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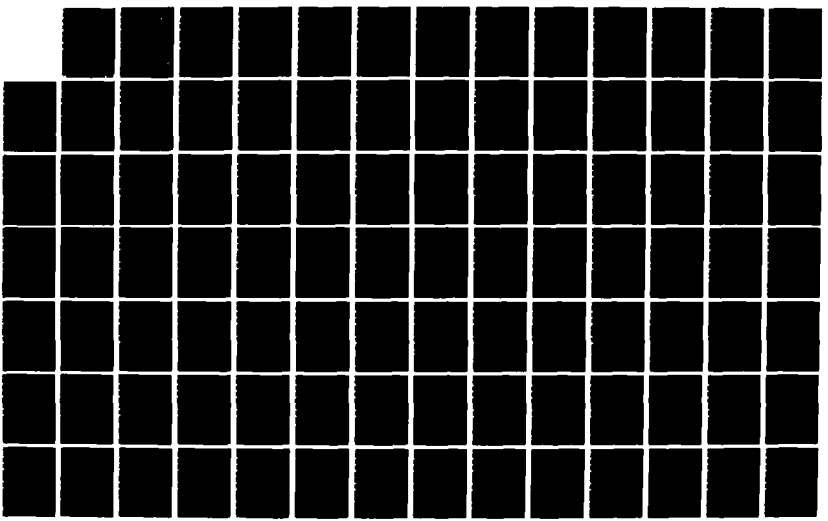

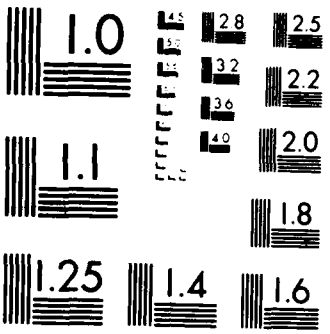
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TECHNICAL REPORT BRL-TR-2865

GRAVES REGISTRATION SIMULATION

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NOVEMBER 1987

US ARMY BALLISTIC RESEARCH LABORATORY
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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

This report describes a simulation methodology developed by the US Army Ballistic Research Laboratory (BRL) which was used to analyze the capabilities of the US Army Graves Registration (GRREG) Service. The GRREG Program provides for essential search, recovery, collection, and disposition of the remains of deceased US personnel in an area of conflict where the prompt return of remains to the Continental United States is not possible. The US Army Quartermaster School commissioned the BRL to conduct a GRREG study to evaluate the GRREG requirements of the future battlefield and analyze the ability of the GRREG system to meet these requirements. A capabilities analysis was conducted to compare alternative organizations and procedures. The analytical tool used for this was a computer generated simulation using the Smalltalk-80 (TM) programming environment.

The GRREG organizations in a Corps are best described as a network of queues where remains await processing. These queues form networks, where the output of one becomes the input of

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another. The network is rather complicated: consisting of several hundred individual queues that are interconnected either in series or in parallel. The network is described in three levels of detail, with the basic level consisting of the individual queues, the intermediate level consisting of three types of collecting points (initial, intermediate, cemetery), and the top level showing the flow from one collecting point to another.

The GRREG queuing network forms a directed connected graph of arcs and nodes with tokens passed along the arcs through the nodes. The tokens represent bodies or trucks, and each node represents a task to be performed on tokens and a queue where the tokens wait their turn for processing. The behavior of an individual queue is controlled by the choices made for a small set of parameters. These parameters are examined as they apply to the various queues in the network.

The BRL study provided 1) a base line analysis of the ability of the present system to handle conventional and contaminated remains, and 2) an analysis of several alternatives, including changes in force structure, equipment, and GRREG procedures. Results and conclusions are given for the various scenarios investigated. The recommendations of the study are intended to provide the Logistics Community a direction for changes in graves registration doctrine, procedures, and organizations.

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I. Introduction

This report describes a simulation methodology developed by the US Army Ballistic Research Laboratory (BRL) which was used to analyze the capabilities of the US Army Graves Registration (GRREG) Service. The report also summarizes the results and conclusions of the simulation analysis.

In 1984, the US Army Quartermaster School commissioned the Ballistics Research Laboratory to conduct a Graves Registration study. The thrust of this study was to evaluate the GRREG requirements of the future battlefield and analyze the ability of the GRREG system to meet these requirements. The study provided 1) a base line analysis of the ability of the present system to handle conventional and contaminated remains, and 2) an analysis of several alternatives, including changes in force structure, equipment, and GRREG procedures. The recommendations of the study are intended to provide the Logistics Community a direction for changes in graves registration doctrine, procedures, and organizations. A large computer simulation was written in Smalltalk-80* in order to perform the analysis.

II. Background

1. History

In October 1980 the Deputy Chief of Staff for Logistics directed the US Army Concepts Analysis Agency to prepare a study of Army capability to process human remains in a combat zone. At the same time the Combat Service Support Mission Area Analysis (CSSMAA) process was identifying specific deficiencies in the Army Graves Registration Program. By July, 1981 the Concepts Analysis Agency had produced a study report.[1] The major conclusions of this report were: current Army capability to provide GRREG is severely limited, divisional GRREG capability is not authorized except through augmentation, planned deployment of the force is inconsistent with anticipated workload, and there is a maldistribution of personnel to various tasks.

The Prioritization of Mission Area Deficiencies published by the Training and Doctrine Command (TRADOC) in May, 1983 listed inadequate graves registration capability as a combat service support deficiency.[2] This deficiency stated that adequate GRREG

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* Smalltalk-80 is a trademark of the Xerox Corporation.

1. US Army Concepts Analysis Agency,"Graves Registration (Grreg) Study ",CAA LOG NO. 213373, July 1983, (SECRET).

capability was not in the force structure and that the time required to train and deploy the minimum essential GRREG force structure will produce inadequate GRREG services during the first phases of a conflict.

The US Army Quartermaster School conducted a Manpower Criteria (MACRIT) Study of MOS57F, Graves Registration Specialist in 1983, and in 1984 produced a Logistics Unit Productivity Study (LUPS) of the Graves Registration Company.[3] [4] Both reports examined the manpower and force structure problems associated with GRREG. The MACRIT Study developed manpower authorization formulas for three different scenarios and attempted to assess the impact of GRREG operations in a chemical environment on processing time and manpower. The LUPS recommended the redesign of the Graves Registration Company to provide a greater number of available manhours in the company itself and to provide more flexible support.

During this time the problems associated with GRREG operations in a nuclear, biological and chemical (NBC) environment were being addressed by the Quartermaster School. The school found that there were no well defined procedures for handling contaminated remains, and doctrine for graves registration services on the Integrated Battlefield was ill-defined.

In August 1984 the US Army Quartermaster School prepared a proposal for the US Army Ballistic Research Laboratory to conduct a study of Graves Registration that would develop procedures for Graves Registration in a NBC environment , explore state of the art technology and materiel systems to enhance GRREG support and provide insights into the organizational and operational changes required to produce adequate graves registration services.

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2. US Army Training and Doctrine Command,"Prioritization of Mission Area Deficiencies ", 1983, (SECRET).

3. US Army Quartermaster School, "Manpower Authorization Criteria (MACRIT) for MOS 57F ", ACN 82545, Final Draft, March 1983.

4. US Army Quartermaster School, "Logistics Unit Productivity Study, Graves Registration Company ", Final Report, June 1984.

2. Scope

The GRREG study was limited to the functional area of graves registration. No attempt was made to examine any other programs for the handling of military deceased.

Within the Graves Registration Program, the study examined all aspects of required services including search and recovery, identification processing, disposition processing, casualty reporting as it affects GRREG units, and command, control and information processing. All analysis that required scenario data was based on the TRADOC standard Europe V scenario and the Jiffy wargame results of that scenario.[5] The study examined both conventional operations and operations in a NBC environment.

The study was completed by the Ballistic Research Laboratory in November 1985, and the study results are applicable to all graves registration units Army wide.

3. Assumptions

The following assumptions were agreed to by the Quartermaster School and the Ballistic Research Laboratory prior to the study:

- Casualty rates will necessitate an early transition to the Graves Registration Program in a future European conflict.
- NBC weapons will be used by Threat forces.
- For simulation purposes, it was assumed that division graves registration augmentations will be available in the divisions under consideration on D-day.†
- For the GRREG simulation, all graves registration organizations will be at full ALO1* strength in personnel and equipment on D-day.

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5. US Army Combined Arms Operations Research Activity, "Europe V, Initial Draft, Volume 2, VII (US) Corps, Critical Incidents 1-10 ", December 1983.

† Actual time between M-day and D-day may not allow for the acquisition, training and deployment of the required number of Graves Registration Specialists.

* ALO1 is defined as the highest authorized personnel strength listed in a unit's Table of Organization and Equipment (TOE).

- Adequate transportation will be available to move conventional remains between echelons.

- The casualty evacuation system for wounded personnel will function as planned.

- Units experiencing greater than 30% killed in action (KIA) will not be capable of self evacuating remains to the appropriate collecting point. All other units will perform evacuation of their human remains to the appropriate collection point.

- Materiel items considered for application to enhance GRREG operations will be limited to those which currently exist or those for which the technology has been demonstrated.

- US GRREG personnel will be required to process some enemy remains.

