,2,UNITS,10,1.0,1.0*
HIS,3,ITEMS,20,1.0,1.0*
PLO,1,TIME,1,5,0,10*
VAR,1,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,1,2,P,PICK-TM,1,1,0.0,90.*
VAP,1,3,W,WAIT-TM,1,1,0.0,90.*
VAR,1,4,S,TRVL+WT,1,1,0.0,90.*
VAR,1,5,C,CYCLE-TM,1,1,0.0,90.*
PLO,2,TIME,2,5,0,10*
VAR,2,1,V,TRAVL-TM,1,1,0.0,90.*
VAR,2,2,P,PICK-TM,1,1,0.0,90.*
VAR,2,3,W,WAIT-TM,1,1,0.0,90.*
VAR,2,4,S,TRVL+WT,1,1,0.0,90.*
VAR,2,5,C,CYCLE-TM,1,1,0.0,90.*
PRI,1,LVF,1,2,LVF,3,3,LVF,3*
PRI,4,FIFO,5,5,FIFO,5,6,FIFO,5*
PRI,7,FIFO,5,8,FIFO,5,9,FIFO,5*
PRI,10,FIFO,5,11,FIFO,5,12,FIFO,5*
PRI,13,FIFO,5,14,FIFO,5,15,FIFO,5*
PRI,16,FIFO,5,17,FIFO,5,18,FIFO,5*
PRI,19,FIFO,5,20,FIFO,5,21,FIFO,5*
PRI,22,FIFO,5,23,FIFO,5,24,FIFO,5*
PRI,25,FIFO,5,26,FIFO,5,27,FIFO,5*
PRI,28,FIFO,5,29,FIFO,5,30,FIFO,5*
PRI,31,FIFO,5,32,FIFO,5,33,FIFO,5*
PRI,34,FIFO,5,35,FIFO,5,36,FIFO,5*
PRI,37,FIFO,5,38,FIFO,5,39,FIFO,5*
PRI,40,FIFO,5,41,FIFO,5,42,FIFO,5*
PRI,43,FIFO,5,44,FIFO,5,45,FIFO,5*
PRI,46,FIFO,5,47,FIFO,5,48,FIFO,5*
PRI,49,FIFO,5,50,FIFO,5,51,FIFO,5*
PRI,52,FIFO,5,53,FIFO,5,54,FIFO,5*
PRI,55,FIFO,5*
PAR,1,9.,1.,20.*
PAR,2,4.,1.,10.*
INI,1,Y,Y,0.0,3000.,Y*
SEE,41981,11854,97339*
ENT,1,0.0,1.,0.0,0.0,1.,0.0,1,0.0,1.,0.0,0.0,2.,0.0*
FIN*
```

C-8 General Input for Layout (8)

0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	AISLE(I)
1.0000	1.0000	1.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	3.0000	
~~3.0000~~	~~3.0000~~	~~3.0000~~	~~3.0000~~	~~3.0000~~	~~4.0000~~	~~4.0000~~	~~4.0000~~	~~4.0000~~	~~4.0000~~	
4.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	6.0000	6.0000	6.0000	
6.0000	6.0000	6.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	8.0000	
8.0000	8.0000	8.0000	8.0000	8.0000	9.0000	9.0000	9.0000	9.0000	9.0000	
9.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	11.0000	11.0000	11.0000	
11.0000	11.0000	11.0000	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	13.0000	
~~13.0000~~	~~13.0000~~	~~13.0000~~	~~13.0000~~	~~13.0000~~	~~14.0000~~	~~14.0000~~	~~14.0000~~	~~14.0000~~	~~14.0000~~	
14.0000	15.0000	15.0000	15.0000	15.0000	15.0000	15.0000	15.0000	15.0000	15.0000	
15.0000										
-4.0000	-3.0000	-3.0000	-2.0000	-2.0000	-1.0000	-1.0000	1.0000	1.0000	2.0000	HLV(I)
2.0000	3.0000	3.0000	3.0000	2.0000	1.0000	-1.0000	-2.0000	-3.0000	-3.0000	
-2.0000	-1.0000	1.0000	2.0000	3.0000	3.0000	2.0000	1.0000	-1.0000	-2.0000	
~~-3.0000~~	~~-3.0000~~	~~-2.0000~~	~~-1.0000~~	~~1.0000~~	~~2.0000~~	~~3.0000~~	~~3.0000~~	~~2.0000~~	~~1.0000~~	
-1.0000	-2.0000	-3.0000	-3.0000	-2.0000	-1.0000	1.0000	2.0000	3.0000	3.0000	
2.0000	1.0000	-1.0000	-2.0000	-3.0000	-3.0000	-2.0000	-1.0000	1.0000	2.0000	
3.0000	3.0000	2.0000	1.0000	-1.0000	-2.0000	-3.0000	-3.0000	-2.0000	-1.0000	
1.0000	2.0000	3.0000	3.0000	2.0000	1.0000	-1.0000	-2.0000	-3.0000	-3.0000	
-2.0000	-1.0000	1.0000	2.0000	3.0000	3.0000	2.0000	1.0000	-1.0000	-2.0000	
~~-3.0000~~	~~-3.0000~~	~~-3.0000~~	~~-2.0000~~	~~-1.0000~~	~~-1.0000~~	~~1.0000~~	~~1.0000~~	~~2.0000~~	~~3.0000~~	
3.0000										
210.0000	406.0000	406.0000	406.0000	406.0000	406.0000	406.0000	406.0000	406.0000	406.0000	X(I)
406.0000	406.0000	406.0000	378.0000	378.0000	378.0000	378.0000	378.0000	378.0000	350.0000	
350.0000	350.0000	350.0000	350.0000	350.0000	322.0000	322.0000	322.0000	322.0000	322.0000	
322.0000	294.0000	294.0000	294.0000	294.0000	294.0000	294.0000	266.0000	266.0000	266.0000	
~~266.0000~~	~~266.0000~~	~~266.0000~~	~~238.0000~~	~~238.0000~~	~~238.0000~~	~~238.0000~~	~~238.0000~~	~~238.0000~~	~~238.0000~~	
210.0000	210.0000	210.0000	210.0000	210.0000	182.0000	182.0000	182.0000	182.0000	182.0000	
182.0000	154.0000	154.0000	154.0000	154.0000	154.0000	154.0000	126.0000	126.0000	126.0000	
126.0000	126.0000	126.0000	98.0000	98.0000	98.0000	98.0000	98.0000	98.0000	70.0000	
70.0000	70.0000	70.0000	70.0000	70.0000	42.0000	42.0000	42.0000	42.0000	42.0000	
42.0000	14.0000	14.0000	14.0000	14.0000	14.0000	14.0000	14.0000	14.0000	14.0000	
14.0000										
44.0000	68.0000	68.0000	100.0000	100.0000	132.0000	132.0000	168.0000	168.0000	208.0000	Y(I)
208.0000	244.0000	244.0000	244.0000	208.0000	168.0000	132.0000	100.0000	68.0000	68.0000	
~~100.0000~~	~~132.0000~~	~~168.0000~~	~~208.0000~~	~~244.0000~~	~~244.0000~~	~~208.0000~~	~~168.0000~~	~~132.0000~~	~~100.0000~~	
68.0000	68.0000	100.0000	132.0000	168.0000	208.0000	244.0000	244.0000	208.0000	168.0000	
132.0000	100.0000	68.0000	68.0000	100.0000	132.0000	168.0000	208.0000	244.0000	244.0000	
208.0000	168.0000	132.0000	100.0000	68.0000	68.0000	100.0000	132.0000	168.0000	208.0000	
244.0000	244.0000	208.0000	168.0000	132.0000	100.0000	68.0000	68.0000	100.0000	132.0000	
168.0000	208.0000	244.0000	244.0000	208.0000	168.0000	132.0000	100.0000	68.0000	68.0000	
~~100.0000~~	~~132.0000~~	~~168.0000~~	~~208.0000~~	~~244.0000~~	~~244.0000~~	~~208.0000~~	~~168.0000~~	~~132.0000~~	~~100.0000~~	
58.0000	68.0000	68.0000	100.0000	132.0000	132.0000	168.0000	168.0000	208.0000	244.0000	
244.0000										
0.0000	.0030	.0060	.0080	.0100	.0110	.0120	.0128	.0136	.0146	FX(I)
.0148	.0153	.0158	.0164	.0171	.0181	.0201	.0221	.0271	.0351	
.0391	.0411	.0421	.0431	.0438	.0446	.0456	.0476	.0516	.0586	
~~.0726~~	~~.0966~~	~~.1066~~	~~.1126~~	~~.1146~~	~~.1166~~	~~.1176~~	~~.1186~~	~~.1206~~	~~.1246~~	
.1346	.1586	.2136	.3336	.3736	.3916	.3976	.4016	.4036	.4076	
.4136	.4236	.4526	.5176	.6476	.7576	.7926	.8066	.8126	.8166	
.8186	.8196	.8216	.8256	.8336	.8516	.8916	.9156	.9256	.9316	
.9336	.9356	.9366	.9374	.9384	.9404	.9444	.9514	.9614	.9694	
.9734	.9754	.9764	.9772	.9778	.9783	.9790	.9800	.9820	.9840	
~~.9890~~	~~.9910~~	~~.9930~~	~~.9950~~	~~.9960~~	~~.9970~~	~~.9977~~	~~.9984~~	~~.9990~~	~~.9995~~	
1.0000										
1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000	8.0000	9.0000	10.0000	XIN(I)
11.0000	12.0000	13.0000	14.0000	15.0000	16.0000	17.0000	18.0000	19.0000	20.0000	
21.0000	22.0000	23.0000	24.0000	25.0000	26.0000	27.0000	28.0000	29.0000	30.0000	
31.0000	32.0000	33.0000	34.0000	35.0000	36.0000	37.0000	38.0000	39.0000	40.0000	
~~41.0000~~	~~42.0000~~	~~43.0000~~	~~44.0000~~	~~45.0000~~	~~46.0000~~	~~47.0000~~	~~48.0000~~	~~49.0000~~	~~50.0000~~	
51.0000	52.0000	53.0000	54.0000	55.0000	56.0000	57.0000	58.0000	59.0000	60.0000	
61.0000	62.0000	63.0000	64.0000	65.0000	66.0000	67.0000	68.0000	69.0000	70.0000	
71.0000	72.0000	73.0000	74.0000	75.0000	76.0000	77.0000	78.0000	79.0000	80.0000	
81.0000	82.0000	83.0000	84.0000	85.0000	86.0000	87.0000	88.0000	89.0000	90.0000	
91.0000	92.0000	93.0000	94.0000	95.0000	96.0000	97.0000	98.0000	99.0000	100.0000	
~~101.0000~~										

C-9 Input Data for Layout (1)

```
    5.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000    1.0000
    1.0000    2.0000    2.0000    2.0000    2.0000    2.0000    2.0000    2.0000    2.0000    2.0000
    2.0000    3.0000    3.0000    3.0000    3.0000    3.0000    3.0000    3.0000    3.0000    3.0000
    3.0000    4.0000    4.0000    4.0000    4.0000    4.0000    4.0000    4.0000    4.0000    4.0000
    4.0000    5.0000    5.0000    5.0000    5.0000    5.0000    5.0000    5.0000    5.0000    5.0000
    5.0000    6.0000    6.0000    6.0000    6.0000    6.0000    6.0000    6.0000    6.0000    6.0000
    6.0000    7.0000    7.0000    7.0000    7.0000    7.0000    7.0000    7.0000    7.0000    7.0000
    7.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000    8.0000
    8.0000    9.0000    9.0000    9.0000    9.0000    9.0000    9.0000    9.0000    9.0000    9.0000
    9.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000   10.0000
   10.0000
```

AISLE(I)

```
   -6.0000   -5.0000   -4.0000   -3.0000   -2.0000   -1.0000    1.0000    2.0000    3.0000    4.0000
    5.0000    5.0000    4.0000    3.0000    2.0000    1.0000    1.0000   -2.0000   -3.0000   -4.0000
   -5.0000   -5.0000   -4.0000   -3.0000   -2.0000   -1.0000    1.0000    2.0000    3.0000    4.0000
    5.0000    5.0000    4.0000    3.0000    2.0000    1.0000   -1.0000   -2.0000   -3.0000   -4.0000
   -5.0000   -5.0000   -4.0000   -3.0000   -2.0000   -1.0000    1.0000    2.0000    3.0000    4.0000
    5.0000    5.0000    4.0000    3.0000    2.0000    1.0000   -1.0000   -2.0000   -3.0000   -4.0000
   -5.0000   -5.0000   -4.0000   -3.0000   -2.0000   -1.0000    1.0000    2.0000    3.0000    4.0000
    5.0000    5.0000    4.0000    3.0000    2.0000    1.0000    1.0000   -2.0000   -3.0000   -4.0000
   -5.0000   -5.0000   -4.0000   -3.0000   -2.0000   -1.0000    1.0000    2.0000    3.0000    4.0000
    5.0000    5.0000    4.0000    3.0000    2.0000    1.0000   -1.0000   -2.0000   -3.0000   -4.0000
   -5.0000
```

HLV(I)

```
  140.0000266.0000266.0000266.0000266.0000266.0000266.0000266.0000266.0000266.0000
  266.0000238.0000238.0000238.0000238.0000238.0000238.0000238.0000238.0000238.0000
  238.0000210.0000210.0000210.0000210.0000210.0000210.0000210.0000210.0000210.0000
  210.0000182.0000182.0000182.0000182.0000182.0000182.0000182.0000182.0000182.0000
  182.0000154.0000154.0000154.0000154.0000154.0000154.0000154.0000154.0000154.0000
  154.0000126.0000126.0000126.0000126.0000126.0000126.0000126.0000126.0000126.0000
  126.0000 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000
   98.0000 70.0000 70.0000 70.0000 70.0000 70.0000 70.0000 70.0000 70.0000 70.0000
   70.0000 42.0000 42.0000 42.0000 42.0000 42.0000 42.0000 42.0000 42.0000 42.0000
   42.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000
   14.0000
```

X(I)

```
   60.0000 84.0000116.0000148.0000180.0000212.0000260.0000292.0000324.0000356.0000
  388.0000388.0000356.0000324.0000292.0000260.0000212.0000180.0000148.0000116.0000
   84.0000 84.0000116.0000148.0000180.0000212.0000260.0000292.0000324.0000356.0000
  388.0000388.0000356.0000324.0000292.0000260.0000212.0000180.0000148.0000116.0000
   84.0000 84.0000116.0000148.0000180.0000212.0000260.0000292.0000324.0000356.0000
  388.0000388.0000356.0000324.0000292.0000260.0000212.0000180.0000148.0000116.0000
   84.0000 84.0000116.0000148.0000180.0000212.0000260.0000292.0000324.0000356.0000
  388.0000388.0000356.0000324.0000292.0000260.0000212.0000180.0000148.0000116.0000
   84.0000 84.0000116.0000148.0000180.0000212.0000260.0000292.0000324.0000356.0000
  388.0000388.0000356.0000324.0000292.0000260.0000212.0000180.0000148.0000116.0000
   84.0000
```

Y(I)

```
    0.0000     .0080     .0130     .0170     .0190     .0210     .0220     .0228     .0235     .0240
     .0245     .0250     .0256     .0264     .0274     .0294     .0314     .0344     .0394     .0464
     .0644     .0994     .1134     .1204     .1244     .1264     .1284     .1294     .1304     .1311
     .1317     .1324     .1334     .1344     .1364     .1384     .1424     .1484     .1584     .1824
     .2474     .3674     .4074     .4314     .4414     .4474     .4514     .4534     .4554     .4564
     .4574     .4584     .4594     .4614     .4634     .4674     .4734     .4834     .5074     .5524
     .6324     .8024     .8314     .8414     .8474     .8514     .8534     .8554     .8564     .8574
     .8581     .8587     .8595     .8605     .8625     .8645     .8665     .8705     .8775     .8915
     .9315     .9495     .9575     .9625     .9655     .9675     .9695     .9705     .9713     .9719
     .9724     .9729     .9735     .9742     .9750     .9760     .9780     .9800     .9840     .9900
    1.0000
```

FX(I)