4. Study Outline

The Graves Registration Study was conducted in three phases; a data collection phase, a requirements analysis phase, and a capabilities analysis phase.

The data collection phase consisted of a literature search, historical analysis and threat analysis. All available studies concerning GRREG were reviewed and both completed and on-going studies that addressed related subjects were reviewed. Detailed data bases of GRREG procedures, organizations, NBC effects, and new technology were constructed. A historical analysis was conducted to place current problems in perspective and gain insight into past experiences with graves registration. A threat analysis was prepared based on the best available information concerning threat tactics, capabilities and doctrine.

The requirements analysis began with the development of a workload for the Europe V, VII Corps TRADOC scenario. The deployment of US forces and the threat array were drawn from the Landwarfare Systems Vulnerability Program (LSVP)† analysis of

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† The Landwarfare Systems Vulnerability Analysis Program (LSVP) is an on-going study effort being conducted for the Defense Nuclear Agency (DNA) by BRL, Harry Diamond Laboratory and the TRADOC Systems Analysis Agency (TRASANA). The program is being managed for DNA by the US Army Nuclear and Chemical Agency (USANCA). The final LSVP reports will be published in calendar year 1986.

VII Corps. Attrition of US personnel and an estimated number of deaths from a Threat nuclear attack was derived from analysis of the LSVP deployment and Threat scenario.[6] Estimated U.S. combat deaths from a chemical attack were derived from the LSVP deployment and Threat scenario. Conventional personnel attrition and U.S. combat deaths were derived from the Jiffy wargame report of the Europe V, VII Corps scenario and Army Force Planning Data and Assumptions.[7] The requirements for operating in a NBC environment were evaluated, as were requirements imposed by productivity enhancing changes to organizational structure, personnel, procedures and equipment.

A capabilities analysis was conducted to compare alternative organizations and procedures. The analytical tool used for this phase was a computer generated simulation using the Smalltalk-80 programming environment.[8] A base case and seven alternatives were evaluated.

Figure 1 is a graphical representation of the study outline.

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6. LSVP Working Group, "Threat Observations for the LSVP Scenario", 1984, (SECRET WORKING PAPER)

7. US Army Concepts Analysis Agency, "Army Force Planning Data and Assumptions ", 1983, (SECRET).

8. Helfman, R., Ralston, M., and Suckling, J.R. "Simulation Using Smalltalk," US Army BRL Technical Report BRL-TR-2764, Oct. 1986.

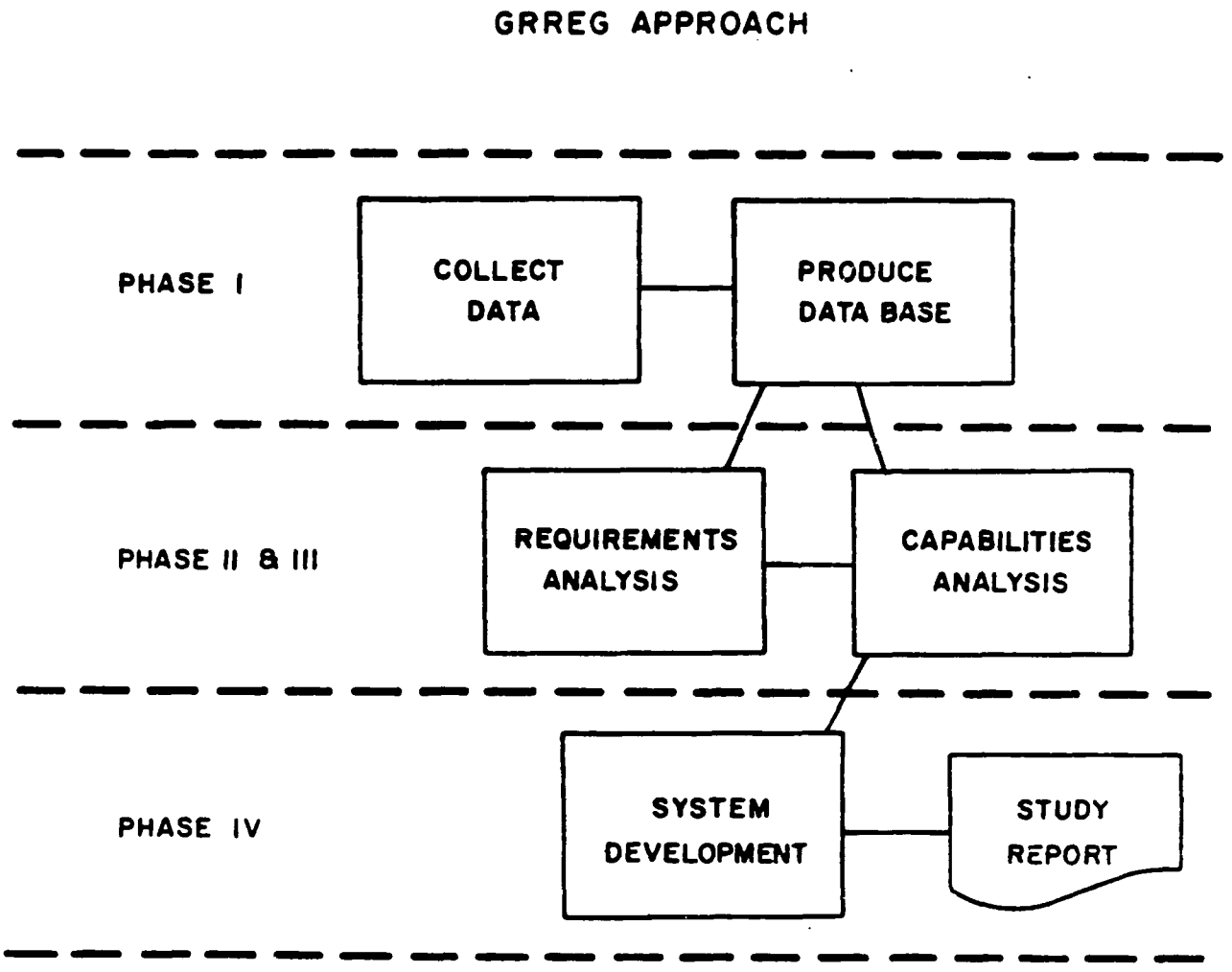

Figure 1. GRREG Study Outline

III. Graves Registration Service

1. Description of GRREG Service

The Graves Registration Program provides for essential search, recovery, collection, and disposition of the remains of deceased US, allied and enemy personnel in an area of conflict where the prompt return of remains to the continental United States is not possible. Disposition of remains, according to current doctrine, is by burial in temporary military cemeteries. The Graves Registration Program is a logistics function under the auspices of the Quartermaster Corps. In a theater of operation, graves registration collection points are established in the Brigade Support Area. Additional collection points are established in the Division and Corps rear areas. The temporary military cemetery is established in the COMMZ or Corps rear. Current doctrine requires that units transport the remains of deceased soldiers to the nearest collection point. From there, graves registration personnel tentatively identify the remains and evacuate them, through intermediate collection points to the temporary cemetery. At the cemetery, operated by a Graves Registration Company, personnel remove personal effects from the remains for shipment to next of kin, and bury the remains.

The US Army Quartermaster Corps has responsibility for the graves registration program. This responsibility includes the organization of units to carry out graves registration functions, acquisition and training of MOS 57F (Graves Registration Specialist) personnel, the development of requirements for new items of equipment to support graves registration operations, and the development of graves registration doctrine.

The graves registration program involves four major functional areas. They are search and recovery, identification, burial, and personal effects processing. All of these functions are carried out in the theater of operations. Personal effects are shipped to next of kin at the earliest possible time.

Graves registration personnel may carry out search and recovery missions in cases where a unit is unable to recover their dead, where a unit has been forced to bury remains in a hasty/temporary grave site, where an aircraft has been downed, to police the battlefield of enemy dead, or in any situation where other units are unable to recover the remains of U.S. servicemen from an area of operations. Search and recovery missions are time consuming and labor intensive. These missions sometimes force elements of a graves registration unit to operate over large geographical areas.

The identification function is carried out by graves registration personnel at a recovery site, a graves registration collection point or at a temporary cemetery. Every effort is made to completely identify remains as soon after death and as close

to the place of death as possible. Experience has shown that timely identification is a significant factor in reducing the number of unknowns in a conflict. All tasks associated with documenting identifications and reporting this information will be considered as part of the identification function in this analysis.

All remains processed as part of a graves registration program are buried in the theater of operations in temporary military cemeteries. Burial is either in individually marked graves or a common grave if mass burial procedures are in effect. Under the graves registration program all cemeteries and grave sites in the theater of operations are considered temporary. The program calls for the eventual return of all remains to next of kin or military cemeteries in the United States unless a permanent military cemetery is authorized by specific legislation. Remains in hasty/temporary graves in the theater of operations are consolidated in temporary military cemeteries if possible.

Current graves registration doctrine and procedures are general in nature and oriented toward the conventional environments of past conflicts. Little attempt has been made in recent years to capitalize on current technology for identifying, reporting, and processing remains.

During peacetime, the graves registration system is not used. Peacetime manpower and fiscal constraints have forced the Army to place graves registration units in the Reserve Component and graves registration elements have been removed from many active unit tables of organization and equipment (TOE). Peacetime deaths of servicemen are handled by the current death program, which emphasizes civilian mortuary services and contract support. Because of this, very few graves registration personnel are in the active force, graves registration procedures have not been kept current and problems posed by future battlefield environments have not been addressed.

2. Organizations and Equipment

Graves registration assets are organized into units ranging in size from the GRREG Battalion to GRREG Team Augmentations. At the lowest echelon, graves registration support is provided by teams, sections and platoons attached to supply and service companies or field service companies. These GRREG elements are organized into collection points that provide for search, recovery, initial identification, and evacuation of remains. These collection points are not organized or equipped to perform burial. All graves registration support to divisions is provided by augmentation to the divisional Supply and Service Company. Divisional GRREG capability is strictly a wartime augmentation.

The Graves Registration Company carries out the final identification of remains, and operates the temporary military

cemetery where remains are buried. The Cemetery Company is also organized to perform search and recovery missions and to operate a collection point. Personal effects are also processed by the Cemetery Company prior to being sent to the personal effects depot for temporary storage and shipment to legal recipients.

3. Doctrine

Current doctrine for graves registration is illustrated by the flow of remains shown in Figure 2. Units have the responsibility of evacuating remains to the appropriate graves registration collection point. This evacuation is normally accomplished by using organic unit transportation assets. However, any available transportation may be utilized. Evacuation from teams, squads, platoons, and companies may be routed through the appropriate battalion headquarters. Remains are unloaded at each echelon in an effort to keep organic unit transportation assets within a units' area of operation. Much of the current GRREG organization and doctrine is dictated by transportation requirements.

Any transportation assets may be used to evacuate remains with the exception of ration trucks. From the losing unit, transportation will normally be organic company or battalion vehicles and aircraft. Once the remains are in graves registration channels, evacuation of remains becomes the responsibility of the graves registration unit. All graves registration units have authorized organic vehicles which may be used for evacuation of remains; however, it must be kept in mind that these vehicles are also required to carry out search and rescue missions, and perform unit administrative tasks. Evacuation of remains within graves registration channels, therefore, depends upon requests for nonorganic transportation and the availability of back haul transportation assets. Doctrine provides guidelines for the transportation of remains within the theater. Remains must be covered at all times while being transported. Remains must be escorted while being evacuated to insure that personal effects are safeguarded and that the remains receive proper treatment while enroute. The vehicle transporting remains must be covered at all times and remains inside the vehicle should not touch each other. This precludes stacking remains one on top of each other in a vehicle and limits the number of remains that can be transported in one vehicle. Utilizing litters the maximum number of remains that can be transported in a 2 and 1/2 ton cargo truck under the constraints of this doctrine is 24.

Doctrine states that identification should be carried out as soon as possible after death and as close to the scene of death as possible. Remains recovered by GRREG personnel on a search and recovery mission are identified at the recovery site if possible. Early identification is felt to be the key to eliminating unknowns. Various identification media are used and doctrine prescribes what combinations are acceptable for positive

identification. It must be remembered, however, that identification media which are used as sole source evidence of identification may be wrong. For this reason, current doctrine stresses the use of multiple identification sources to confirm the identity of remains.

Burial is the only accepted disposition method for remains under current graves registration doctrine. Remains are buried in individually marked graves at consolidated temporary military cemeteries in the theater of operations. The intent of current GRREG doctrine is to discourage the use of small scattered cemeteries and consolidate the burial of remains as much as possible. Doctrine prohibits the use of isolated/hasty graves unless their use is absolutely unavoidable e.g. where a unit is unable to evacuate their dead and are being forced to move. Consolidated cemeteries are required by doctrine for many reasons. Consolidation makes it easier to carry out the return of remains program, and the organization and basis of allocation of graves registration companies makes it impossible to have decentralized burial within a theater of operations. Consolidation also makes the care and maintenance of cemeteries easier, limits the possibilities that a burial site could be lost, and makes it less likely that a cemetery would fall into enemy hands particularly since current doctrine places temporary military cemeteries in the COMMZ.

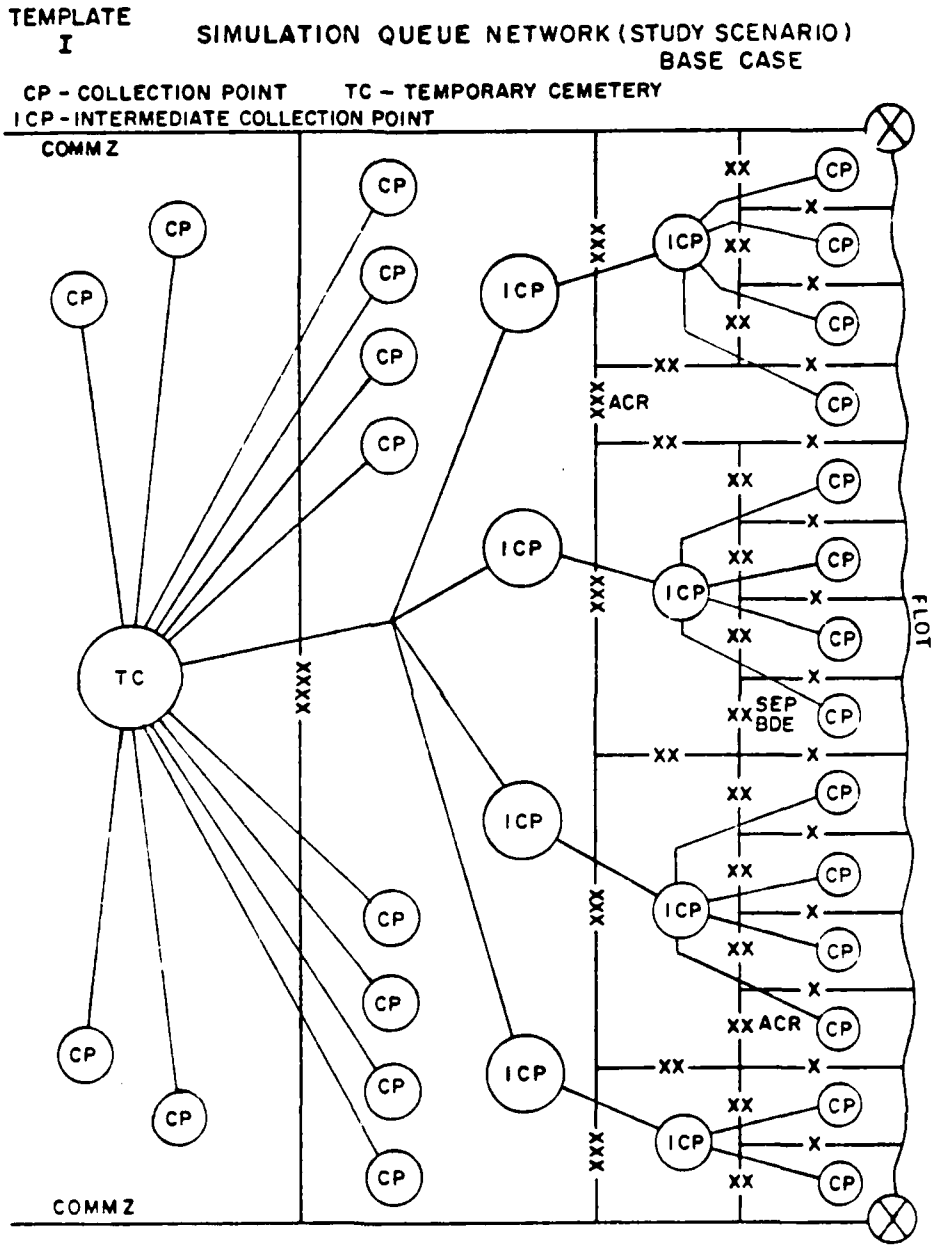

Figure 2. Top Level Network

I. GRREG Queuing Network Model

1. Introduction

For analytical purposes, the graves registration organizations in a Corps are best described as a network of queues where remains await processing. These queues form networks, where the output of one becomes the input of another. The network is rather complicated: consisting of several hundred individual queues that are interconnected either in series or in parallel. The network will be described in three levels of detail, with the basic level consisting of the individual queues, the intermediate level consisting of the three types of collecting points (initial, intermediate, cemetery), and the top level showing the flow from one collecting point to another. Figure 2 illustrates the queues and networks in the corps slice of the theater at this top level. Except for the remains of personnel who die in the COMMZ and are brought directly to the cemetery for processing, all remains in the theater will pass through a minimum of two collecting points prior to burial.

The GRREG queuing network forms a directed connected graph of arcs and nodes, (see Figure 3), with tokens passed along the arcs through the nodes. The tokens represent bodies or trucks, and each node represents a task to be performed on tokens and a queue where the tokens wait their turn for processing. The meaning of these terms depends on the level of detail in the network. At the top level, the nodes (circles) represent the collecting points, the arcs (lines) represent the connecting roads, and the tokens represent the trucks carrying bodies. At the intermediate level, the nodes represent individual tasks from the basic task list, the arcs represent movement from one task to the next, and the tokens represent the individual bodies at the collecting point.