```
    1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000    9.0000   10.0000
   11.0000   12.0000   13.0000   14.0000   15.0000   16.0000   17.0000   18.0000   19.0000   20.0000
   21.0000   22.0000   23.0000   24.0000   25.0000   26.0000   27.0000   28.0000   29.0000   30.0000
   31.0000   32.0000   33.0000   34.0000   35.0000   36.0000   37.0000   38.0000   39.0000   40.0000
   41.0000   42.0000   43.0000   44.0000   45.0000   46.0000   47.0000   48.0000   49.0000   50.0000
   51.0000   52.0000   53.0000   54.0000   55.0000   56.0000   57.0000   58.0000   59.0000   60.0000
   61.0000   62.0000   63.0000   64.0000   65.0000   66.0000   67.0000   68.0000   69.0000   70.0000
   71.0000   72.0000   73.0000   74.0000   75.0000   76.0000   77.0000   78.0000   79.0000   80.0000
   81.0000   82.0000   83.0000   84.0000   85.0000   86.0000   87.0000   88.0000   89.0000   90.0000
   91.0000   92.0000   93.0000   94.0000   95.0000   96.0000   97.0000   98.0000   99.0000  100.0000
  101.0000
```

XIN(I)

C-10 Input Data for Layout (2)

```
 0.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000
 1.0000   1.0000   1.0000   2.0000   2.0000   2.0000   2.0000   2.0000   2.0000   2.0000
 2.0000   2.0000   2.0000   2.0000   2.0000   3.0000   3.0000   3.0000   3.0000   3.0000
 3.0000   3.0000   3.0000   3.0000   3.0000   3.0000   3.0000   4.0000   4.0000   4.0000
 4.0000   4.0000   4.0000   4.0000   4.0000   4.0000   4.0000   4.0000   4.0000   5.0000
 5.0000   5.0000   5.0000   5.0000   5.0000   5.0000   5.0000   5.0000   5.0000   5.0000
 5.0000   6.0000   6.0000   6.0000   6.0000   6.0000   6.0000   6.0000   6.0000   6.0000
 6.0000   6.0000   6.0000   7.0000   7.0000   7.0000   7.0000   7.0000   7.0000   7.0000
 7.0000   7.0000   7.0000   7.0000   7.0000   8.0000   8.0000   8.0000   8.0000   8.0000
 8.0000   8.0000   8.0000   8.0000   8.0000   8.0000   8.0000   8.0000   8.0000   8.0000
 8.0000
 0.0000   5.0000   5.0000   3.0000   3.0000   1.0000   1.0000  -1.0000  -1.0000  -3.0000
-3.0000  -5.0000  -5.0000  -5.0000  -5.0000  -3.0000  -3.0000  -1.0000  -1.0000   1.0000
 1.0000   3.0000   3.0000   5.0000   5.0000   5.0000   5.0000   3.0000   3.0000   1.0000
 1.0000  -1.0000  -1.0000  -3.0000  -3.0000  -5.0000  -5.0000  -5.0000  -5.0000  -3.0000
-3.0000  -1.0000  -1.0000   1.0000   1.0000   3.0000   3.0000   5.0000   5.0000   5.0000
 5.0000   3.0000   3.0000   1.0000   1.0000  -1.0000  -1.0000  -3.0000  -3.0000  -5.0000
-5.0000  -5.0000  -5.0000  -3.0000  -3.0000  -1.0000  -1.0000   1.0000   1.0000   3.0000
 3.0000   5.0000   5.0000   5.0000   5.0000   3.0000   3.0000   1.0000   1.0000  -1.0000
-1.0000  -3.0000  -3.0000  -5.0000  -5.0000  -5.0000  -5.0000  -4.0000  -4.0000  -2.0000
-2.0000  -1.0000  -1.0000   1.0000   1.0000   2.0000   2.0000   4.0000   4.0000   5.0000
 5.0000
232.0000210.0000210.0000210.0000210.0000210.0000210.0000210.0000210.0000210.0000
210.0000210.0000210.0000192.0000192.0000192.0000182.0000182.0000182.0000182.0000
192.0000182.0000192.0000192.0000192.0000154.0000154.0000154.0000154.0000154.0000
154.0000154.0000154.0000154.0000154.0000154.0000154.0000126.0000126.0000126.0000
126.0000126.0000126.0000126.0000126.0000126.0000126.0000126.0000126.0000 98.0000
 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000
 98.0000 70.0000 70.0000 70.0000 70.0000 70.0000 70.0000 70.0000 70.0000 70.0000
 70.0000 70.0000 70.0000 42.0000 42.0000 42.0000 42.0000 42.0000 42.0000 42.0000
 42.0000 42.0000 42.0000 42.0000 42.0000 14.0000 14.0000 14.0000 14.0000 14.0000
 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000
 14.0000
212.0000380.0000380.0000312.0000312.0000240.0000240.0000180.0000180.0000112.0000
112.0000 48.0000 48.0000 48.0000 48.0000112.0000112.0000180.0000180.0000240.0000
240.0000312.0000312.0000380.0000380.0000380.0000380.0000312.0000312.0000240.0000
240.0000180.0000180.0000112.0000112.0000 48.0000 48.0000 48.0000 48.0000112.0000
112.0000180.0000180.0000240.0000240.0000312.0000312.0000380.0000380.0000380.0000
380.0000312.0000312.0000240.0000240.0000180.0000180.0000112.0000112.0000 48.0000
 48.0000 48.0000 48.0000112.0000112.0000180.0000180.0000240.0000240.0000312.0000
312.0000380.0000380.0000380.0000380.0000312.0000312.0000240.0000240.0000180.0000
180.0000112.0000112.0000 48.0000 48.0000 48.0000 48.0000 88.0000 98.0000136.0000
136.0000180.0000180.0000240.0000240.0000288.0000288.0000336.0000336.0000380.0000
380.0000
 0.0000    .1100    .1750    .1890    .2030    .2070    .2110    .2160    .2200    .2380
  .2560    .3860    .5060    .5610    .6010    .6110    .6190    .6210    .6230    .6250
  .6270    .6350    .6430    .6830    .7180    .7420    .7660    .7720    .7770    .7790
  .7810    .7830    .7850    .7910    .7970    .8260    .8500    .8600    .8700    .8740
  .8780    .8790    .8800    .8810    .8820    .8850    .8880    .8980    .9080    .9140
  .9200    .9220    .9240    .9248    .9256    .9264    .9272    .9292    .9312    .9382
  .9452    .9492    .9532    .9552    .9562    .9570    .9577    .9584    .9591    .9601
  .9611    .9651    .9691    .9711    .9731    .9741    .9751    .9757    .9762    .9768
  .9774    .9784    .9794    .9814    .9834    .9854    .9874    .9884    .9894    .9901
  .9908    .9913    .9918    .9923    .9928    .9934    .9940    .9950    .9960    .9980
 1.0000
 1.0000   2.0000   3.0000   4.0000   5.0000   6.0000   7.0000   8.0000   9.0000  10.0000
11.0000  12.0000  13.0000  14.0000  15.0000  16.0000  17.0000  18.0000  19.0000  20.0000
21.0000  22.0000  23.0000  24.0000  25.0000  26.0000  27.0000  28.0000  29.0000  30.0000
31.0000  32.0000  33.0000  34.0000  35.0000  36.0000  37.0000  38.0000  39.0000  40.0000
41.0000  42.0000  43.0000  44.0000  45.0000  46.0000  47.0000  48.0000  49.0000  50.0000
51.0000  52.0000  53.0000  54.0000  55.0000  56.0000  57.0000  58.0000  59.0000  60.0000
61.0000  62.0000  63.0000  64.0000  65.0000  66.0000  67.0000  68.0000  69.0000  70.0000
71.0000  72.0000  73.0000  74.0000  75.0000  76.0000  77.0000  78.0000  79.0000  80.0000
81.0000  82.0000  83.0000  84.0000  85.0000  86.0000  87.0000  88.0000  89.0000  90.0000
91.0000  92.0000  93.0000  94.0000  95.0000  96.0000  97.0000  98.0000  99.0000100.0000
101.0000
```

AISLE(I)

HLV(I)

X(I)

Y(I)

FX(I)

XIN(I)

C-11 Input Data for Layout (3)

AISLE(I)

0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	2.0000
2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	3.0000	3.0000	3.0000
3.0000	3.0000	3.0000	3.0000	3.0000	4.0000	4.0000	4.0000	4.0000	4.0000
4.0000	4.0000	4.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000
5.0000	6.0000	6.0000	5.0000	6.0000	6.0000	6.0000	6.0000	6.0000	7.0000
7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	8.0000	8.0000	8.0000
8.0000	8.0000	8.0000	8.0000	8.0000	9.0000	9.0000	9.0000	9.0000	9.0000
9.0000	9.0000	9.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000	10.0000
10.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	12.0000
12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	13.0000	13.0000	13.0000
13.0000									

HLV(I)

0.0000	3.0000	3.0000	1.0000	1.0000	-1.0000	-1.0000	-3.0000	-3.0000	-3.0000
-3.0000	-1.0000	-1.0000	1.0000	1.0000	3.0000	3.0000	3.0000	3.0000	1.0000
1.0000	-1.0000	-1.0000	-3.0000	-3.0000	-3.0000	-3.0000	-1.0000	-1.0000	1.0000
1.0000	3.0000	3.0000	3.0000	3.0000	1.0000	1.0000	-1.0000	-1.0000	-3.0000
-3.0000	-3.0000	-3.0000	-1.0000	-1.0000	1.0000	1.0000	3.0000	3.0000	3.0000
3.0000	1.0000	1.0000	-1.0000	-1.0000	-3.0000	-3.0000	-3.0000	-3.0000	-1.0000
-1.0000	1.0000	1.0000	3.0000	3.0000	3.0000	3.0000	1.0000	1.0000	-1.0000
-1.0000	-3.0000	-3.0000	-3.0000	-3.0000	-1.0000	-1.0000	1.0000	1.0000	3.0000
3.0000	3.0000	3.0000	1.0000	1.0000	-1.0000	-1.0000	-3.0000	-3.0000	-3.0000
-3.0000	-1.0000	-1.0000	1.0000	1.0000	3.0000	3.0000	2.0000	2.0000	-2.0000
-2.0000									

X(I)

48.0000	70.0000	70.0000	70.0000	70.0000	70.0000	70.0000	70.0000	70.0000	98.0000
98.0000	98.0000	98.0000	98.0000	98.0000	98.0000	98.0000	126.0000	126.0000	126.0000
126.0000	126.0000	126.0000	126.0000	126.0000	154.0000	154.0000	154.0000	154.0000	154.0000
154.0000	154.0000	154.0000	182.0000	182.0000	182.0000	182.0000	182.0000	182.0000	182.0000
182.0000	210.0000	210.0000	210.0000	210.0000	210.0000	210.0000	210.0000	210.0000	238.0000
238.0000	238.0000	238.0000	238.0000	238.0000	238.0000	238.0000	266.0000	266.0000	266.0000
266.0000	266.0000	266.0000	266.0000	266.0000	294.0000	294.0000	294.0000	294.0000	294.0000
294.0000	294.0000	294.0000	322.0000	322.0000	322.0000	322.0000	322.0000	322.0000	322.0000
322.0000	350.0000	350.0000	350.0000	350.0000	350.0000	350.0000	350.0000	350.0000	378.0000
378.0000	378.0000	378.0000	378.0000	378.0000	378.0000	378.0000	406.0000	406.0000	406.0000
406.0000									

Y(I)

140.0000	236.0000	236.0000	172.0000	172.0000	108.0000	108.0000	44.0000	44.0000	44.0000
44.0000	108.0000	108.0000	172.0000	172.0000	236.0000	236.0000	236.0000	236.0000	172.0000
172.0000	108.0000	108.0000	44.0000	44.0000	44.0000	44.0000	108.0000	108.0000	172.0000
172.0000	236.0000	236.0000	236.0000	236.0000	172.0000	172.0000	108.0000	108.0000	44.0000
44.0000	44.0000	44.0000	108.0000	108.0000	172.0000	172.0000	236.0000	236.0000	236.0000
236.0000	172.0000	172.0000	108.0000	108.0000	44.0000	44.0000	44.0000	44.0000	108.0000
108.0000	172.0000	172.0000	236.0000	236.0000	236.0000	236.0000	172.0000	172.0000	108.0000
108.0000	44.0000	44.0000	44.0000	44.0000	108.0000	108.0000	172.0000	172.0000	236.0000
236.0000	236.0000	236.0000	172.0000	172.0000	108.0000	108.0000	44.0000	44.0000	44.0000
44.0000	108.0000	108.0000	172.0000	172.0000	236.0000	236.0000	204.0000	204.0000	76.0000
76.0000									

FX(I)

0.0000	.0650	.1750	.1890	.2030	.2210	.2390	.3590	.4830	.5290
.5840	.5940	.6020	.6100	.6180	.6580	.6930	.7170	.7410	.7470
.7520	.7580	.7640	.7980	.8170	.8270	.8370	.8410	.8450	.8490
.8530	.8630	.8730	.8790	.8850	.8870	.8890	.8910	.8930	.9000
.9070	.9120	.9160	.9180	.9200	.9220	.9240	.9280	.9320	.9350
.9390	.9400	.9420	.9440	.9460	.9500	.9540	.9560	.9580	.9590
.9600	.9610	.9620	.9640	.9660	.9680	.9700	.9710	.9720	.9730
.9740	.9760	.9780	.9790	.9810	.9817	.9825	.9832	.9839	.9849
.9859	.9869	.9879	.9885	.9891	.9898	.9905	.9915	.9925	.9933
.9941	.9946	.9951	.9956	.9961	.9969	.9977	.9983	.9988	.9994
1.0000									

XIN(I)

1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000	8.0000	9.0000	10.0000
11.0000	12.0000	13.0000	14.0000	15.0000	16.0000	17.0000	18.0000	19.0000	20.0000
21.0000	22.0000	23.0000	24.0000	25.0000	26.0000	27.0000	28.0000	29.0000	30.0000
31.0000	32.0000	33.0000	34.0000	35.0000	36.0000	37.0000	38.0000	39.0000	40.0000
41.0000	42.0000	43.0000	44.0000	45.0000	46.0000	47.0000	48.0000	49.0000	50.0000
51.0000	52.0000	53.0000	54.0000	55.0000	56.0000	57.0000	58.0000	59.0000	60.0000
61.0000	62.0000	63.0000	64.0000	65.0000	66.0000	67.0000	68.0000	69.0000	70.0000
71.0000	72.0000	73.0000	74.0000	75.0000	76.0000	77.0000	78.0000	79.0000	80.0000
81.0000	82.0000	83.0000	84.0000	85.0000	86.0000	87.0000	88.0000	89.0000	90.0000
91.0000	92.0000	93.0000	94.0000	95.0000	96.0000	97.0000	98.0000	99.0000	100.0000
101.0000									

C-12 Input Data for Layout (4)

AISLE(I)

```
15.0000  1.0000  1.0000  1.0000  1.0000  1.0000  1.0000  2.0000  2.0000  2.0000
 2.0000  2.0000  2.0000  4.0000  4.0000  4.0000  3.0000  3.0000  3.0000  5.0000
 5.0000  5.0000  6.0000  6.0000  6.0000  8.0000  8.0000  8.0000  7.0000  7.0000
 7.0000  9.0000  9.0000  9.0000 10.0000 10.0000 10.0000 12.0000 12.0000 12.0000
11.0000 11.0000 11.0000 13.0000 13.0000 13.0000 14.0000 14.0000 14.0000 16.0000
16.0000 16.0000 15.0000 15.0000 15.0000 17.0000 17.0000 17.0000 18.0000 18.0000
18.0000 20.0000 20.0000 20.0000 19.0000 19.0000 19.0000 21.0000 21.0000 21.0000
22.0000 22.0000 22.0000 24.0000 24.0000 24.0000 23.0000 23.0000 23.0000 25.0000
25.0000 25.0000 26.0000 26.0000 26.0000 28.0000 28.0000 28.0000 27.0000 27.0000
27.0000 29.0000 29.0000 29.0000 29.0000 29.0000 30.0000 30.0000 30.0000 30.0000
30.0000
```

HLV(I)