Tokens are created by a generator (source) node. Each generator node has one arc leading to a task node's queue. Here the tokens wait their turn for processing. Examples of process (task) nodes are unloading trucks and taking finger prints. After the processing is completed the token travels on an arc to the next queue. This pattern is repeated until a final (sink) node is reached. An example of a sink node is a temporary cemetery plot. The sink node's queues hold tokens that represent the throughput of the GRREG services.

As mentioned before, the network can be viewed at three different levels. The description of the GRREG network will start at the top level with some basic definitions; then move to the intermediate level and a detailed discussion of the three types of collecting points; and conclude at the basic level with an examination of the various queue parameters.

2. Top Level Network

The top level nodes are the collection points:

1. Initial Collecting Point [CP]
2. Intermediate Collecting Point [IP]
3. Temporary Cemetery [TC]

and the low level network defines these nodes in more detail. A simple high level network example is shown below.

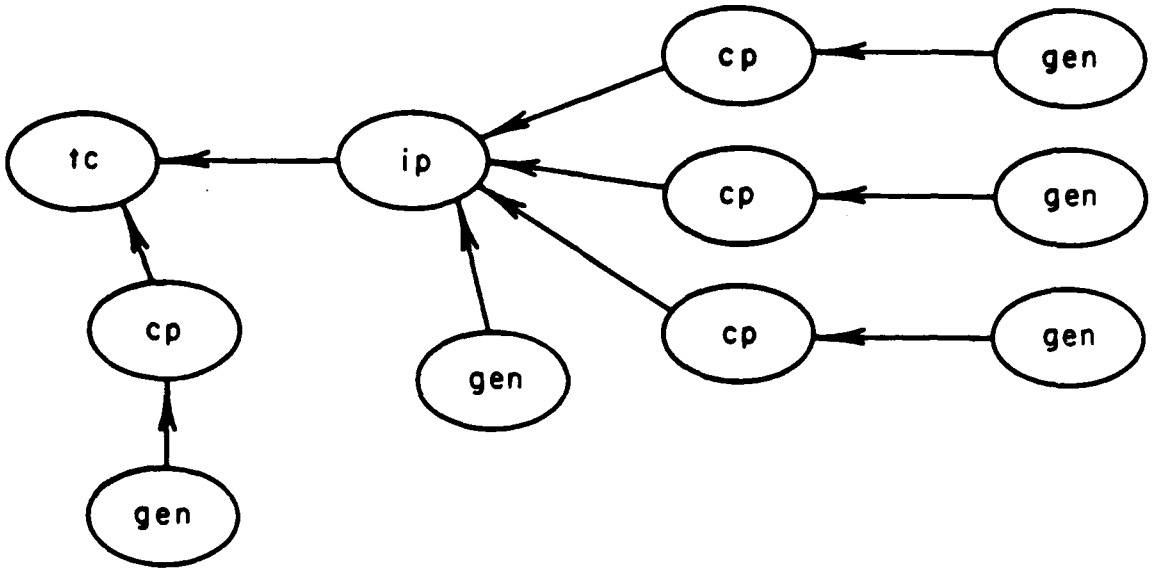

Figure 3. Example High Level Network

Each generator ([gen]) creates a work load of tokens, which consists of trucks filled with a random number of bodies. These tokens pass through collection point nodes on trucks until they

reach the Temporary Cemetery node ([tc]).

3. Intermediate Level Networks

The intermediate level networks represent the three types of collecting points (initial, intermediate, temporary cemetery). See Figures 4, 5, and 6. At the intermediate level, incoming tokens represent trucks full of bodies. Some of them start in the field, while others come from previous collection points. The trucks line up at the in-truck-queue (inTruckQ). Here a pool of workers is assigned the task of unloading the truck. This pool contains several workers, with one worker on the truck, and the remainder (in pairs) on the ground to carry the bodies to the processing location. Here the bodies receive an evacuation number (evac#) from one of the workers. The bodies do not physically move at this stage, but are added to the the identification and personal effects queue (checkID).

Each collection point node has a limited capability to do processing, which is a function of the number of workers assigned to the collection point. Each task node requires one or more workers to perform the given task. When multiple workers are assigned to a task node, task characteristics determine whether the work is performed in parallel or in series. For example, tasks like loading (unloading) trucks need workers in pairs for each body to be loaded (unloaded) at one time, plus one worker in the truck. Tasks like identification require only one worker per body, while other tasks can only be done by at most one worker at any given time. An example of the latter is filling out the convoy list.

Most of the arcs in the collection points and the temporary cemeteries are simple and represent serial task queues. The exceptions are the branching, joining, and forking of arcs at nodes, to be explained below.

Branching occurs when a token can be put on one of several queues after service. This happens, for example, after the body has received an evacuation number. If the body has already been processed through an initial collecting point, then the next task is to check the records to be sure there are no errors in processing up to this point. However, if the body has not been processed then the complete identification process must be carried out.

Forking occurs when a token is split and put on two or more queues. An example of this is can be seen at the temporary cemetery, where the holes in the ground are prepared while the body goes through final processing.

Joining occurs when a node waits for all parts of a forked token to arrive before processing continues. After the above holes and the final processing are completed, the body is ready

for placing in the hole.

4. Basic Level Queues

The nodes at the end of the arcs in Figures 4, 5, and 6 represent tasks to be performed by workers (inTruckQ, unloadQ, evac#, ...) . These nodes consist of a queue for incoming tokens (trucks or bodies), where the tokens wait for a turn to be processed. These nodes also require one or more workers to perform the processing on the bodies. Some task nodes can have more than one worker at a time (e.g. n workers can perform the ID task on n bodies), while other tasks are restricted to one worker (e.g. the Evac task), thus only one body at a time. The hardest task nodes for worker allocation are the loading and unloading of the trucks, as described above, which consume two workers per body and one extra worker on the truck.

The actual processing of bodies is done at the level of tasks. This requires that needed resources be allocated to the task for specified time period, and then released back to the system for other tasks to consume.

To illustrate in more detail, the following are needed by the simulation to process a task.

1. a body
2. one or more workers to be consumed while the body is being processed.
3. some storage for the body and the worker (this holds the resources until the task is completed).
4. the limits on the number of workers required (as above).
5. a delay time for the execution of the task (this is the amount of time needed to complete the task).
6. arcs for the disposition of the body for its next task.

Note that 1) and 2) are consumable resources for the simulation, 3) can be forgotten until there is no more computer resources, and 4), 5), and 6) are constraints that differentiate the tasks.

The way these work is as follows. For each collection point there is a fixed set of workers. These workers are allocated to each task that meets the above needs for processing. When a task is ready to run, the body and the worker(s) are stored in a task object for storage in the time queue. After the delay time is consumed by the simulation, the task is run to free its

resources. These are:

1. the body, which is placed on the next task's input queue.

2. the worker(s), which can get another body for this task or start a new kind of task.

The task lists for the three types of collecting points are given in Tables 2, 3, and 4.

5. Parameters for Basic Level Queues

The behavior of an individual queue is controlled by the choices made for a small set of parameters. These parameters will be examined as they apply to the various queues in the network.

a. **Arrival Parameters.** The calling population (casualty workload) for the GRREG model is finite; limited by the intensity and nature of the battle and the troop population. The simulation was run well past the last battle (i.e. no arrivals) to determine the time needed to work off the backlog.

Some queues experienced only bulk arrivals, (occurring whenever trucks arrived with bodies). Other queues had no bulk arrivals, and some had both bulk and single arrivals.

The arrival rate for bulk arrivals changed daily and depended upon battle conditions and troop populations in the vicinity. For some queues, the arrival rate was the sum of the departure (throughput) rates of one or more previous queues in the chain.

b. **Service Parameters.** Each queue in the network represents one of the tasks from the basic task list for the collection point. (See tables 2, 3, and 4). The service times for each task are independent and normally distributed. The number of servers (MOS 57F workers) at each service center changes throughout the simulation. A 'worker to task' scheduler assigns workers to individual tasks based on several factors including task priority and queue backlog. The worker stays only until task completion, at which time he is reassigned to either the same task or possibly another task. Thus tasks may get no workers assigned, or may get one or more workers.

c. **Queue Discipline.** Queue discipline is first come, first served, and queue capacity is assumed to be infinite. However, for some excursions, balking was allowed at the truck arrival queues whenever the backlog reached a critical peak. The trucks would then proceed to the next higher echelon collecting point and try to join the input queue there.

6. Task Priorities

Workers are scheduled to tasks by a priority scheduling mechanism. The scheduler takes an idle worker and assigns him to a certain task based on task priorities to be disc ssed below. When the task is over, the worker is returned to the idle state, to await reassignment to another task.

For any idle worker, the scheduler tries a set of schemes to give the worker a task. The order of the schemes defines a priority, in that the first task found is the one assigned to the worker. The task priorities from highest to lowest are:

- end of the day
- trucks to be unloaded
- trucks to be loaded
- workers needing assistance
- tasks with no workers assigned
- tasks with a large backlog
- perform the previous task again
- random choice

The first priority is to check for the end of the working day. The next two priorities are to unload incoming trucks, then to load trucks. The fourth priority is to find "helpers" when needed. For example, some task might require two workers yet have only one worker currently assigned. Thus one helper is needed. The fifth priority is to fill tasks where no workers are assigned. Then if all tasks have workers assigned, the sixth priority is to reduce large backlogs. If there are none, then the seventh priority is to reassign the worker to the previous task. Finally, if the worker had no previous task, the last priority is to choose one at random.