```
-4.0000 -3.0000 -3.0000 -2.0000 -2.0000 -1.0000 -1.0000  1.0000  1.0000  2.0000
 2.0000  3.0000  3.0000  3.0000  2.0000  1.0000 -1.0000 -2.0000 -3.0000 -3.0000
-2.0000 -1.0000  1.0000  2.0000  3.0000  3.0000  2.0000  1.0000 -1.0000 -2.0000
-3.0000 -3.0000 -2.0000 -1.0000  1.0000  2.0000  3.0000  3.0000  2.0000  1.0000
-1.0000 -2.0000 -3.0000 -3.0000 -2.0000 -1.0000  1.0000  2.0000  3.0000  3.0000
 2.0000  1.0000 -1.0000 -2.0000 -3.0000 -3.0000 -2.0000 -1.0000  1.0000  2.0000
 3.0000  3.0000  2.0000  1.0000 -1.0000 -2.0000 -3.0000 -3.0000 -2.0000 -1.0000
 1.0000  2.0000  3.0000  3.0000  2.0000  1.0000 -1.0000 -2.0000 -3.0000 -3.0000
-2.0000 -1.0000  1.0000  2.0000  3.0000  3.0000  2.0000  1.0000 -1.0000 -2.0000
-3.0000 -3.0000 -3.0000 -2.0000 -1.0000 -1.0000  1.0000  1.0000  2.0000  3.0000
 3.0000
```

X(I)

```
210.0000406.0000406.0000406.0000406.0000406.0000406.0000406.0000406.0000406.0000
406.0000406.0000406.0000378.0000378.0000378.0000378.0000378.0000378.0000350.0000
350.0000350.0000350.0000350.0000350.0000322.0000322.0000322.0000322.0000322.0000
322.0000294.0000294.0000294.0000294.0000294.0000294.0000266.0000266.0000266.0000
266.0000266.0000266.0000238.0000238.0000238.0000238.0000238.0000238.0000238.0000
210.0000210.0000210.0000210.0000210.0000182.0000182.0000182.0000182.0000182.0000
182.0000154.0000154.0000154.0000154.0000154.0000154.0000126.0000126.0000126.0000
126.0000126.0000126.0000 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000 70.0000
 70.0000 70.0000 70.0000 70.0000 70.0000 42.0000 42.0000 42.0000 42.0000 42.0000
 42.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000
 14.0000
```

Y(I)

```
 28.0000 52.0000 52.0000 84.0000 84.0000116.0000116.0000168.0000168.0000208.0000
208.0000244.0000244.0000244.0000208.0000168.0000116.0000 84.0000 52.0000 52.0000
 84.0000116.0000168.0000208.0000244.0000244.0000208.0000168.0000116.0000 84.0000
 52.0000 52.0000 84.0000116.0000168.0000208.0000244.0000244.0000208.0000168.0000
116.0000 84.0000 52.0000 52.0000 84.0000116.0000168.0000208.0000244.0000244.0000
208.0000168.0000116.0000 84.0000 52.0000 52.0000 84.0000116.0000168.0000208.0000
244.0000244.0000208.0000168.0000116.0000 84.0000 52.0000 52.0000 84.0000116.0000
168.0000208.0000244.0000244.0000208.0000168.0000116.0000 84.0000 52.0000 52.0000
 84.0000116.0000168.0000208.0000244.0000244.0000208.0000168.0000116.0000 84.0000
 52.0000 52.0000 52.0000 84.0000116.0000116.0000168.0000168.0000203.0000244.0000
244.0000
```

FX(I)

```
 0.0000   .0030   .0060   .0080   .0100   .0110   .0120   .0128   .0136   .0146
  .0148   .0153   .0158   .0164   .0171   .0181   .0201   .0221   .0271   .0351
  .0391   .0411   .0421   .0431   .0438   .0446   .0456   .0476   .0516   .0546
  .0726   .0966   .1066   .1126   .1146   .1166   .1176   .1186   .1206   .1246
  .1346   .1586   .2136   .3336   .3736   .3916   .3976   .4016   .4036   .4076
  .4136   .4236   .4526   .5176   .6476   .7576   .7926   .8066   .8126   .8166
  .8186   .8196   .8216   .8256   .8336   .8516   .8916   .9156   .9256   .9316
  .9336   .9356   .9366   .9374   .9384   .9404   .9444   .9514   .9614   .9694
  .9734   .9754   .9764   .9772   .9779   .9793   .9790 [illegible]  .9823   .9843
  .9890   .9910   .9930   .9950   .9961   .9971   .9977   .9984   .9990   .9995
 1.0000
```

XIN(I)

```
 1.0000  2.0000  3.0000  4.0000  5.0000  6.0000  7.0000  8.0000  9.0000 10.0000
11.0000 12.0000 13.0000 14.0000 15.0000 16.0000 17.0000 18.0000 19.0000 20.0000
21.0000 22.0000 23.0000 24.0000 25.0000 26.0000 27.0000 28.0000 29.0000 30.0000
31.0000 32.0000 33.0000 34.0000 35.0000 36.0000 37.0000 38.0000 39.0000 40.0000
41.0000 42.0000 43.0000 44.0000 45.0000 46.0000 47.0000 48.0000 49.0000 50.0000
51.0000 52.0000 53.0000 54.0000 55.0000 56.0000 57.0000 58.0000 59.0000 60.0000
61.0000 62.0000 63.0000 64.0000 65.0000 66.0000 67.0000 68.0000 69.0000 70.0000
71.0000 72.0000 73.0000 74.0000 75.0000 76.0000 77.0000 78.0000 79.0000 80.0000
81.0000 82.0000 83.0000 84.0000 85.0000 86.0000 87.0000 88.0000 89.0000 90.0000
91.0000 92.0000 93.0000 94.0000 95.0000 96.0000 97.0000 98.0000 99.0000100.0000
101.0000
```

C-13 Input Data for Layout (5)

```
  9.0000   1.0000   1.0000   1.0000   1.0000   1.0000   2.0000   2.0000   2.0000   2.0000
  2.0000   4.0000   4.0000   4.0000   4.0000   4.0000   3.0000   3.0000   3.0000   3.0000
  3.0000   5.0000   5.0000   5.0000   5.0000   5.0000   6.0000   6.0000   6.0000   6.0000
  6.0000   8.0000   8.0000   8.0000   8.0000   8.0000   7.0000   7.0000   7.0000   7.0000
  7.0000   9.0000   9.0000   9.0000   9.0000   9.0000  10.0000  10.0000  10.0000  10.0000
 10.0000  12.0000  12.0000  12.0000  12.0000  12.0000  11.0000  11.0000  11.0000  11.0000
 11.0000  13.0000  13.0000  13.0000  13.0000  13.0000  14.0000  14.0000  14.0000  14.0000
 14.0000  16.0000  16.0000  16.0000  16.0000  16.0000  15.0000  15.0000  15.0000  15.0000
 15.0000  17.0000  17.0000  17.0000  17.0000  17.0000  18.0000  18.0000  18.0000  18.0000
 18.0000  20.0000  20.0000  20.0000  20.0000  20.0000  19.0000  19.0000  19.0000  19.0000
 19.0000
```

AISLE(I)

```
 -6.0000  -5.0000  -4.0000  -3.0000  -2.0000  -1.0000   1.0000   2.0000   3.0000   4.0000
  5.0000   5.0000   4.0000   3.0000   2.0000   1.0000   1.0000  -2.0000  -3.0000  -4.0000
 -5.0000  -5.0000  -4.0000  -3.0000  -2.0000  -1.0000   1.0000   2.0000   3.0000   4.0000
  5.0000   5.0000   4.0000   3.0000   2.0000   1.0000  -1.0000  -2.0000  -3.0000  -4.0000
 -5.0000  -5.0000  -4.0000  -3.0000  -2.0000  -1.0000   1.0000   2.0000   3.0000   4.0000
  5.0000   5.0000   4.0000   3.0000   2.0000   1.0000  -1.0000  -2.0000  -3.0000  -4.0000
 -5.0000  -5.0000  -4.0000  -3.0000  -2.0000  -1.0000   1.0000   2.0000   3.0000   4.0000
  5.0000   5.0000   4.0000   3.0000   2.0000   1.0000   1.0000  -2.0000  -3.0000  -4.0000
 -5.0000  -5.0000  -4.0000  -3.0000  -2.0000  -1.0000   1.0000   2.0000   3.0000   4.0000
  5.0000   5.0000   4.0000   3.0000   2.0000   1.0000  -1.0000  -2.0000  -3.0000  -4.0000
 -5.0000
```

HLV(I)

```
140.0000266.0000266.0000266.0000266.0000266.0000266.0000266.0000266.0000266.0000
266.0000238.0000238.0000238.0000238.0000238.0000238.0000238.0000238.0000238.0000
238.0000210.0000210.0000210.0000210.0000210.0000210.0000210.0000210.0000210.0000
210.0000182.0000182.0000182.0000182.0000182.0000182.0000182.0000182.0000182.0000
182.0000154.0000154.0000154.0000154.0000154.0000154.0000154.0000154.0000154.0000
154.0000126.0000126.0000126.0000126.0000126.0000126.0000126.0000126.0000126.0000
126.0000 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000 98.0000
 98.0000 70.0000 70.0000 70.0000 70.0000 70.0000 70.0000 70.0000 70.0000 70.0000
 70.0000 42.0000 42.0000 42.0000 42.0000 42.0000 42.0000 42.0000 42.0000 42.0000
 42.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000 14.0000
 14.0000
```

X(I)

```
 60.0000 84.0000116.0000148.0000180.0000212.0000260.0000292.0000324.0000356.0000
388.0000388.0000356.0000324.0000292.0000260.0000212.0000180.0000148.0000116.0000
 84.0000 84.0000116.0000148.0000180.0000212.0000260.0000292.0000324.0000356.0000
388.0000388.0000356.0000324.0000292.0000260.0000212.0000180.0000148.0000116.0000
 84.0000 84.0000116.0000148.0000180.0000212.0000260.0000292.0000324.0000356.0000
388.0000388.0000356.0000324.0000292.0000260.0000212.0000180.0000148.0000116.0000
 84.0000 84.0000116.0000148.0000180.0000212.0000260.0000292.0000324.0000356.0000
388.0000388.0000356.0000324.0000292.0000260.0000212.0000180.0000148.0000116.0000
 84.0000 84.0000116.0000148.0000180.0000212.0000260.0000292.0000324.0000356.0000
388.0000388.0000356.0000324.0000292.0000260.0000212.0000180.0000148.0000116.0000
 84.0000
```

Y(I)

```
  0.0000    .0080    .0130    .0170    .0190    .0218    .0220    .0228    .0235    .0240
   .0245    .0250    .0256    .0264    .0274    .0294    .0314    .0344    .0394    .0464
   .0644    .0994    .1134    .1204    .1244    .1264    .1284    .1294    .1304    .1311
   .1317    .1324    .1334    .1344    .1364    .1384    .1424    .1484    .1584    .1824
   .2474    .3674    .4074    .4314    .4414    .4474    .4514    .4534    .4554    .4564
   .4574    .4584    .4594    .4614    .4634    .4674    .4734    .4934    .5074    .5624
   .6924    .8024    .8314    .8414    .8474    .8514    .8534    .8554    .8564    .8574
   .8581    .8587    .8595    .8605    .8625    .8645    .8665    .8705    .8775    .8915
   .9315    .9495    .9575    .9625    .9655    .9675    .9695    .9705    .9713    .9719
   .9724    .9729    .9735    .9742    .9750    .9760    .9780    .9800    .9848    .9900
  1.0000
```

FX(I)