Starting at the top of the list, a few of these tasks will be examined in more detail. The first scheduling priority is to check for the end of the work day. The scheduler checks for:

1. working over 7.5 hours in one day
2. the condition of 'lightsOut'

Current doctrine specifies a maximum of 7.5 hours per day per worker to be devoted to GRREG tasks. The condition 'lightsOut' occurs when the collection point is close to the front, and it is

not safe to run lights at night. If either of these are true, then the worker goes to sleep. This requires that he alsp be scheduled for wakeup in the morning.

The next two schemes for tasking are to unload and to load trucks, in that order. If trucks are ready to be unloaded or loaded, then the scheduler tries to find workers to start unloading or loading them respectively. Scheduling workers for trucks is more complex than most other tasks, since it takes one or more workers on the truck to move a body to the tail gate, where pairs of workers can take it to the first queue for assigning evacuation numbers.

Table 1 below is used to determine what each worker is to do in order to unload trucks. The column on the left gives the number of idle workers looking for work, and the code inside the table gives instructions to the scheduler. For example, if there are currently no workers unloading, then the first and second workers are stored on a list of helpers, since one or two workers alone cannot unload a truck. The third worker gets onto the truck, and the other two remain on the ground to carry bodies.

TABLE 1. Disposition of Helpers for (Un)Loading Task

number of helpers	current number of (un)loading workers			
	0	3	5	7
1	-	-	-	t
2	-	a2	a2	t
3	a3	a2t	a2t	t
4	a3t	a4	a2t	t
5	a5	a4t	a2t	t
6	a5t	a4t	a2t	t
7	a7	a4t	a2t	t
>7	a7t	a4t	a2t	t

Key: aN = add N workers to the task.
t = retask all unused help workers.

7. Model Assumptions

The following assumptions were made when programming the GRREG queuing network simulation in Smalltalk.

- Only the conventional workload, derived from the Europe V, VII Corps, Jiffy wargame report, was used as the simulation workload.

- The simulation ran 24 hrs a day. Operations at brigade/division collection points, however, were conducted in daylight only. Daylight was assumed from 0600 to 1800 hrs daily.

- The scenario called for hostilities to cease after five days. No remains were generated after this time. The simulation continued for another 5 to 15 days, however, to determine if collection points and cemeteries would be able to complete the processing of their backlogs after they stopped receiving remains.

- Unloading trucks received priority assignment of workers at all collection points and cemeteries. All workers would be allocated to this task as needed. The only exceptions were in the case of workers assigning evacuation numbers and preparing convoy lists. A worker engaged in either of these tasks could not be reassigned until his queue was empty. The assignment priority of all other tasks was determined by task order,worker requirements for the task and worker availability. Workers would always continue current tasks until their queue was empty or until they were pulled to unload trucks.

- Trucks would arrive at collection points and the cemetery at random times. Trucks were generated as needed, until all remains allocated to a collection point during a given period had been delivered.

- Trucks would arrive bearing remains in random amounts between 12 and 24.

- Standard delay times were used when sending remains through the network to simulate travel times. Delay times between echelon were 3 hrs by day and 6 hrs by night.

- All 57F MOS personnel in the simulation were considered interchangeable. The scheduler represented a supervisor and performed the necessary task control functions.

- Only graves registration tasks were simulated. Support and administrative tasks such as maintenance were not simulated.

- All workers performed 7.5 hours of graves registration tasks every 24 hour period. All workers at a collection point or cemetery performed their tasks in one block. Split shifts were not simulated.

- Workers at each collection point and cemetery consisted of the maximum authorized strength of E5 and below 57F personnel. Two additional personnel were added to the GRREG authorization of the Armored Cavalry Regiment because their TOE authorization of GRREG personnel (2) was not adequate to perform some tasks which required a minimum of 3 personnel. Officers were not included in the simulation.

TABLE 2. Task List Initial Collecting Point

Task Time per Remain (min)	Task
2	Unload remains
5	Assign an evac number and record
55	Check ID tags, field medical card, prepare statement of recognition, record of recovery (if necessary), inventory PE and fingerprint
10	Place remains, documents and PE in human remains pouch and move to holding area
5	Prepare convoy list
5	Miscellaneous record keeping
2	Load on transportation

TABLE 3. Task List Intermediate Collecting Point

Task Time per Remain (min)	Task
2	Unload remains
5	Assign evac number and record
25	Compare remains with documentation and fingerprint
5	Move remains to holding area
5	Record on convoy list
2	Load remains on transportation

TABLE 4. Task List Temporary Cemetery

Task Time per Remain (min)	Task
2	Unload remains
5	Check evac number and PE seal
5	Move to processing area
5	Assign processing number and record
15	Compare remains and PE with documentation
20	Remove clothing and examine
15	Fingerprint remains
30	Perform detailed ID; consists of anatomical, dental, and/or skeletal charting, photography and comparison of evidence with records; assumed that this 30 minutes is the time for all types of ID cases averaged over every remain processed
5	Shroud remains
10	Prepare plates, tags and attach
5	Move remains to holding area
10	Dig grave site (mechanical digging)
10	Move remains to grave site
20	Prepare internment and plot records and 3x5 card
30	Place remains in grave and cover (manual)
15	Prepare and ship PE