```
  1.0000   2.0000   3.0000   4.0000   5.0000   6.0000   7.0000   8.0000   9.0000  10.0000
 11.0000  12.0000  13.0000  14.0000  15.0000  16.0000  17.0000  18.0000  19.0000  20.0000
 21.0000  22.0000  23.0000  24.0000  25.0000  26.0000  27.0000  28.0000  29.0000  30.0000
 31.0000  32.0000  33.0000  34.0000  35.0000  36.0000  37.0000  38.0000  39.0000  40.0000
 41.0000  42.0000  43.0000  44.0000  45.0000  46.0000  47.0000  48.0000  49.0000  50.0000
 51.0000  52.0000  53.0000  54.0000  55.0000  56.0000  57.0000  58.0000  59.0000  60.0000
 61.0000  62.0000  63.0000  64.0000  65.0000  66.0000  67.0000  68.0000  69.0000  70.0000
 71.0000  72.0000  73.0000  74.0000  75.0000  76.0000  77.0000  78.0000  79.0000  80.0000
 81.0000  82.0000  83.0000  84.0000  85.0000  86.0000  87.0000  88.0000  89.0000  90.0000
 91.0000  92.0000  93.0000  94.0000  95.0000  96.0000  97.0000  98.0000  99.0000100.0000
101.0000
```

XIN(I)

C-14 Input Data for Layout (6)

AISLE(I)

0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	2.0000	2.0000	2.0000
2.0000	2.0000	2.0000	4.0000	4.0000	4.0000	4.0000	4.0000	4.0000	3.0000
3.0000	3.0000	3.0000	3.0000	3.0000	5.0000	5.0000	5.0000	5.0000	5.0000
5.0000	6.0000	6.0000	6.0000	6.0000	6.0000	6.0000	8.0000	8.0000	8.0000
8.0000	8.0000	8.0000	7.0000	7.0000	7.0000	7.0000	7.0000	7.0000	9.0000
9.0000	9.0000	9.0000	9.0000	9.0000	10.0000	10.0000	10.0000	10.0000	10.0000
10.0000	12.0000	12.0000	12.0000	12.0000	12.0000	12.0000	11.0000	11.0000	11.0000
11.0000	11.0000	11.0000	13.0000	13.0000	13.0000	13.0000	13.0000	13.0000	14.0000
14.0000	14.0000	14.0000	14.0000	14.0000	16.0000	16.0000	16.0000	16.0000	16.0000
16.0000	16.0000	16.0000	15.0000	15.0000	15.0000	15.0000	15.0000	15.0000	15.0000
15.0000									

HLV(I)

3.0000	5.0000	5.0000	3.0000	3.0000	1.0000	1.0000	-1.0000	-1.0000	-3.0000
-3.0000	-5.0000	-5.0000	-5.0000	-5.0000	-3.0000	-3.0000	-1.0000	-1.0000	1.0000
1.0000	3.0000	3.0000	5.0000	5.0000	5.0000	5.0000	3.0000	3.0000	1.0000
1.0000	-1.0000	-1.0000	-3.0000	-3.0000	-5.0000	-5.0000	-5.0000	-5.0000	-3.0000
-3.0000	-1.0000	-1.0000	1.0000	1.0000	3.0000	3.0000	5.0000	5.0000	5.0000
5.0000	3.0000	3.0000	1.0000	1.0000	-1.0000	-1.0000	-3.0000	-3.0000	-5.0000
-5.0000	-5.0000	-5.0000	-3.0000	-3.0000	-1.0000	-1.0000	1.0000	1.0000	3.0000
3.0000	5.0000	5.0000	5.0000	5.0000	3.0000	3.0000	1.0000	1.0000	-1.0000
-1.0000	-3.0000	-3.0000	-5.0000	-5.0000	-5.0000	-5.0000	-4.0000	-4.0000	-2.0000
-2.0000	-1.0000	-1.0000	1.0000	1.0000	2.0000	2.0000	4.0000	4.0000	5.0000
5.0000									

X(I)

232.0000	210.0000	210.0000	210.0000	210.0000	210.0000	210.0000	210.0000	210.0000	210.0000
210.0000	210.0000	210.0000	182.0000	182.0000	182.0000	182.0000	182.0000	182.0000	182.0000
182.0000	182.0000	182.0000	182.0000	182.0000	154.0000	154.0000	154.0000	154.0000	154.0000
154.0000	154.0000	154.0000	154.0000	154.0000	154.0000	154.0000	126.0000	126.0000	126.0000
126.0000	126.0000	126.0000	126.0000	126.0000	126.0000	126.0000	126.0000	126.0000	98.0000
98.0000	98.0000	98.0000	98.0000	98.0000	98.0000	98.0000	98.0000	98.0000	98.0000
98.0000	70.0000	70.0000	70.0000	70.0000	70.0000	70.0000	70.0000	70.0000	70.0000
70.0000	70.0000	70.0000	42.0000	42.0000	42.0000	42.0000	42.0000	42.0000	42.0000
42.0000	42.0000	42.0000	42.0000	42.0000	14.0000	14.0000	14.0000	14.0000	14.0000
14.0000	14.0000	14.0000	14.0000	14.0000	14.0000	14.0000	14.0000	14.0000	14.0000
14.0000									

Y(I)

208.0000	376.0000	376.0000	312.0000	312.0000	240.0000	240.0000	172.0000	172.0000	104.0000
104.0000	44.0000	44.0000	44.0000	44.0000	104.0000	104.0000	172.0000	172.0000	240.0000
240.0000	312.0000	312.0000	376.0000	376.0000	376.0000	376.0000	312.0000	312.0000	240.0000
240.0000	172.0000	172.0000	104.0000	104.0000	44.0000	44.0000	44.0000	44.0000	104.0000
104.0000	172.0000	172.0000	240.0000	240.0000	312.0000	312.0000	376.0000	376.0000	376.0000
376.0000	312.0000	312.0000	240.0000	240.0000	172.0000	172.0000	104.0000	104.0000	44.0000
44.0000	44.0000	44.0000	104.0000	104.0000	172.0000	172.0000	240.0000	240.0000	312.0000
312.0000	376.0000	376.0000	376.0000	376.0000	312.0000	312.0000	240.0000	240.0000	172.0000
172.0000	104.0000	104.0000	44.0000	44.0000	44.0000	44.0000	80.0000	80.0000	128.0000
128.0000	172.0000	172.0000	240.0000	240.0000	288.0000	288.0000	336.0000	336.0000	376.0000
376.0000									

FX(I)

0.0000	.0050	.0090	.0270	.0410	.1710	.2810	.4010	.4660	.4840
.4980	.5020	.5060	.5080	.5100	.5180	.5260	.5660	.6010	.6560
.6960	.7060	.7140	.7160	.7180	.7200	.7220	.7240	.7340	.7630
.7870	.8110	.8350	.8410	.8460	.8480	.8500	.8510	.8520	.8560
.8590	.8630	.8790	.8890	.8990	.9030	.9060	.9070	.9080	.9088
.9096	.9116	.9136	.9206	.9266	.9336	.9396	.9416	.9436	.9444
.9452	.9459	.9466	.9476	.9486	.9526	.9566	.9606	.9646	.9666
.9676	.9684	.9691	.9697	.9703	.9713	.9723	.9743	.9763	.9793
.9803	.9813	.9823	.9829	.9834	.9839	.9844	.9851	.9857	.9867
.9877	.9897	.9917	.9937	.9957	.9957	.9977	.9984	.9990	.9995
1.0000									

XIN(I)

1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000	8.0000	9.0000	10.0000
11.0000	12.0000	13.0000	14.0000	15.0000	16.0000	17.0000	18.0000	19.0000	20.0000
21.0000	22.0000	23.0000	24.0000	25.0000	26.0000	27.0000	28.0000	29.0000	30.0000
31.0000	32.0000	33.0000	34.0000	35.0000	36.0000	37.0000	38.0000	39.0000	40.0000
41.0000	42.0000	43.0000	44.0000	45.0000	46.0000	47.0000	48.0000	49.0000	50.0000
51.0000	52.0000	53.0000	54.0000	55.0000	56.0000	57.0000	58.0000	59.0000	60.0000
61.0000	62.0000	63.0000	64.0000	65.0000	66.0000	67.0000	68.0000	69.0000	70.0000
71.0000	72.0000	73.0000	74.0000	75.0000	76.0000	77.0000	78.0000	79.0000	80.0000
81.0000	82.0000	83.0000	84.0000	85.0000	86.0000	87.0000	88.0000	89.0000	90.0000
91.0000	92.0000	93.0000	94.0000	95.0000	96.0000	97.0000	98.0000	99.0000	100.0000
101.0000									

C-15 Input Data for Layout (7)

AISLE(I)

0.0000	2.0000	2.0000	2.0000	2.0000	1.0000	1.0000	1.0000	1.0000	3.0000
3.0000	3.0000	3.0000	4.0000	4.0000	4.0000	4.0000	6.0000	6.0000	6.0000
6.0000	5.0000	5.0000	5.0000	5.0000	7.0000	7.0000	7.0000	7.0000	8.0000
8.0000	8.0000	8.0000	10.0000	10.0000	10.0000	10.0000	9.0000	9.0000	9.0000
9.0000	11.0000	11.0000	11.0000	11.0000	12.0000	12.0000	12.0000	12.0000	14.0000
14.0000	14.0000	14.0000	13.0000	13.0000	13.0000	13.0000	15.0000	15.0000	15.0000
15.0000	16.0000	16.0000	16.0000	16.0000	18.0000	18.0000	18.0000	18.0000	17.0000
17.0000	17.0000	17.0000	19.0000	19.0000	19.0000	19.0000	20.0000	20.0000	20.0000
20.0000	22.0000	22.0000	22.0000	22.0000	21.0000	21.0000	21.0000	21.0000	23.0000
23.0000	23.0000	23.0000	24.0000	24.0000	24.0000	24.0000	26.0000	26.0000	25.0000
25.0000									

HLV(I)

0.0000	3.0000	3.0000	1.0000	1.0000	-1.0000	-1.0000	-3.0000	-3.0000	-3.0000
-3.0000	-1.0000	-1.0000	1.0000	1.0000	3.0000	3.0000	3.0000	3.0000	1.0000
1.0000	-1.0000	-1.0000	-3.0000	-3.0000	-3.0000	-3.0000	-1.0000	-1.0000	1.0000
1.0000	3.0000	3.0000	3.0000	3.0000	1.0000	1.0000	-1.0000	-1.0000	-3.0000
-3.0000	-3.0000	-3.0000	-1.0000	-1.0000	1.0000	1.0000	3.0000	3.0000	3.0000
3.0000	1.0000	1.0000	-1.0000	-1.0000	-3.0000	-3.0000	-3.0000	-3.0000	-1.0000
-1.0000	1.0000	1.0000	3.0000	3.0000	3.0000	3.0000	1.0000	1.0000	-1.0000
-1.0000	-3.0000	-3.0000	-3.0000	-3.0000	-1.0000	-1.0000	1.0000	1.0000	3.0000
3.0000	3.0000	3.0000	1.0000	1.0000	-1.0000	-1.0000	-3.0000	-3.0000	-3.0000
-3.0000	-1.0000	-1.0000	1.0000	1.0000	3.0000	3.0000	2.0000	2.0000	-2.0000
-2.0000									

X(I)

48.0000	70.0000	70.0000	70.0000	70.0000	70.0000	70.0000	70.0000	70.0000	98.0000
98.0000	98.0000	98.0000	98.0000	98.0000	98.0000	98.0000	126.0000	126.0000	126.0000
126.0000	126.0000	126.0000	126.0000	126.0000	154.0000	154.0000	154.0000	154.0000	154.0000
154.0000	154.0000	154.0000	182.0000	182.0000	182.0000	182.0000	182.0000	182.0000	192.0000
182.0000	210.0000	210.0000	210.0000	210.0000	210.0000	210.0000	210.0000	210.0000	238.0000
238.0000	238.0000	238.0000	238.0000	238.0000	238.0000	238.0000	266.0000	266.0000	266.0000
266.0000	266.0000	266.0000	266.0000	266.0000	294.0000	294.0000	294.0000	294.0000	294.0000
294.0000	294.0000	294.0000	322.0000	322.0000	322.0000	322.0000	322.0000	322.0000	322.0000
322.0000	350.0000	350.0000	350.0000	350.0000	350.0000	350.0000	350.0000	350.0000	378.0000
378.0000	378.0000	378.0000	378.0000	378.0000	378.0000	378.0000	406.0000	406.0000	406.0000
406.0000									

Y(I)

140.0000	236.0000	236.0000	172.0000	172.0000	108.0000	108.0000	44.0000	44.0000	44.0000
44.0000	108.0000	108.0000	172.0000	172.0000	236.0000	236.0000	236.0000	236.0000	172.0000
172.0000	108.0000	108.0000	44.0000	44.0000	44.0000	44.0000	108.0000	108.0000	172.0000
172.0000	236.0000	236.0000	236.0000	236.0000	172.0000	172.0000	108.0000	108.0000	44.0000
44.0000	44.0000	44.0000	108.0000	108.0000	172.0000	172.0000	236.0000	236.0000	236.0000
236.0000	172.0000	172.0000	108.0000	108.0000	44.0000	44.0000	44.0000	44.0000	108.0000
108.0000	172.0000	172.0000	236.0000	236.0000	236.0000	236.0000	172.0000	172.0000	108.0000
108.0000	44.0000	44.0000	44.0000	44.0000	108.0000	108.0000	172.0000	172.0000	236.0000
236.0000	236.0000	236.0000	172.0000	172.0000	108.0000	108.0000	44.0000	44.0000	44.0000
44.0000	108.0000	108.0000	172.0000	172.0000	236.0000	236.0000	204.0000	204.0000	76.0000
76.0000									

FX(I)

0.0000	.0180	.0360	.1660	.2560	.3960	.4610	.4750	.4890	.4970
.5050	.5450	.5800	.6350	.6750	.6850	.6930	.6990	.7050	.7340
.7580	.7820	.8060	.8120	.8170	.8210	.8250	.8350	.8450	.8550
.8650	.8690	.8730	.8750	.8770	.8840	.8910	.8970	.9030	.9050
.9070	.9090	.9110	.9160	.9200	.9240	.9280	.9300	.9320	.9340
.9360	.9400	.9440	.9470	.9500	.9520	.9540	.9550	.9560	.9580
.9600	.9620	.9640	.9650	.9660	.9670	.9680	.9700	.9720	.9740
.9760	.9770	.9780	.9787	.9794	.9814	.9824	.9834	.9844	.9852
.9859	.9866	.9873	.9883	.9893	.9903	.9913	.9919	.9925	.9930
.9935	.9943	.9951	.9959	.9967	.9972	.9977	.9983	.9989	.9995
1.0000									

XIN(I)

1.0000	2.0000	3.0000	4.0000	5.0000	6.0000	7.0000	8.0000	9.0000	10.0000
11.0000	12.0000	13.0000	14.0000	15.0000	16.0000	17.0000	18.0000	19.0000	20.0000
21.0000	22.0000	23.0000	24.0000	25.0000	26.0000	27.0000	28.0000	29.0000	30.0000
31.0000	32.0000	33.0000	34.0000	35.0000	36.0000	37.0000	38.0000	39.0000	40.0000
41.0000	42.0000	43.0000	44.0000	45.0000	46.0000	47.0000	48.0000	49.0000	50.0000
51.0000	52.0000	53.0000	54.0000	55.0000	56.0000	57.0000	58.0000	59.0000	60.0000
61.0000	62.0000	63.0000	64.0000	65.0000	66.0000	67.0000	68.0000	69.0000	70.0000
71.0000	72.0000	73.0000	74.0000	75.0000	76.0000	77.0000	78.0000	79.0000	80.0000
81.0000	82.0000	83.0000	84.0000	85.0000	86.0000	87.0000	88.0000	89.0000	90.0000
91.0000	92.0000	93.0000	94.0000	95.0000	96.0000	97.0000	98.0000	99.0000	100.0000
101.0000									

C-16 Input Data for Layout (8)

```
**GASP FILE STORAGE AREA DUMP AT TIME  0.          **

MAXIMUM NUMBER OF ENTRIES IN FILE STORAGE AREA =  2

                    PRINTOUT OF FILE NUMBER   1
                        TNOW =  0.
                        QQTIM=  0.

                              FILE CONTENTS
ENTRY  1   =    0.          .1000E+01      0.            0.          .1000E+01     0.

ENTRY  2   =    0.          .1000E+01      0.            0.          .2000E+01     0.

                    PRINTOUT OF FILE NUMBER   2
                        TNOW =  0.
                        QQTIM=  0.

                        THE FILE IS EMPTY

                    PRINTOUT OF FILE NUMBER   3
                        TNOW =  0.
                        QQTIM=  0.

                        THE FILE IS EMPTY

                    PRINTOUT OF FILE NUMBER   4
                        TNOW =  0.
                        QQTIM=  0.

                        THE FILE IS EMPTY
```

C-17 Typical File Storage Area at Time Zero

```
PRINTCUT OF FILE NUMBER   5
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER   6
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER   7
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER   8
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER   9
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTCUT OF FILE NUMBER  10
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  11
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTCUT OF FILE NUMBER  12
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  13
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  14
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY
```

C-17 (Continued)

```
PRINTOUT OF FILE NUMBER  15
     TNOW =   0.
     QQTIM=   0.

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  16
     TNOW =   0.
     QQTIM=   0.

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  17
     TNOW =   0.
     QQTIM=   0.

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  18
     TNOW =   0.
     QQTIM=   0.

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  19
     TNOW =   0.
     QQTIM=   0.

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  20
     TNOW =   0.
     QQTIM=   0.

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  21
     TNOW =   0.
     QQTIM=   0.

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  22
     TNOW =   0.
     QQTIM=   0.

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  23
     TNOW =   0.
     QQTIM=   0.

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  24
     TNOW =   0.
     QQTIM=   0.

     THE FILE IS EMPTY
```

C-17 (Continued)

```
PRINTOUT OF FILE NUMBER  25
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  26
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  27
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  28
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  29
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  30
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  31
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  32
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  33
    TNOW =  0.
    QQTIM=  0.

    THE FILE IS EMPTY
```

C-17 (Continued)

```
**GASP FILE STORAGE AREA DUMP AT TIME    .3000E+04**

MAXIMUM NUMBER OF ENTRIES IN FILE STORAGE AREA = 32

PRINTOUT OF FILE NUMBER   1
    TNOW =    .3000E+04
    QQTIM=    .3000E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE        2.0775
STANDARD DEVIATION             .3737
MAXIMUM NUMBER IN FILE        4

FILE CONTENTS
ENTRY   1   =   .3000E+04   .1000E+01   .6800E+02   .5000E+01   .2000E+01   .1000E+02

ENTRY   2   =   .3002E+04   .1000E+01   .5400E+02   .9000E+01   .1000E+01   .8000E+01
```

C-18 Typical File Storage Area at Time 3,000

PRINTOUT OF FILE NUMBER 2
TNOW = .3000E+04
QQTIM= .3000E+04

TIME PERIOD FOR STATISTICS .3000E+04
AVERAGE NUMBER IN FILE 2.7882
STANDARD DEVIATION 3.5276
MAXIMUM NUMBER IN FILE 18

FILE CONTENTS

ENTRY	1	=	.2987E+04	.1000E+01	.5500E+02	.4000E+01	.1000E+01	.8000E+01
ENTRY	2	=	.2987E+04	.1000E+01	.5600E+02	.5000E+01	.1000E+01	.9000E+01
ENTRY	3	=	.2987E+04	.1000E+01	.5700E+02	.6000E+01	.1000E+01	.9000E+01
ENTRY	4	=	.2987E+04	.1000E+01	.5800E+02	.9000E+01	.1000E+01	.9000E+01
ENTRY	5	=	.2987E+04	.1000E+01	.6700E+02	.4000E+01	.1000E+01	.1000E+02
ENTRY	6	=	.2987E+04	.1000E+01	.8100E+02	.6000E+01	.1000E+01	.1300E+02
ENTRY	7	=	.2987E+04	.1000E+01	.8900E+02	.8000E+01	.1000E+01	.1400E+02
ENTRY	8	=	.2987E+04	.1000E+01	.9500E+02	.8000E+01	.1000E+01	.1500E+02

PRINTOUT OF FILE NUMBER 3
TNOW = .3000E+04
QQTIM= .2939E+04

TIME PERIOD FOR STATISTICS .3000E+04
AVERAGE NUMBER IN FILE 2.9192
STANDARD DEVIATION 3.6241
MAXIMUM NUMBER IN FILE 16

FILE CONTENTS

ENTRY	1	=	.2987E+04	.1000E+01	.6900E+02	.4000E+01	.2000E+01	.1100E+02
ENTRY	2	=	.2987E+04	.1000E+01	.7600E+02	.3000E+01	.2000E+01	.1200E+02

C-18 (Continued)

```
PRINTOUT OF FILE NUMBER   4
         TNOW =    .3000E+04
         QQTIM=    .2965E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0477
STANDARD DEVIATION              .2130
MAXIMUM NUMBER IN FILE        1

         THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER   5
         TNOW =    .3000E+04
         QQTIM=    .2989E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0357
STANDARD DEVIATION              .1855
MAXIMUM NUMBER IN FILE        1

         THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER   6
         TNOW =    .3000E+04
         QQTIM=    .2944E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0405
STANDARD DEVIATION              .1971
MAXIMUM NUMBER IN FILE        1

         THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER   7
         TNOW =    .3000E+04
         QQTIM=    .2962E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0535
STANDARD DEVIATION              .2251
MAXIMUM NUMBER IN FILE        1

         THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER   8
         TNOW =    .3000E+04
         QQTIM=    .2993E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0807
STANDARD DEVIATION              .2724
MAXIMUM NUMBER IN FILE        1

         THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER   9
         TNOW =    .3000E+04
         QQTIM=    .2994E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0957
STANDARD DEVIATION              .2941
MAXIMUM NUMBER IN FILE        1

         THE FILE IS EMPTY
```

C-18 (Continued)

```
PRINTOUT OF FILE NUMBER  10
    TNOW =    .3000E+04
    QQTIM=    .2997E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .1445
STANDARD DEVIATION               .3516
MAXIMUM NUMBER IN FILE          1

THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  11
    TNOW =    .3000E+04
    QQTIM=    .3000E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .1795
STANDARD DEVIATION               .3838
MAXIMUM NUMBER IN FILE          1

FILE CONTENTS
ENTRY   1   =   .2987E+04   .1000E+01   .5400E+02   .9000E+01   .1000E+01   .8000E+01

PRINTOUT OF FILE NUMBER  12
    TNOW =    .3000E+04
    QQTIM=    .2997E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .1382
STANDARD DEVIATION               .3452
MAXIMUM NUMBER IN FILE          1

THE FILE IS EMPTY
```

C-18 (Continued)

```
PRINTOUT OF FILE NUMBER  13
  TNOW =    .3000E+04
  QQTIM=    .2999E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .1081
STANDARD DEVIATION              .3105
MAXIMUM NUMBER IN FILE         1

  THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  14
  TNOW =    .3000E+04
  QQTIM=    .2999E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0739
STANDARD DEVIATION              .2616
MAXIMUM NUMBER IN FILE         1

                FILE CONTENTS
ENTRY   1   *   .2999E+04   .2000E+01   .6800E+02   .5000E+01   .2000E+01   .1000E+02

PRINTOUT OF FILE NUMBER  15
  TNOW =    .3000E+04
  QQTIM=    .2974E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0487
STANDARD DEVIATION              .2153
MAXIMUM NUMBER IN FILE         1

  THE FILE IS EMPTY
```

C-18 (Continued)

```
PRINTOUT OF FILE NUMBER  16
     TNOW =    .3000E+04
     QQTIM=    .2975E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0335
STANDARD DEVIATION              .1799
MAXIMUM NUMBER IN FILE        1

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  17
     TNOW =    .3000E+04
     QQTIM=    .2924E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0324
STANDARD DEVIATION              .1770
MAXIMUM NUMBER IN FILE        1

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  18
     TNOW =    .3000E+04
     QQTIM=    .2873E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0255
STANDARD DEVIATION              .1576
MAXIMUM NUMBER IN FILE        1

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  19
     TNOW =    .3000E+04
     QQTIM=    .2358E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0008
STANDARD DEVIATION              .0290
MAXIMUM NUMBER IN FILE        1

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  20
     TNOW =    .3000E+04
     QQTIM=    .2519E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0011
STANDARD DEVIATION              .0332
MAXIMUM NUMBER IN FILE        1

     THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER  21
     TNOW =    .3000E+04
     QQTIM=    .1013E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          .0003
STANDARD DEVIATION              .0177
MAXIMUM NUMBER IN FILE        1

     THE FILE IS EMPTY
```

C-18 (Continued)

```
PRINTOUT OF FILE NUMBER  22
     TNOW =    .3000E+04
     QQTIM=    .2671E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .0015
STANDARD DEVIATION               .0388
MAXIMUM NUMBER IN FILE       1

     THE FILE IS EMPTY
```

```
PRINTOUT OF FILE NUMBER  23
     TNOW =    .3000E+04
     QQTIM=    .2523E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .0032
STANDARD DEVIATION               .0564
MAXIMUM NUMBER IN FILE       1

     THE FILE IS EMPTY
```

```
PRINTOUT OF FILE NUMBER  24
     TNOW =    .3000E+04
     QQTIM=    .2893E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .0048
STANDARD DEVIATION               .0688
MAXIMUM NUMBER IN FILE       1

     THE FILE IS EMPTY
```

```
PRINTOUT OF FILE NUMBER  25
     TNOW =    .3000E+04
     QQTIM=    .2676E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .0072
STANDARD DEVIATION               .0846
MAXIMUM NUMBER IN FILE       1

     THE FILE IS EMPTY
```

```
PRINTOUT OF FILE NUMBER  26
     TNOW =    .3000E+04
     QQTIM=    .2841E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .0124
STANDARD DEVIATION               .1107
MAXIMUM NUMBER IN FILE       1

     THE FILE IS EMPTY
```

```
PRINTOUT OF FILE NUMBER  27
     TNOW =    .3000E+04
     QQTIM=    .2777E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .0076
STANDARD DEVIATION               .0869
MAXIMUM NUMBER IN FILE       1

     THE FILE IS EMPTY
```

C-18 (Continued)

```
PRINTOUT OF FILE NUMBER 28
      TNOW =    .3000E+04
      QQTIM=    .2780E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .0023
STANDARD DEVIATION               .0483
MAXIMUM NUMBER IN FILE         1

      THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER 29
      TNOW =    .3000E+04
      QQTIM=    .2366E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .0003
STANDARD DEVIATION               .0158
MAXIMUM NUMBER IN FILE         1

      THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER 30
      TNOW =    .3000E+04
      QQTIM=    .1047E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .0007
STANDARD DEVIATION               .0271
MAXIMUM NUMBER IN FILE         1

      THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER 31
      TNOW =    .3000E+04
      QQTIM=    .2280E+04

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .0008
STANDARD DEVIATION               .0279
MAXIMUM NUMBER IN FILE         1

      THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER 32
      TNOW =    .3000E+04
      QQTIM=  0.

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE          0.0000
STANDARD DEVIATION              0.0000
MAXIMUM NUMBER IN FILE         0

      THE FILE IS EMPTY

PRINTOUT OF FILE NUMBER 33
      TNOW =    .3000E+04
      QQTIM=    .6477E+03

TIME PERIOD FOR STATISTICS  .3000E+04
AVERAGE NUMBER IN FILE           .0008
STANDARD DEVIATION               .0283
MAXIMUM NUMBER IN FILE         1