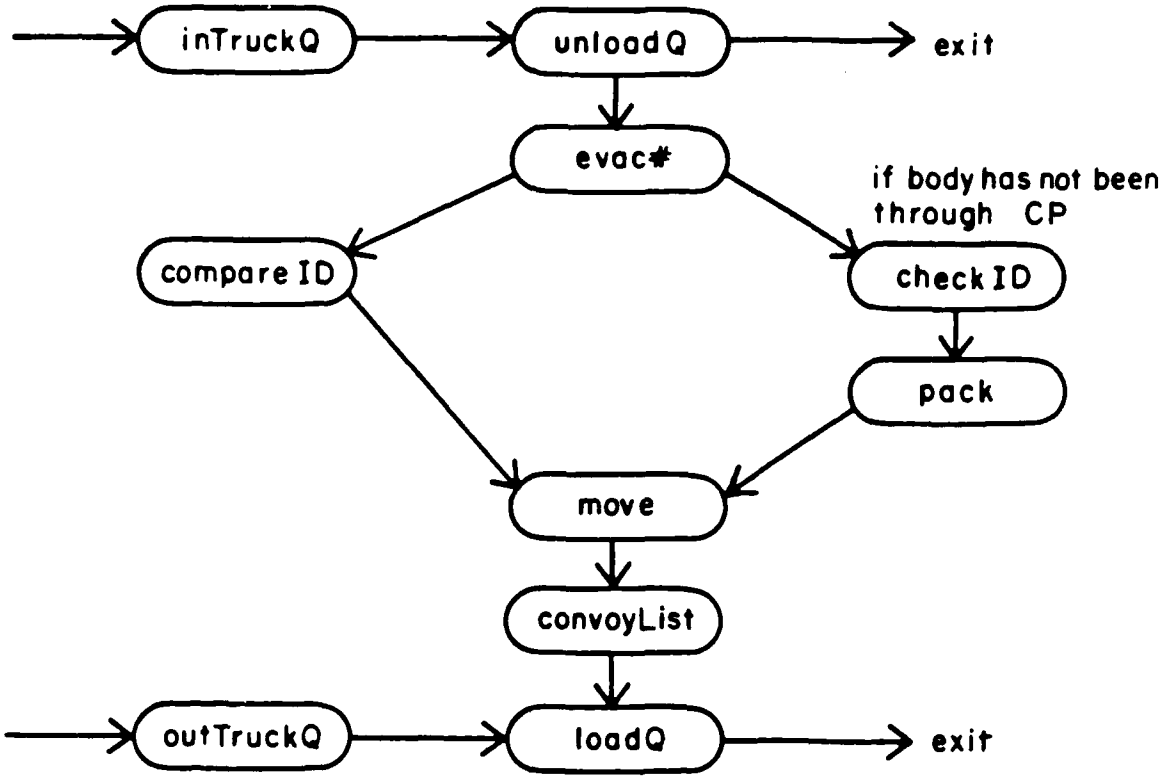

Figure 4. Initial Collecting Point Task Network

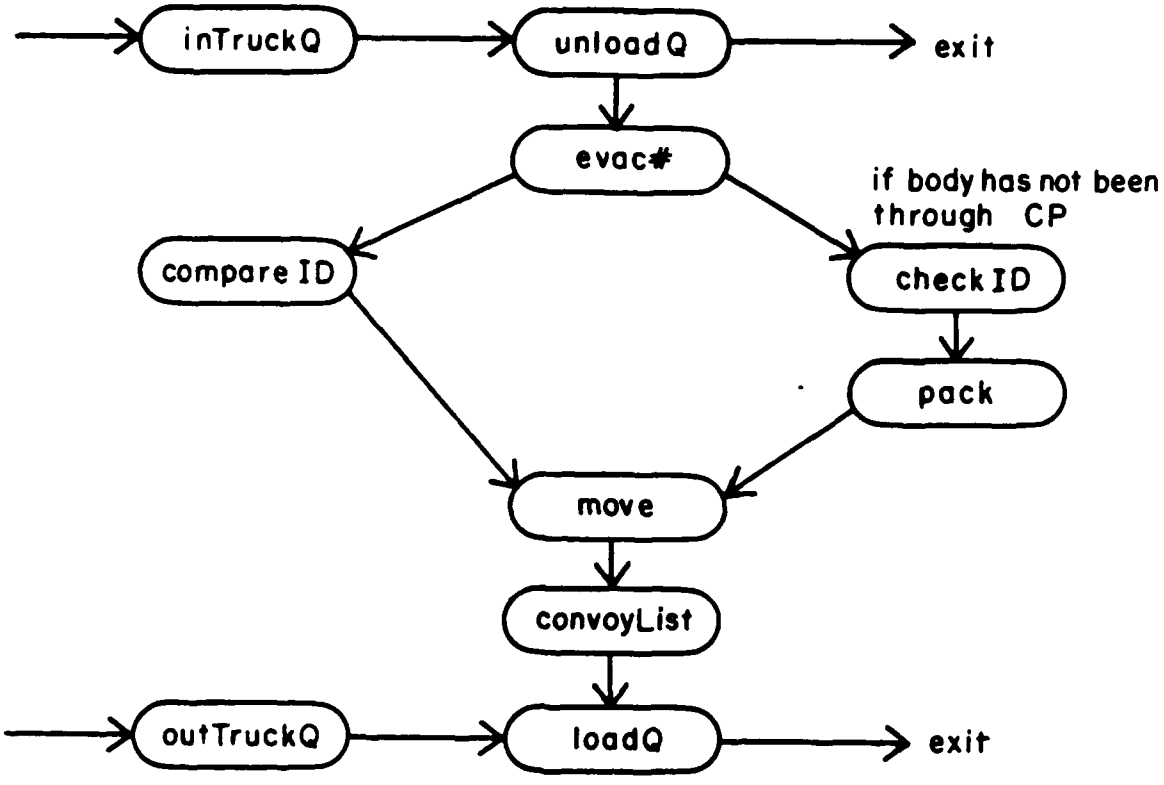

Figure 5. Intermediate Collecting Point Task Network

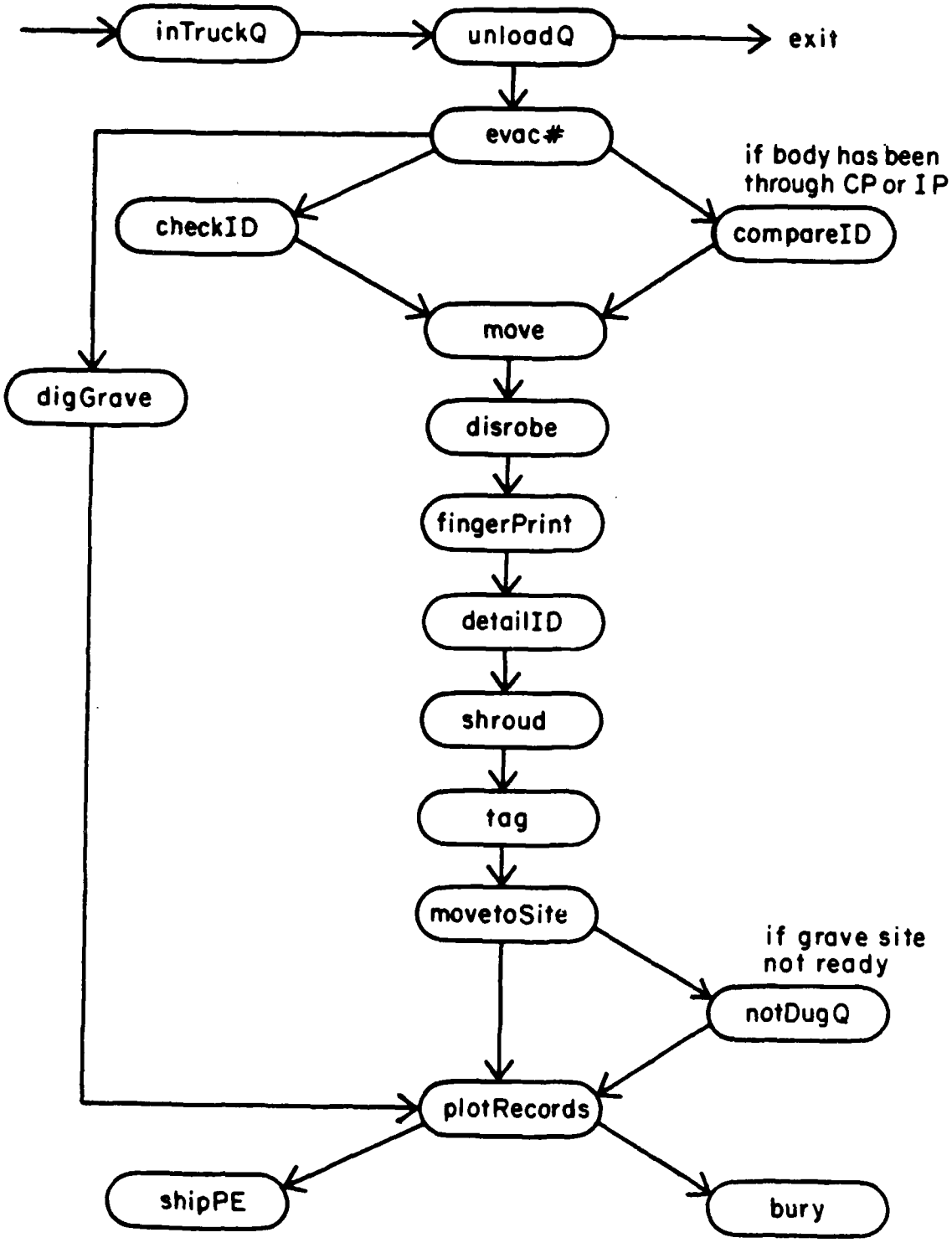

Figure 6. Temporary Cemetery Task Network

V. Capabilities Analysis

1. Introduction

This section describes the various scenarios investigated. These include the base case and 7 alternatives as listed below:

- base case
- LUPS I
- LUPS II
- Double workforce
- Zero ID processing
- Evacuation
- Decentralized
- Contaminated Remains

The computer simulation model was run for the base case and for 6 of the 7 excursions. (As discussed below, the LUPS I excursion was not simulated.)

2. Simulation Task List

Table 5 gives the tasks used for the base case simulation. Each task is listed with the mean time to perform per remain, maximum number of workers, minimum number of workers and allowable combinations of workers. Tasks are listed in order of precedence. Table 6 is a description of the tasks listed in the simulation task list. Unloading trucks is always a priority task. Once a worker is assigned to an ID task he will continue to do that task until the queue is empty; unless a new truck arrives. Assigning evacuation numbers and preparing the convoy list are only performed by at most one worker during any given time period.

The Corps and COMMZ initial collection points were not simulated. This decision was based on the fact that their relatively large numbers of assigned personnel could process their small workloads without difficulty during each critical incident. It was unnecessary to simulate their operations. The workloads from these collection points were added to the cemetery workload after the appropriate delay.

All collection points, as well as the temporary cemetery had the ability to perform the initial processing of remains. The

simulation program was written with the capability to route remains through initial processing if they arrived from a previous collection point without initial processing. This option was only exercised in the evacuation to higher echelon excursion. In all other excursions, corps intermediate collection points only received remains that had completed initial processing. Division intermediate collection points performed both initial and intermediate processing.

3. Base Case

Figure 7 shows the assets and organization of the base case simulation. The base case simulated the entire corps GRREG network and the conventional corps workload. All divisional remains were piped through an intermediate collection point in the Corps for processing. Initial processing in the corps rear and COMMZ areas was not simulated.

The GRREG organizations in the Corps were not able to maintain adequate performance in the base case simulation. Figures 8 through 53 show the workload, remains processed and remains processed per worker over time for each simulated node in the base case. The number of remains processed is shown on the vertical axis and time in days is shown on the horizontal axis of each graph. The workload was generated from day one to day five. Each brigade collection point was simulated for 10 days, or until the workload was processed. Division rear collection points were simulated for 15 days. Corps intermediate collection points and the cemetery were simulated for 20 days.

The workload and throughput (remains processed) was calculated for each collection point/cemetery, and is shown on a combined graph for each one of these service centers. The upper curve on each of these graphs represents the simulated workload (represented as number of remains) for that collection point/cemetery over time. The lower curve on each of these graphs represents the throughput (number of remains processed) for that collection point/cemetery over time. Both curves are cumulative. The space between these curves represents the total backlog (number of unprocessed or partially processed remains) for that collection point/cemetery over time.

Throughput per worker was calculated for each day and is shown on the second graph for each collection point/cemetery. Low values do not indicate that there was a lack of productive activity during that period. Low values usually mean that few remains completed processing during that period. Throughput per worker provides an estimate of the ability of a collection point/cemetery to complete processing of remains at a sustained rate. Average daily productivity will fall between the high and low throughput values on this graph for each collection point/cemetery.