      THE FILE IS EMPTY
```

C-18 (Continued)

	YMAX	YMIN	YMED	AISLS	VECS	HMAX	HMIN	HMED	MRL
Layout(1)	272.0000	44.0000	148.0000	15.0000	2.0000	4.0000	-4.0000	0.0000	0.0000
Layout(2)	412.0000	60.0000	236.0000	10.0000	2.0000	6.0000	-6.0000	0.0000	0.0000
Layout(3)	412.0000	8.0000	212.0000	8.0000	2.0000	6.0000	-6.0000	0.0000	0.0000
Layout(4)	272.0000	8.0000	140.0000	13.0000	2.0000	4.0000	-4.0000	0.0000	0.0000
Layout(5)	272.0000	28.0000	140.0000	30.0000	2.0000	4.0000	-4.0000	0.0000	2.0000
Layout(6)	412.0000	60.0000	236.0000	20.0000	2.0000	6.0000	-6.0000	0.0000	3.0000
Layout(7)	412.0000	8.0000	208.0000	16.0000	2.0000	6.0000	-6.0000	0.0000	3.0000
Layout(8)	272.0000	8.0000	140.0000	26.0000	2.0000	4.0000	-4.0000	0.0000	2.0000

C-19 Last Part of Input Data for all Layouts

APPENDIX D

Output Summary Report

GASP SUMMARY REPORT

SIMULATION PROJECT NUMBER 1 BY Y. BENMAHMUD

DATE 47 207 1982 RUN NUMBER 1 OF 1

CURRENT TIME = .3000E+04

PARAMETER SET	1 =	.9000E+01	.1000E+01	.2000E+02	0.
PARAMETER SET	2 =	.4000E+01	.1000E+01	.1000E+02	0.

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN	STD DEV	SD OF MEAN	CV	MINIMUM	MAXIMUM	OBS
Q(1)	.9360E+01	.2786E+01	.2492E+00	.2977E+00	.2000E+01	.1600E+02	125
Q(2)	.9857E+01	.2853E+01	.2615E+00	.2894E+00	.5000E+01	.1800E+02	119
TUN(1)	.4720E+02	.1501E+02	.1348E+01	.3179E+00	.7000E+01	.8600E+02	124
TUN(2)	.4965E+02	.1693E+02	.1552E+01	.3409E+00	.1900E+02	.1000E+03	119
TVT(1)	.4885E+01	.1596E+01	.1434E+00	.3268E+00	.7879E+00	.9152E+01	124
TVT(2)	.4986E+01	.1533E+01	.1406E+00	.3075E+00	.2061E+01	.9061E+01	119
TPT(1)	.1861E+02	.6051E+01	.5443E+00	.3257E+00	.2800E+01	.3320E+02	124
TPT(2)	.1952E+02	.6919E+01	.6343E+00	.3545E+00	.7200E+01	.4000E+02	119
TMT(1)	.2912E+00	.8277E+00	.7433E-01	.2842E+01	0.	.4855E+01	124
TMT(2)	.3213E+00	.8808E+00	.8074E-01	.2741E+01	0.	.4218E+01	119
SVWT(1)	.5176E+01	.1788E+01	.1606E+00	.3455E+00	.7879E+00	.1051E+02	124
SVWT(2)	.5307E+01	.1708E+01	.1565E+00	.3217E+00	.2061E+01	.1094E+02	119
PCT(1)	.2378E+02	.7227E+01	.6490E+00	.3038E+00	.3588E+01	.4152E+02	124
PCT(2)	.2482E+02	.7970E+01	.7306E+00	.3211E+00	.1006E+02	.4771E+02	119

D-1 Results Summary Report for Layout (1)

GASP SUMMARY REPORT

SIMULATION PROJECT NUMBER 2 BY Y. BENMAHMUD

DATE 4/ 20/ 1982 RUN NUMBER 1 OF 1

CURRENT TIME = .3000E+04

PARAMETER SET	1 =	.9000E+01	.1000E+01	.2000E+02	0.
PARAMETER SET	2 =	.4000E+01	.1000E+01	.1000E+02	0.

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN	STD DEV	SD OF MEAN	CV	MINIMUM	MAXIMUM	OBS
Q(1)	.9580E+01	.2889E+01	.2649E+00	.3016E+00	.3000E+01	.1600E+02	119
Q(2)	.9672E+01	.2817E+01	.2582E+00	.2912E+00	.2000E+01	.1800E+02	119
TUN(1)	.4836E+02	.1662E+02	.1530E+01	.3437E+00	.1700E+02	.9700E+02	118
TUN(2)	.4821E+02	.1501E+02	.1382E+01	.3113E+00	.7000E+01	.8700E+02	118
TVT(1)	.5186E+01	.1874E+01	.1725E+00	.3613E+00	.1818E+01	.9667E+01	118
TVT(2)	.5285E+01	.1795E+01	.1652E+00	.3396E+00	.1303E+01	.1036E+02	118
TPT(1)	.1881E+02	.6837E+01	.6294E+00	.3634E+00	.6000E+01	.3800E+02	118
TPT(2)	.1875E+02	.6145E+01	.5657E+00	.3277E+00	.2000E+01	.3400E+02	118
TWT(1)	.6856E+00	.1551E+01	.1428E+00	.2262E+01	0.	.6048E+01	118
TWT(2)	.5562E+00	.1353E+01	.1245E+00	.2432E+01	0.	.7164E+01	118
SVWT(1)	.5872E+01	.2294E+01	.2112E+00	.3906E+00	.1818E+01	.1268E+02	118
SVWT(2)	.5842E+01	.2107E+01	.1940E+00	.3608E+00	.1303E+01	.1140E+02	118
PCT(1)	.2468E+02	.7944E+01	.7313E+00	.3218E+00	.8618E+01	.4559E+02	118
PCT(2)	.2459E+02	.7265E+01	.6688E+00	.2954E+00	.6255E+01	.4323E+02	118

D-2 Results Summary Report for Layout (2)

GASP SUMMARY REPORT

SIMULATION PROJECT NUMBER 3 BY Y. BENMAHMUD

DATE 4/ 20/ 1982 RUN NUMBER 1 OF 1

CURRENT TIME = .3000E+04

PARAMETER SET	1 =	.9000E+01	.1000E+01	.2000E+02	0.
PARAMETER SET	2 =	.4000E+01	.1000E+01	.1000E+02	0.

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN	STD DEV	SD OF MEAN	CV	MINIMUM	MAXIMUM	OPS
Q(1)	.9755E+01	.2536E+01	.2521E+00	.2661E+00	.3000E+01	.1600E+02	106
Q(2)	.9391E+01	.3047E+01	.2986E+00	.3245E+00	.2000E+01	.1600E+02	110
TUN(1)	.4987E+02	.1491E+02	.1438E+01	.2970E+00	.2000E+02	.9700E+02	106
TUN(2)	.4627E+02	.1688E+02	.1616E+01	.3647E+00	.7000E+01	.9100E+02	109
TVT(1)	.7476E+01	.1919E+01	.1864E+00	.2567E+00	.3015E+01	.1335E+02	106
TVT(2)	.7494E+01	.2111E+01	.2022E+00	.2816E+00	.2970E+01	.1318E+02	109
TPT(1)	.1958E+02	.6128E+01	.5952E+00	.3130E+00	.4000E+01	.3780E+02	106
TPT(2)	.1800E+02	.6943E+01	.6650E+00	.3857E+00	.2800E+01	.3540E+02	109
TWT(1)	.8035E+00	.1699E+01	.1641E+00	.2102E+01	0.	.7897E+01	106
TWT(2)	.1190E+01	.2330E+01	.2230E+00	.2009E+01	0.	.1093E+02	109
SVWT(1)	.8280E+01	.2345E+01	.2278E+00	.2832E+00	.3485E+01	.1348E+02	106
SVWT(2)	.8685E+01	.2894E+01	.2772E+00	.3332E+00	.2970E+01	.1736E+02	109
PCT(1)	.2786E+02	.7075E+01	.6872E+00	.2540E+00	.1491E+02	.4971E+02	106
PCT(2)	.2669E+02	.8450E+01	.8103E+00	.3170E+00	.7239E+01	.4655E+02	109

D-3 Results Summary Report for Layout (3)

GASP SUMMARY REPORT

SIMULATION PROJECT NUMBER 4 BY Y. BENMAHMUD

DATE 4/ 20/ 1982 RUN NUMBER 1 OF 1

CURRENT TIME = .3000E+04

PARAMETER SET	1 =	.9000E+01	.1000E+01	.2000E+02	0.
PARAMETER SET	2 =	.4000E+01	.1000E+01	.1000E+02	0.

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN	STD DEV	SD OF MEAN	CV	MINIMUM	MAXIMUM	OBS
Q(1)	.9250E+01	.2822E+01	.2620E+00	.3051E+00	.3000E+01	.1600E+02	116
Q(2)	.9955E+01	.2804E+01	.2650E+00	.2817E+00	.2000E+01	.1600E+02	112
TUN(1)	.4673E+02	.1605E+02	.1490E+01	.3434E+00	.1300E+02	.9700E+02	116
TUN(2)	.4982E+02	.1593E+02	.1505E+01	.3197E+00	.7000E+01	.9100E+02	112
TVT(1)	.6110E+01	.1676E+01	.1555E+00	.2743E+00	.1530E+01	.9227E+01	116
TVT(2)	.6163E+01	.1440E+01	.1360E+00	.2336E+00	.1636E+01	.9182E+01	112
TPT(1)	.1825E+02	.6569E+01	.6099E+00	.3599E+00	.5200E+01	.3700E+02	116
TPT(2)	.1958E+02	.6490E+01	.6132E+00	.3314E+00	.2000E+01	.3640E+02	112
TWT(1)	.9737E+00	.1851E+01	.1718E+00	.1901E+01	0.	.8385E+01	116
TWT(2)	.6667E+00	.1477E+01	.1395E+00	.2215E+01	0.	.6758E+01	112
SVWT(1)	.7084E+01	.2303E+01	.2138E+00	.3251E+00	.1603E+01	.1496E+02	116
SVWT(2)	.6830E+01	.2008E+01	.1897E+00	.2940E+00	.1636E+01	.1448E+02	112
PCT(1)	.2533E+02	.7636E+01	.7090E+00	.3014E+00	.8883E+01	.4683E+02	116
PCT(2)	.2641E+02	.7438E+01	.7028E+00	.2816E+00	.4436E+01	.4361E+02	112

D-4 Results Summary Report for Layout (4)

GASP SUMMARY REPORT

SIMULATION PROJECT NUMBER 5 BY Y. BENMAHMUD

DATE 4/ 20/ 1992 RUN NUMBER 1 OF 1

CURRENT TIME = .3000E+04

PARAMETER SET	1 =	.9000E+01	.1000E+01	.2000E+02	0.
PARAMETER SET	2 =	.4000E+01	.1000E+01	.1000E+02	0.

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN	STD DEV	SD OF MEAN	CV	MINIMUM	MAXIMUM	OBS
Q(1)	.9941E+01	.2817E+01	.2583E+00	.2834E+00	.4000E+01	.1600E+02	119
Q(2)	.9299E+01	.2793E+01	.2478E+00	.3003E+00	.2000E+01	.1800E+02	127
TUN(1)	.5017E+02	.1656E+02	.1519E+01	.3301E+00	.1900E+02	.9700E+02	119
TUN(2)	.4672E+02	.1515E+02	.1344E+01	.3241E+00	.7000E+01	.1000E+03	127
TVT(1)	.4892E+01	.1433E+01	.1311E+00	.2923E+00	.2061E+01	.8618E+01	119
TVT(2)	.4642E+01	.1455E+01	.1292E+00	.3137E+00	.7879E+00	.8515E+01	127
TPT(1)	.1981E+02	.6703E+01	.6144E+00	.3383E+00	.7600E+01	.3880E+02	119
TPT(2)	.1839E+02	.6103E+01	.5413E+00	.3318E+00	.2800E+01	.4000E+02	127
TWT(1)	.2318E+00	.7525E+00	.6698E-01	.3246E+01	0.	.4842E+01	119
TWT(2)	.3021E+00	.8849E+00	.7652E-01	.2929E+01	0.	.4915E+01	127
SVWT(1)	.5124E+01	.1599E+01	.1466E+00	.3122E+00	.2061E+01	.1145E+02	119
SVWT(2)	.4944E+01	.1739E+01	.1543E+00	.3517E+00	.7879E+00	.1108E+02	127
PCT(1)	.2494E+02	.7699E+01	.7057E+00	.3087E+00	.1006E+02	.4710E+02	119
PCT(2)	.2333E+02	.7149E+01	.6344E+00	.3064E+00	.3588E+01	.4706E+02	127

D-5 Results Summary Report for Layout (5)

GASP SUMMARY REPORT

SIMULATION PROJECT NUMBER 6 BY Y. BENMAHMUD

DATE 4/ 20/ 1982 RUN NUMBER 1 OF 1

CURRENT TIME = .3000E+04

PARAMETER SET	1 =	.9000E+01	.1000E+01	.2000E+02	0.
PARAMETER SET	2 =	.4000E+01	.1000E+01	.1000E+02	0.

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN	STD DEV	SD OF MEAN	CV	MINIMUM	MAXIMUM	OBS
Q(1)	.9661E+01	.2771E+01	.2519E+00	.2868E+00	.2000E+01	.1600E+02	121
Q(2)	.9579E+01	.2898E+01	.2634E+00	.3025E+00	.3000E+01	.1800E+02	121
TUN(1)	.4839E+02	.1572E+02	.1429E+01	.3248E+00	.7000E+01	.8900E+02	121
TUN(2)	.4854E+02	.1633E+02	.1484E+01	.3364E+00	.1700E+02	.1000E+03	121
TVT(1)	.5009E+01	.1592E+01	.1448E+00	.3179E+00	.1303E+01	.9333E+01	121