The following observations can be made from analysis of the results of the base case simulation:

- Brigade collection points were unable to maintain a manageable backlog while they were receiving remains. Only the lightly committed Brigades were able to complete processing of remains during the scenario. Backlogs at Brigade collection points ranged from 50 to 375 remains.

- Most brigade collection points completed processing of their backlog within 5 days after the end of the scenario.

- The heavily committed 2nd ACR had the worst collection point performance and still had a backlog of over 300 remains on day 10 of the simulation. This occurred despite the fact that an additional two workers were added to the authorized GRREG assets of this organization. Authorized GRREG assets in ACR TOEs are seriously inadequate.

- Two Division rear collection points had not completed processing of their backlog after 15 days (3rd ID and 1st AD). The less heavily committed 1st ID was able to complete processing of its' backlog after 14 days while the lightly committed 7th ID maintained nearly a zero backlog throughout the scenario.

- Corps intermediate collection points were overstaffed and underutilized. Because of delay times and backlogs at forward collection points, most corps intermediate collection points did not start receiving significant numbers of remains until day 3 of the simulation. All corps intermediate collection points were able to maintain near zero backlogs for the entire simulation. Daily worker productivity for these collection points was consistently less than the forward collection points.

- Because of poor performance and bottlenecks in forward areas less than half of the workload generated had been received by the cemetery after 20 days of simulation. Cemetery backlog gradually increased until it exceeded 400 remains at day 15. Cemetery performance was stable however, and productivity ranged between 1 and 2 remains per worker per day. The cemetery had almost completed processing of its' backlog by the end of the simulation. While a backlog of 400 remains may be unacceptable at a brigade collection point, it is not excessive at a cemetery in the COMMZ. Cemetery assets are adequate to meet projected workloads.

4. LUPS I

The LUPS I initiative eliminates the Corps and COMMZ GRREG assets in Supply and Service Companies and adds these assets to the Graves Registration Company. The organizational changes of LUPS I are shown in Figure 54. These changes increase the capability of the Graves Registration Company by 41 personnel; a 41% increase. The Graves Registration Company assumes the functions of initial processing of remains and must operate two collection points for the receipt of remains.

The LUPS I initiative will result in a straightforward increase in cemetery capability with little adverse effect on collection point capability since corps and COMMZ collection points are underutilized. It is clear, however, that this initiative does little to relieve the backlog in the forward areas. For this reason the LUPS I initiative was not evaluated by simulation.

5. LUPS II

The LUPS II initiative takes LUPS I cemetery organization and adds the GRREG assets from the corps intermediate collection points (Field Service Companies). LUPS II organization is shown in Figure 55. This change increases LUPS I cemetery capability by an additional 9% but eliminates intermediate collection points. In order to fill in for the elimination of these assets in the Corps, the LUPS II initiative takes one half of the Graves Registration Company and assigns it to the Corps to operate a forward cemetery.

The LUPS II initiative eliminates redundant intermediate processing and underutilization of assets in the Corps but it does not address the bottleneck in the forward areas. Splitting the cemetery operation would eliminate transportation requirements through the Corps, but if all divisional casualties are sent to the Corps cemetery the COMMZ cemetery will be underutilized. All casualty estimates indicate that GRREG workload requirements in a conventional environment, in the COMMZ, are extremely low. There is simply no demonstrated need for extensive GRREG capability in the COMMZ to support COMMZ casualties. The base case simulation indicates that corps intermediate collection points are underutilized but it is not clear that these assets should go towards increasing cemetery capability.

6. Double the Workforce

An excursion was conducted to explore the sensitivity of the collection point backlog to increases in the number of workers. This excursion used base case workloads and organization. The number of productive workers at each collection point in a division slice of the Corps was doubled. The corps intermediate, division rear and brigade forward collection points were

simulated. Figure 56 shows the assets and organization of this excursion.

Doubling the workforce resulted in a reduction of backlog in all simulated collection points. Figures 57 through 68 show the performance of individual collection points in this excursion. The percent reductions in total backlog (when compared with the base case) for the brigade/ACR collection points are; collection point 1 - 70%, collection point 2 - 77%, collection point 3 - 67%, collection point 4 - 29%, average - 53%. Only the ACR (collection point 4) was unable to process all remains by the end of this excursion. The reductions in backlog and speedy processing of remains at brigade/ACR collection points resulted in a fast increase in the workload of the division intermediate collection point. The extra workers assigned to the division intermediate collection point, however, were able to complete the processing of all remains by the end of the excursion. Backlog at the corps intermediate collection point remained near zero for this excursion.

7. **Zero ID-Processing**

The sensitivity of backlog to ID-processing tasks in the collection points was explored with this excursion. Identification processing time was eliminated from the task list for a division slice of the base case. Base case workload and organization was used. Table 7 shows the modified task list. Figure 69 shows the assets and organization of the excursion.

Elimination of identification tasks from the collection points resulted in substantial decrease in backlog at all brigade collection points. The percent reductions in total backlog (when compared with the base case) for the brigade/ACR collection points in this excursion are; collection point 1 - 81%, collection point 2 - 88%, collection point 3 - 73%, collection point 4 - 23%, average - 57%. The average reduction in backlog for this excursion exceeded the reduction in backlog produced by doubling the workforce. All brigade collection points had completed processing of their workload within six days. While performance improved at the division rear collection point, backlog increased. Backlog at the Division rear collection point exceeded 800 remains by day 5 of the simulation and over 600 remains were still unprocessed at day 15. Figures 70 through 79 show collection point performance for this excursion.

Backlog was increased at the Division rear as a result of quicker processing performance in the forward Brigades. Reducing ID task times will have the desired effect of shifting the workload to the rear areas, but unless intermediate collection points are eliminated or expanded with more personnel a bottleneck will result.

8. Evacuation to Higher Echelon

In practice, most GRREG collection points would begin to evacuate remains to the next higher echelon without processing, when backlogs became unacceptable. This excursion was designed to evaluate the effects of evacuation of unprocessed remains on the system. Figure 80 shows the assets and organization of this excursion. A division slice of the base case and base case workload was used. Evacuation decisions were based on a collection points backlog. When the backlog of a given collection point reach a 2 day level, based on mean processing times, all succeeding remains were automatically sent to the queues of the next collection point after the standard delay.

Figures 81 through 92 show the performance of collection points in this excursion. Evacuation of unprocessed remains reduced the backlogs of forward and rear collection points to a manageable level and reduced the delay time of remains reaching the cemetery by more than 50%. The percent reductions in total backlog (when compared with the base case) for brigade/ACR collection points in this excursion are; collection point 1 - 71%, collection point 2 - 81%, collection point 3 - 0%, collection point 4 - 79%, average - 75%. Brigade collection point 3 actually experienced an increase in backlog during this excursion since its' total backlog never exceeded the two day limit and balking did not take place. The average percent decrease in total backlog for brigade/ACR collection points in this excursion (75%) was the highest of all excursions tested. This was a result of the dramatic decrease in backlog at the Armored Cavalry Regiment. This was the only excursion that resulted in reducing the backlog of the Armored Cavalry Regiment to a manageable level. The division and corps intermediate collection points completed processing of all remains by the end of the excursion. The increase in backlog at the cemetery that would result from such an evacuation policy was not evaluated.

9. Decentralized Excursion

A decentralized excursion was conducted to evaluate the performance of division cemeteries. Base case workloads were used, but the base case organization was changed to allow for division cemeteries. Total 57F strength in the Corps remained the same but personnel assets were reorganized to provide for a cemetery in each division rear as well as the COMMZ. This organization was simulated for a division slice of the Corps. Figure 93 shows the assets and organization of the decentralized excursion. Cemetery and collection point tasks are unchanged. Decentralized excursion performance is illustrated by Figures 94 through 103.

Backlog in the brigade/ACR collection points was only moderately reduced by this excursion. The percent reductions in total backlog (when compared with the base case) for brigade/ACR collection points are; collection point 1 - 58%, collection point

2 - 65%, collection point 3 - 49%, collection point 4 - 30%, average - 47%. Only the Armored Cavalry Regiment and the division cemetery had unprocessed remains at the end of this excursion. Backlog at the division cemetery at the end of the excursion exceeded 800 remains. Given the modest improvement in collection point backlog and the large backlog of unprocessed remains in the division rear, it is unlikely that this organization would be an acceptable alternative.

10. Contaminated Remains

An excursion was conducted to evaluate the processing of chemically contaminated remains at a contaminated remains collection point. A new task list for contaminated remains was developed and is shown in Table 8. Task times were increased to reflect worst case work/rest cycles and estimated MOPP degradation. One Brigade collection point was simulated with its base case workload and the contaminated remains task list. Figure 104 shows the organization of the contaminated remains excursion. Figures 105 and 106 show the results of this excursion.

Contaminated remains processing increased backlog and reduced throughput in the collection point by more than 60% when compared with the base case. By day 10 of the simulation the collection point's backlog exceeded 150 remains. By contrast, the same collection point had completed processing of this workload using conventional procedures in the base case. Worker productivity fell to less than 0.5 remains per day for this excursion. Processing contaminated remains has a severe negative effect on performance.