TVT(2)	.4914E+01	.1538E+01	.1398E+00	.3129E+00	.1819E+01	.8304E+01	121
TPT(1)	.1903E+02	.6301E+01	.5728E+00	.3311E+00	.2600E+01	.3480E+02	121
TPT(2)	.1901E+02	.6620E+01	.6018E+00	.3482E+00	.6900E+01	.3880E+02	121
TMT(1)	.3616E+00	.9837E+00	.8943E-01	.2720E+01	0.	.5339E+01	121
TMT(2)	.4581E+00	.1129E+01	.1027E+00	.2465E+01	0.	.4903E+01	121
SVMT(1)	.5371E+01	.1828E+01	.1652E+00	.3403E+00	.1303E+01	.1093E+02	121
SVMT(2)	.5372E+01	.1874E+01	.1704E+00	.3488E+00	.1819E+01	.1138E+02	121
PCT(1)	.2440E+02	.7420E+01	.6745E+00	.3041E+00	.6073E+01	.4389E+02	121
PCT(2)	.2438E+02	.7658E+01	.6962E+00	.3141E+00	.8619E+01	.4612E+02	121

D-6 Results Summary Report for Layout (6)

GASP SUMMARY REPORT

SIMULATION PROJECT NUMBER 7 BY Y. BENMAHMUD

DATE 4/ 28/ 1982 RUN NUMBER 1 OF 1

CURRENT TIME = .3000E+04

PARAMETER SET	1 =	.9000E+01	.1000E+01	.2000E+02	0.
PARAMETER SET	2 =	.4000E+01	.1000E+01	.1000E+02	0.

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN	STD DEV	SD OF MEAN	CV	MINIMUM	MAXIMUM	OBS
Q(1)	.9576E+01	.3000E+01	.2769E+00	.3141E+00	.3000E+01	.1800E+02	118
Q(2)	.9675E+01	.2692E+01	.2457E+00	.2782E+00	.2000E+01	.1600E+02	120
TUN(1)	.4848E+02	.1638E+02	.1514E+01	.3379E+00	.1700E+02	.9700E+02	117
TUN(2)	.4809E+02	.1528E+02	.1401E+01	.3177E+00	.7000E+01	.8900E+02	119
TVT(1)	.5451E+01	.1525E+01	.1410E+00	.2798E+00	.1955E+01	.9076E+01	117
TVT(2)	.5321E+01	.1500E+01	.1375E+00	.2819E+00	.1803E+01	.8742E+01	119
TPT(1)	.1895E+02	.6601E+01	.6103E+00	.3483E+00	.6200E+01	.3880E+02	117
TPT(2)	.1883E+02	.6268E+01	.5746E+00	.3329E+00	.2800E+01	.3560E+02	119
TWT(1)	.5687E+00	.1330E+01	.1230E+00	.2339E+01	0.	.6642E+01	117
TWT(2)	.4592E+00	.1186E+01	.1088E+00	.2584E+01	0.	.6309E+01	119
SVWT(1)	.6019E+01	.1903E+01	.1759E+00	.3162E+00	.2379E+01	.1267E+02	117
SVWT(2)	.5780E+01	.1835E+01	.1682E+00	.3175E+00	.1803E+01	.1059E+02	119
PCT(1)	.2497E+02	.7692E+01	.7111E+00	.3080E+00	.9179E+01	.4688E+02	117
PCT(2)	.2461E+02	.7308E+01	.6699E+00	.2970E+00	.4603E+01	.4319E+02	119

D-7 Results Summary Report for Layout (7)

GASP SUMMARY REPORT

SIMULATION PROJECT NUMBER 8 BY Y. BENMAHMUD

DATE 4/ 20/ 1992 RUN NUMBER 1 OF 1

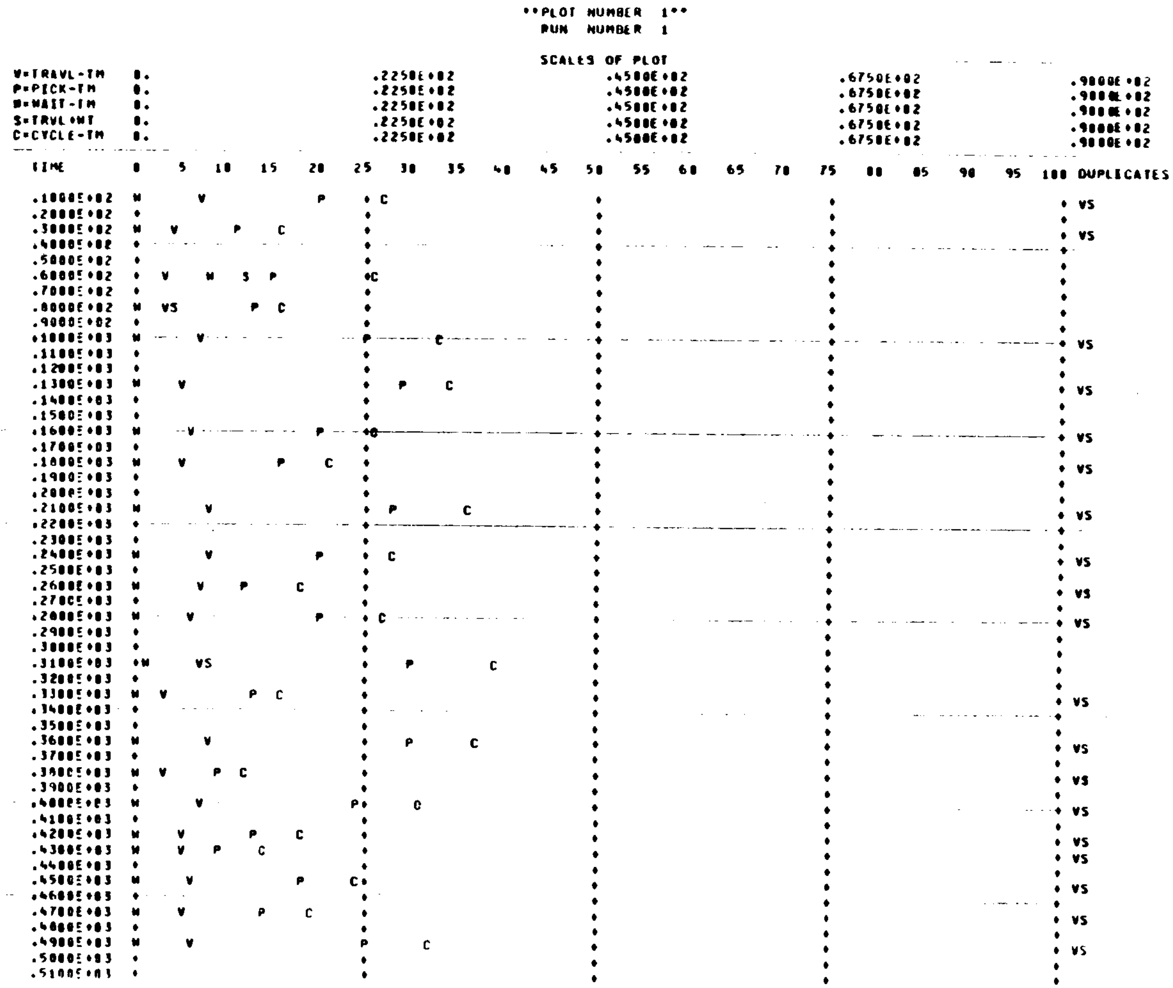
CURRENT TIME = .3000E+04

PARAMETER SET	1 =	.9000E+01	.1000E+01	.2000E+02	0.
PARAMETER SET	2 =	.4000E+01	.1000E+01	.1000E+02	0.

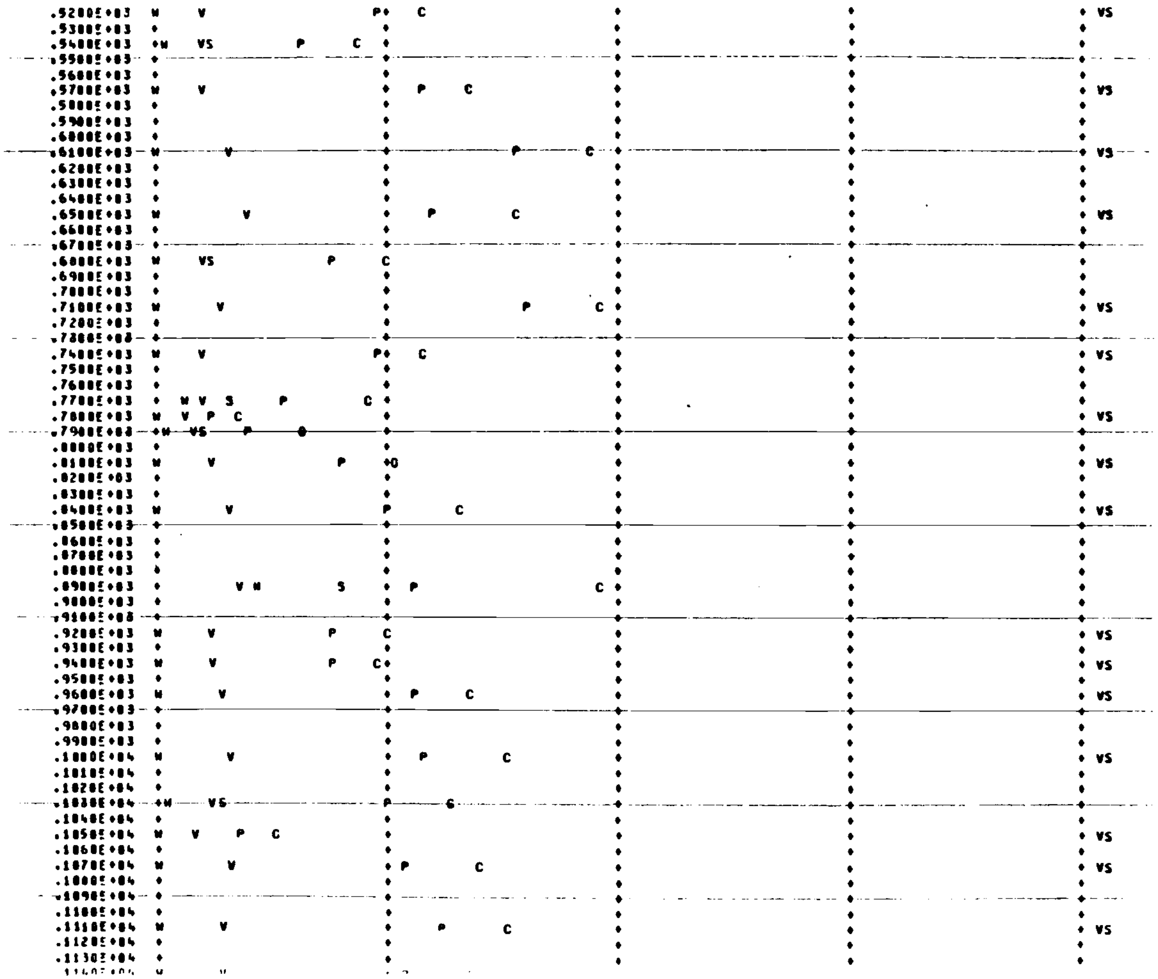
STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN	STD DEV	SD OF MEAN	CV	MINIMUM	MAXIMUM	OBS
Q(1)	.9403E+01	.2436E+01	.2188E+00	.2591E+00	.2000E+01	.1600E+02	124
Q(2)	.9847E+01	.3186E+01	.2932E+00	.3235E+00	.3000E+01	.1800E+02	118
TUN(1)	.4720E+02	.1419E+02	.1274E+01	.3005E+00	.7000E+01	.9700E+02	124
TUN(2)	.4977E+02	.1773E+02	.1639E+01	.3563E+00	.1300E+02	.1000E+03	117
TVT(1)	.4906E+01	.1419E+01	.1274E+00	.2893E+00	.1079E+01	.8636E+01	124
TVT(2)	.4984E+01	.1355E+01	.1253E+00	.2719E+00	.2303E+01	.8636E+01	117
TPT(1)	.1858E+02	.5719E+01	.5136E+00	.3078E+00	.2600E+01	.3800E+02	124
TPT(2)	.1955E+02	.7129E+01	.6591E+00	.3647E+00	.5280E+01	.3920E+02	117
TWT(1)	.3595E+00	.9936E+00	.8923E-01	.2764E+01	0.	.7115E+01	124
TWT(2)	.5545E+00	.1116E+01	.1032E+00	.2012E+01	0.	.4394E+01	117
SVWT(1)	.5265E+01	.1697E+01	.1524E+00	.3223E+00	.1879E+01	.1040E+02	124
SVWT(2)	.5538E+01	.1686E+01	.1559E+00	.3045E+00	.2303E+01	.1038E+02	117
PCT(1)	.2384E+02	.6786E+01	.6022E+00	.2812E+00	.5012E+01	.4663E+02	124
PCT(2)	.2509E+02	.8123E+01	.7515E+00	.3241E+00	.7776E+01	.4818E+02	117

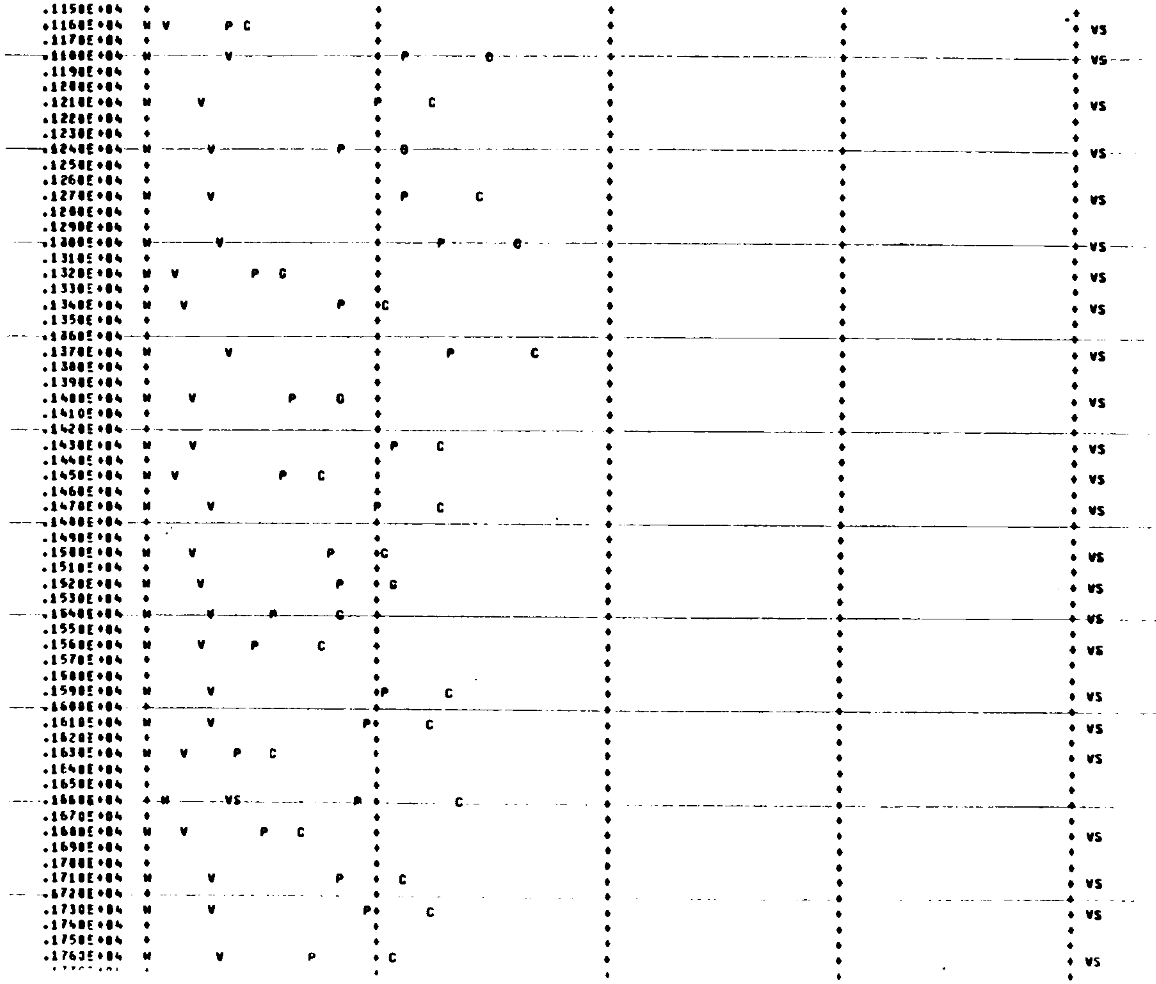
D-8 Results Summary Report for Layout (8)



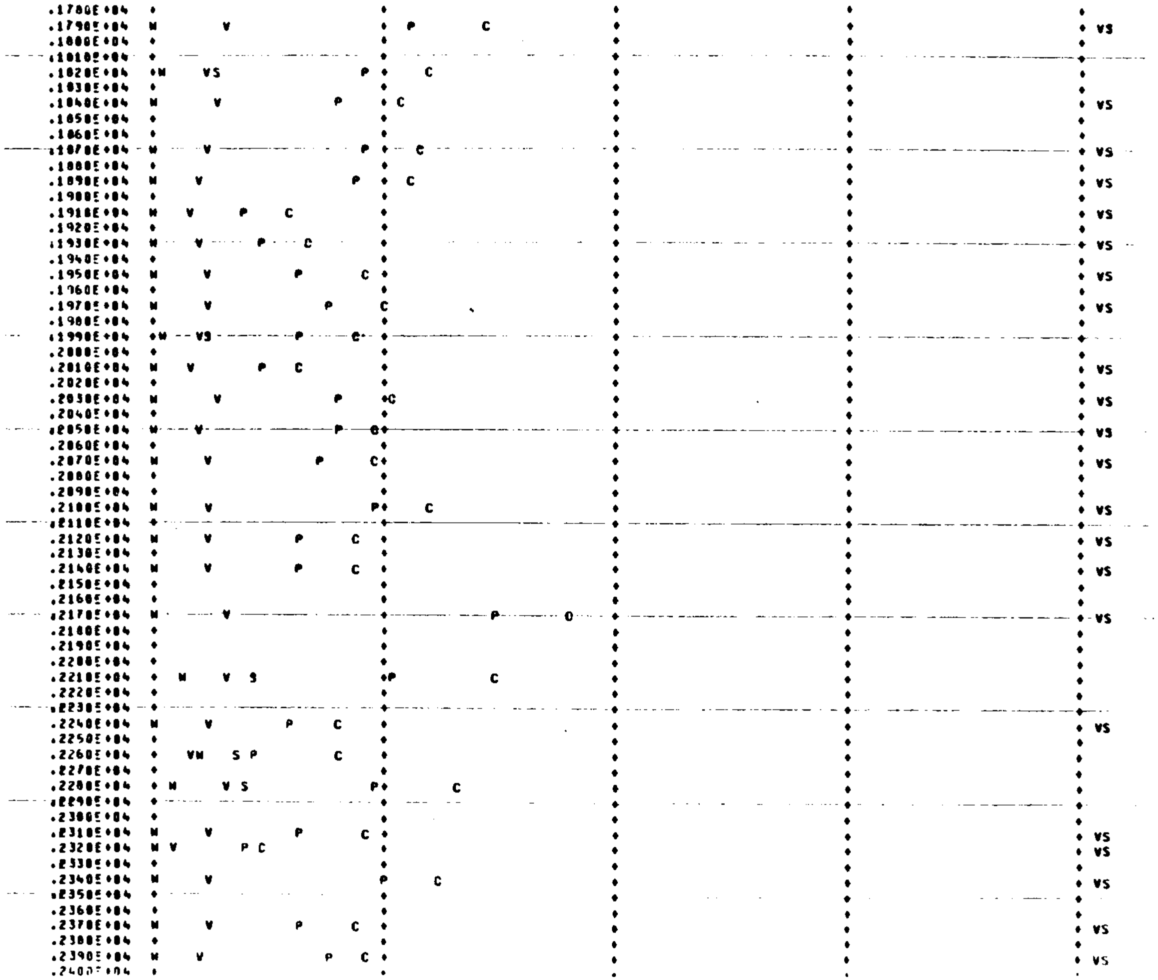
D-9 Typical Plot of Traveling, Waiting, and Picking Cycle Time against Time



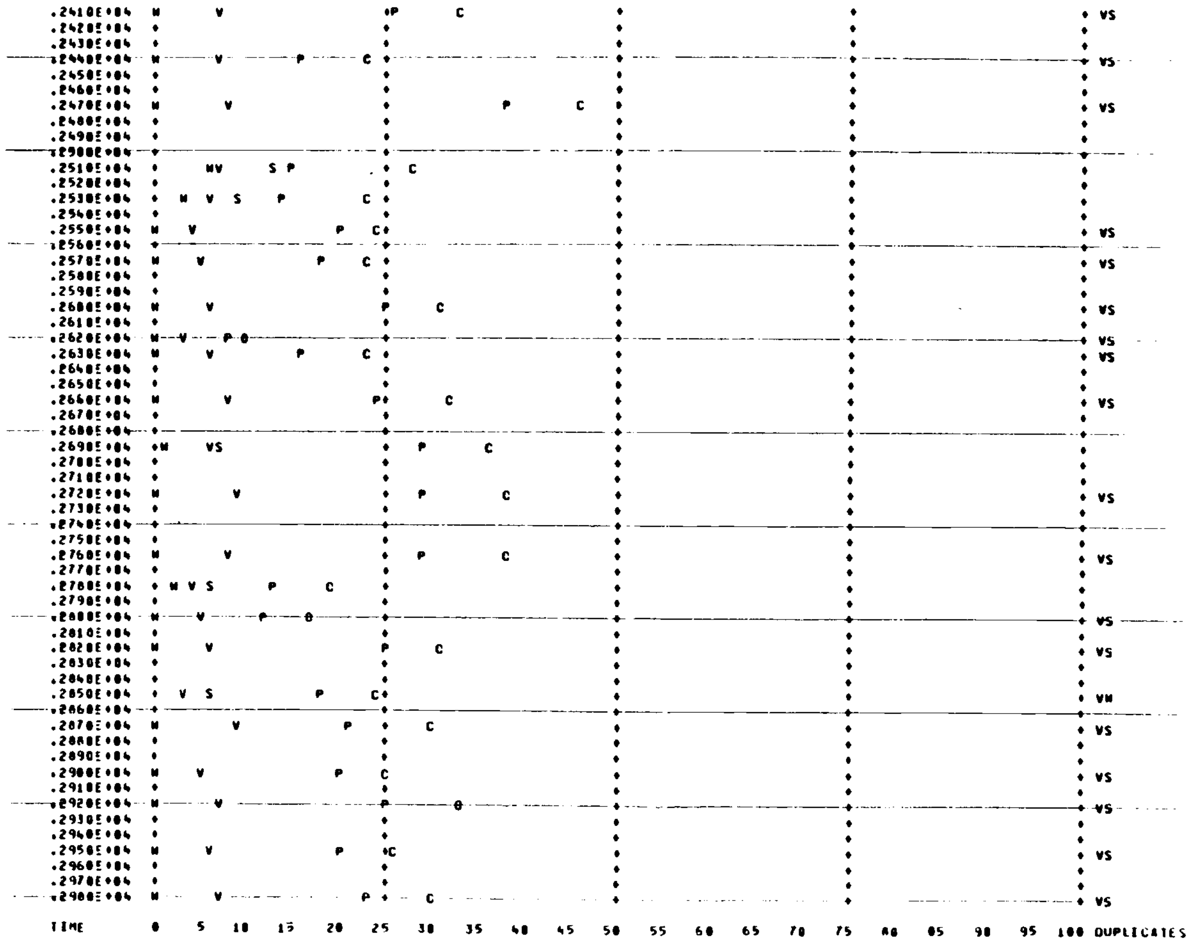
D-9 (Continued)



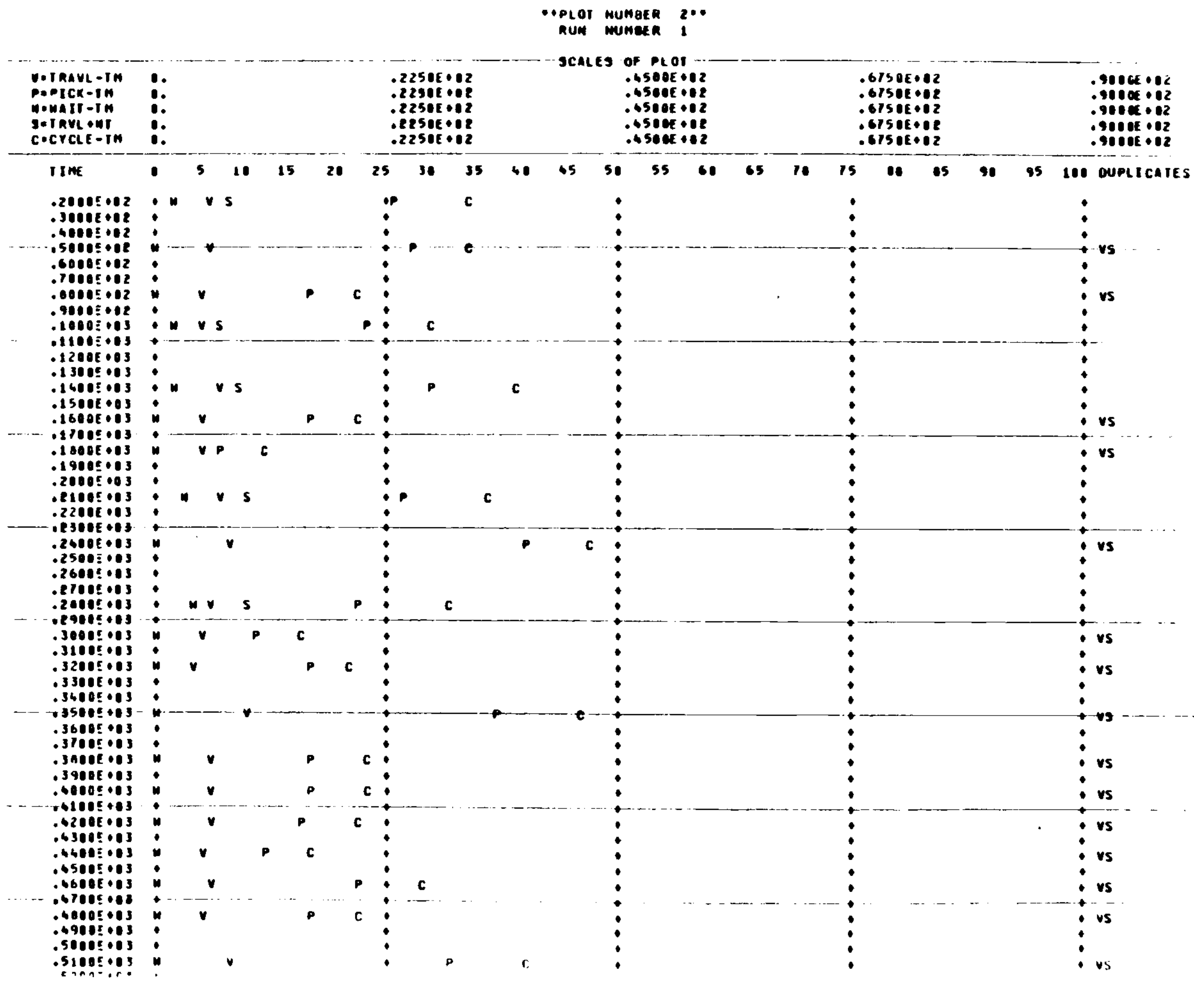
D-9 (Continued)



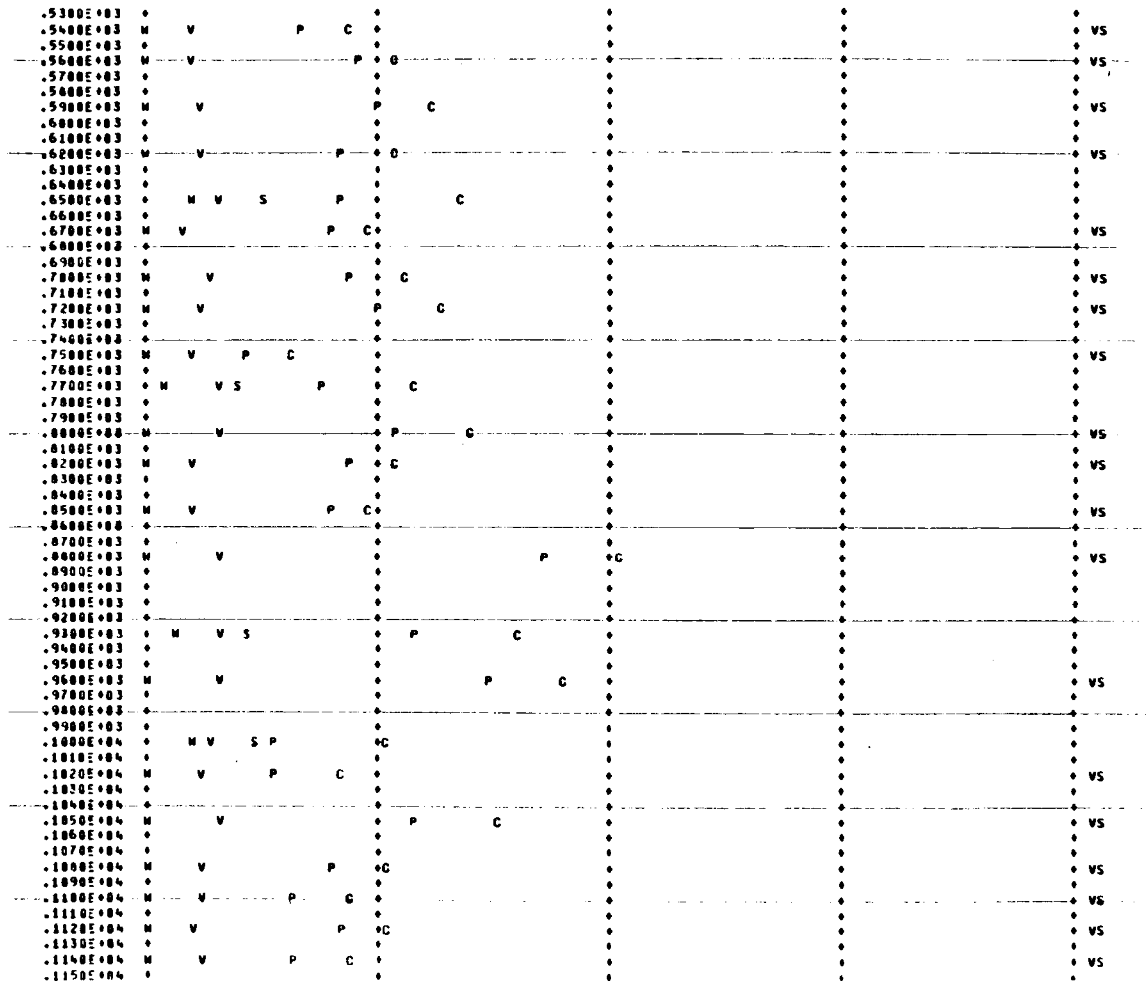
D-9 (Continued)



D-9 (Continued)



D-9 (Continued)



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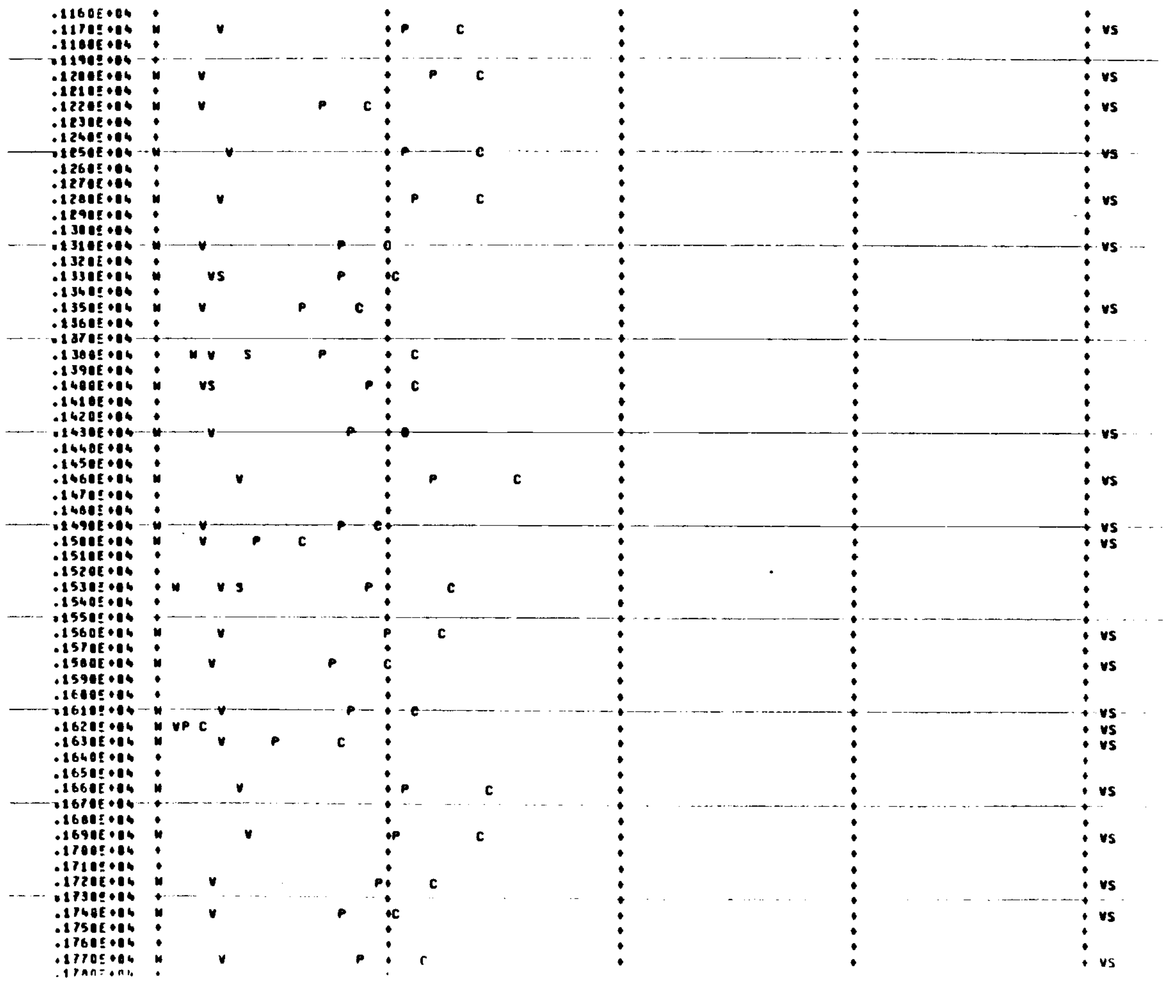

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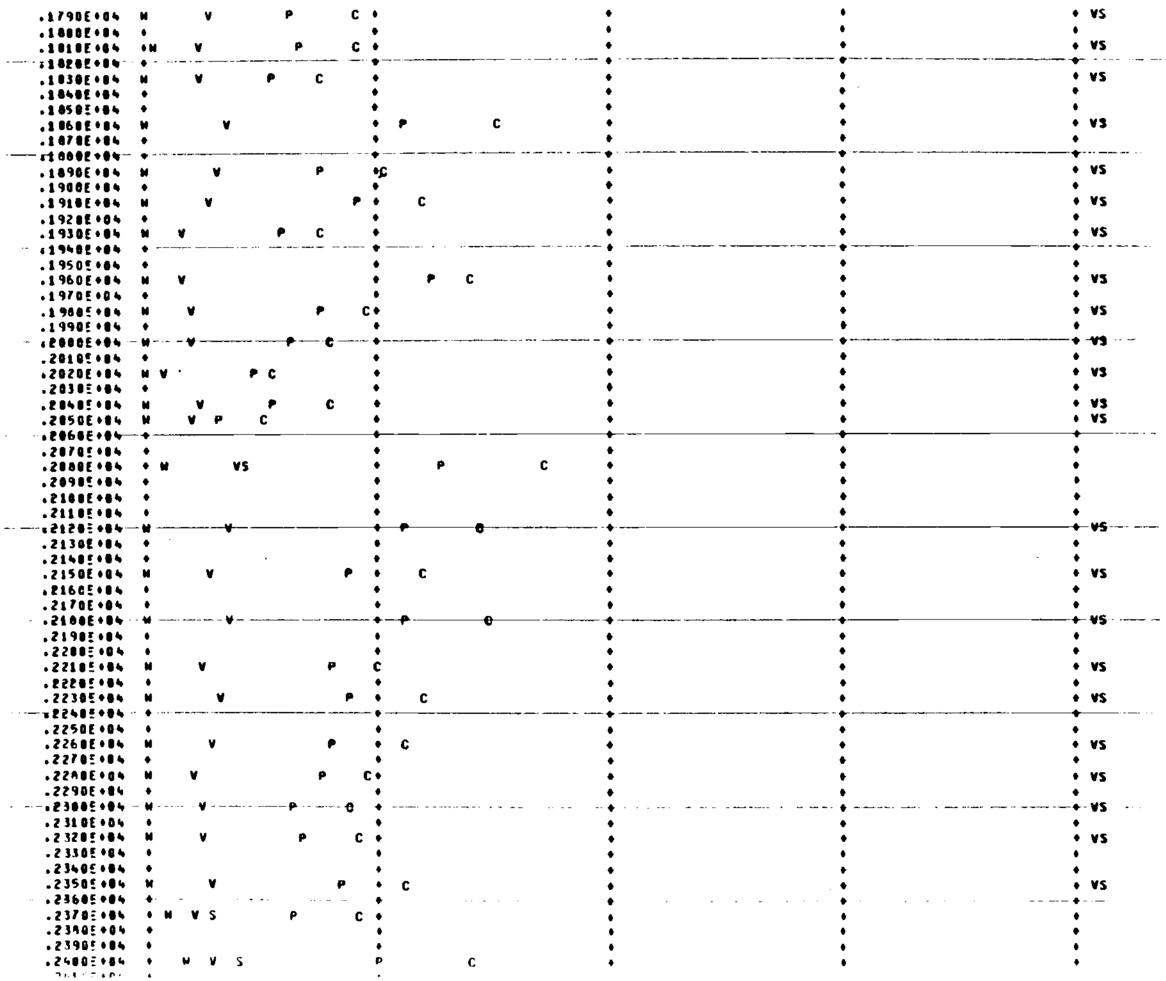

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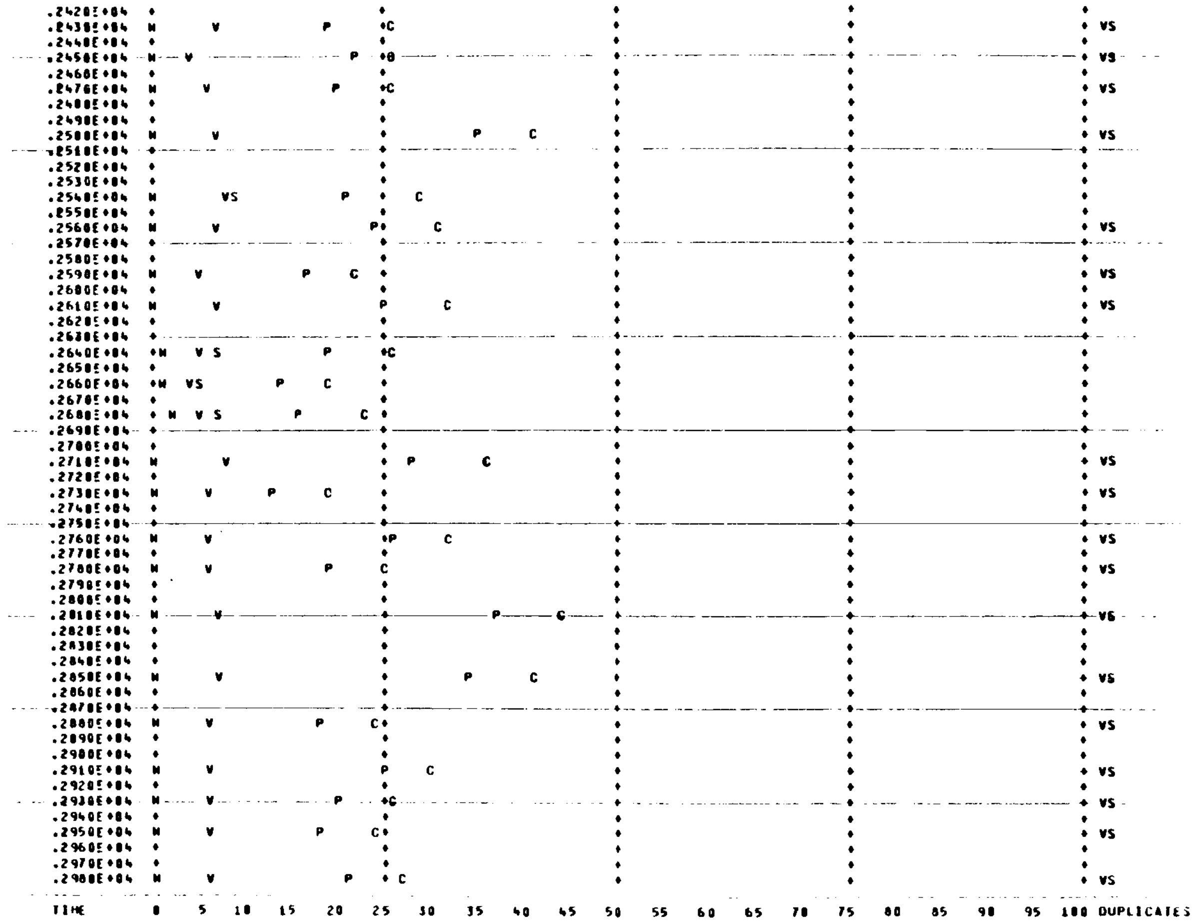

D-9 (Continued)