11. Conclusions

The excursion that was most effective at reducing average backlog at brigade/ACR collection points was the evacuation to higher echelon excursion. The disadvantage of this excursion, however, is that it substantially increases cemetery backlog and the number of remains received by the cemetery without initial processing. In operation, these may be serious disadvantages. The effect these disadvantages on cemetery performance and rates of identification may be severe.

The results of the decentralized excursion show that division cemetery operations are not feasible unless the number of 57F soldiers available for division cemeteries is increased. With the limited assets available, a centralized cemetery operation is more efficient.

Elimination of ID processing was slightly more effective in reducing backlog at brigade/ACR collection points than doubling the workforce of these collection points. Both excursions reduced average backlog by more than 50%. It is unlikely, however, that brigade/ACR collection point strength could be doubled in our

current force structure. A more realistic alternative would be to reduce ID processing times through the development of a highly accurate, automated, sole-source ID method and, at the same time, increase brigade/ACR collection point strength as much as possible without removing assets from the cemetery. In emergency situations, where brigade/ACR collection points must move quickly or if an unexpected surge in workload occurs, evacuation of unprocessed remains to the next higher echelon should be implemented.

Results of the base case simulation support the pending reorganization of the GRREG force structure in the corps rear area. Initial and intermediate collection points in the corps rear area are redundant and underutilized. These assets could be better utilized at brigade/ACR collection points or cemeteries in the Corps and COMMZ.

The authorization of personnel in GRREG augmentations in the TOEs of Armored Cavalry Units is seriously inadequate. Projected workloads for Armored Cavalry Regiments far exceed the capability of their GRREG augmentations. The situation in Armored Cavalry Regiments is much worse than in the Brigades of Heavy Divisions. GRREG augmentations to Armored Cavalry Regiment TOEs should be reviewed.

TABLE 5. Base Case Simulation Task List

Initial Collection Point

Task Number	Min Personnel	Max Personnel	Pairs	Time(min)
1	3	7	1+[2,4,6]	2
2	1	1	0	5
3	1	infinite	0	55
4	2	infinite	2	10
5	1	1	0	5
6	4	6	[2,4,6]	2
7	1	infinite	0	5

Intermediate Collection Point

Task Number	Min Personnel	Max Personnel	Pairs	Time(min)
1	3	7	1+[2,4,6]	2
2	1	1	0	5
3	1	infinite	0	25
4	2	infinite	2	5
5	1	1	0	5
6	4	6	[2,4,6]	2

Temporary Cemetery

Task Number	Min Personnel	Max Personnel	Pairs	Time(min)
1	3	7	1+[2,4,6]	2
2	1	1	0	5
3	2	infinite	2	5
4	1	1	0	5
5	1	infinite	0	15
6	2	infinite	2	20
7	1	infinite	0	15
8	1	infinite	0	30
9	2	infinite	2	5
10	1	2	0	10
11	2	infinite	2	5
12	1	1	0	10
13	2	infinite	2	10
14	1	1	0	20
15	2	infinite	2	30
16	1	infinite	0	15

TABLE 6. Task Descriptions

Initial Collection Point

Task Number	Description
1	Unload remains.
2	Assign an evacuation number.
3	Check ID, DD1380, PE, prepare forms, fingerprint.
4	Put remains/documents in pouch, move remains.
5	Prepare convoy list of remains.
6	Load remains.
7	Misc.

Intermediate Collection Point

Task Number	Description
1	Unload remains.
2	Assign evacuation number.
3	Compare remains and PE with ID documentation.
4	Move remains to holding area.
5	Record on convoy list.
6	Misc.

Temporary Cemetery

Task Number	Description
1	Unload remains.
2	Check evacuation number and PE seal.
3	Move remains to processing area.
4	Assign processing number.
5	Compare remains and PE with documentation.
6	Remove clothing and examine remains.
7	Fingerprint remains.
8	Perform detailed ID; dental,anatomical,skeletal.
9	Shroud remains.
10	Prepare embossed plates and tags; attach.
11	Move remains to holding area.
12	Open grave.
13	Move remains to grave.
14	Prepare interment and plot records.
15	Place remains in grave and cover.
16	Prepare PE for shipment.

TABLE 7. Zero ID Excursion, Simulation Task List

Initial Collection Point

Task Number	Min Personnel	Max Personnel	Pairs	Time(min)
1	3	7	1+[2,4,6]	2
2	1	1	0	5
3	0	0	0	0
4	2	infinite	2	10
5	1	1	0	5
6	4	6	[2,4,6]	2
7	1	infinite	0	5

Intermediate Collection Point

Task Number	Min Personnel	Max Personnel	Pairs	Time(min)
1	3	7	1+[2,4,6]	2
2	1	1	0	5
3	0	0	0	0
4	2	infinite	2	5
5	1	1	0	5
6	4	6	[2,4,6]	2

TABLE 8. Contaminated Remains Excursion, Simulation Task List

Contaminated Remains Collection Point

Task	Min Personnel	Max Personnel	Pairs	Time(min)
Donn MOPP IV	all	all	2	15
Unload	3	7	1+[2,4,6]	4
Remove from Pouch	2	infinite	2	3
Monitor Remains	1	infinite	0	20
Assign Evac #	1	1	0	9
ID Tasks	1	infinite	0	101
Place in Pouch/Move	2	infinite	2	10
Decon Pouch Exterior	1	infinite	0	15
Convoy List	1	1	0	9
Load Remains	4	6	[2,4,6]	4

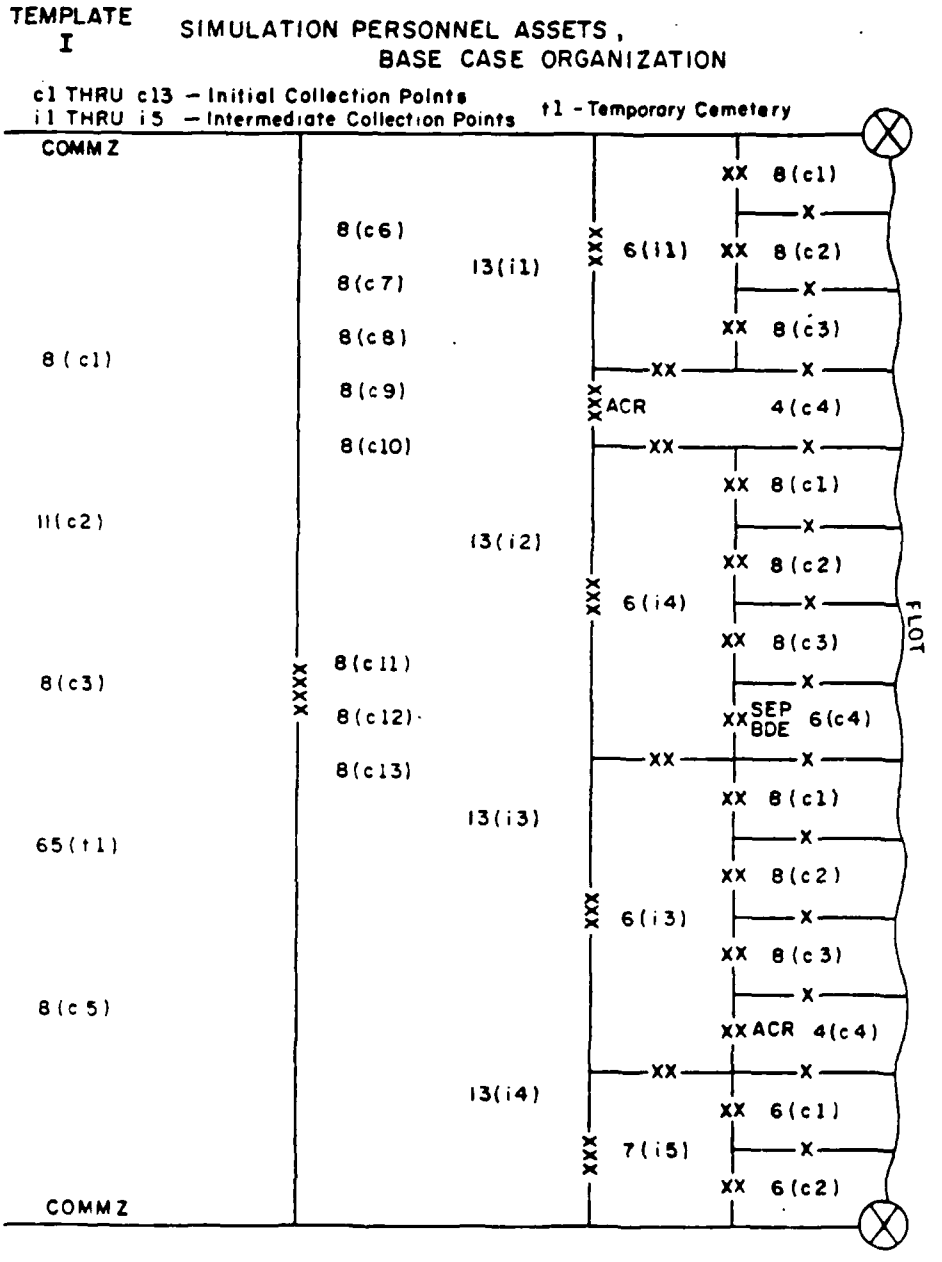

Figure 7. Base Case Organization

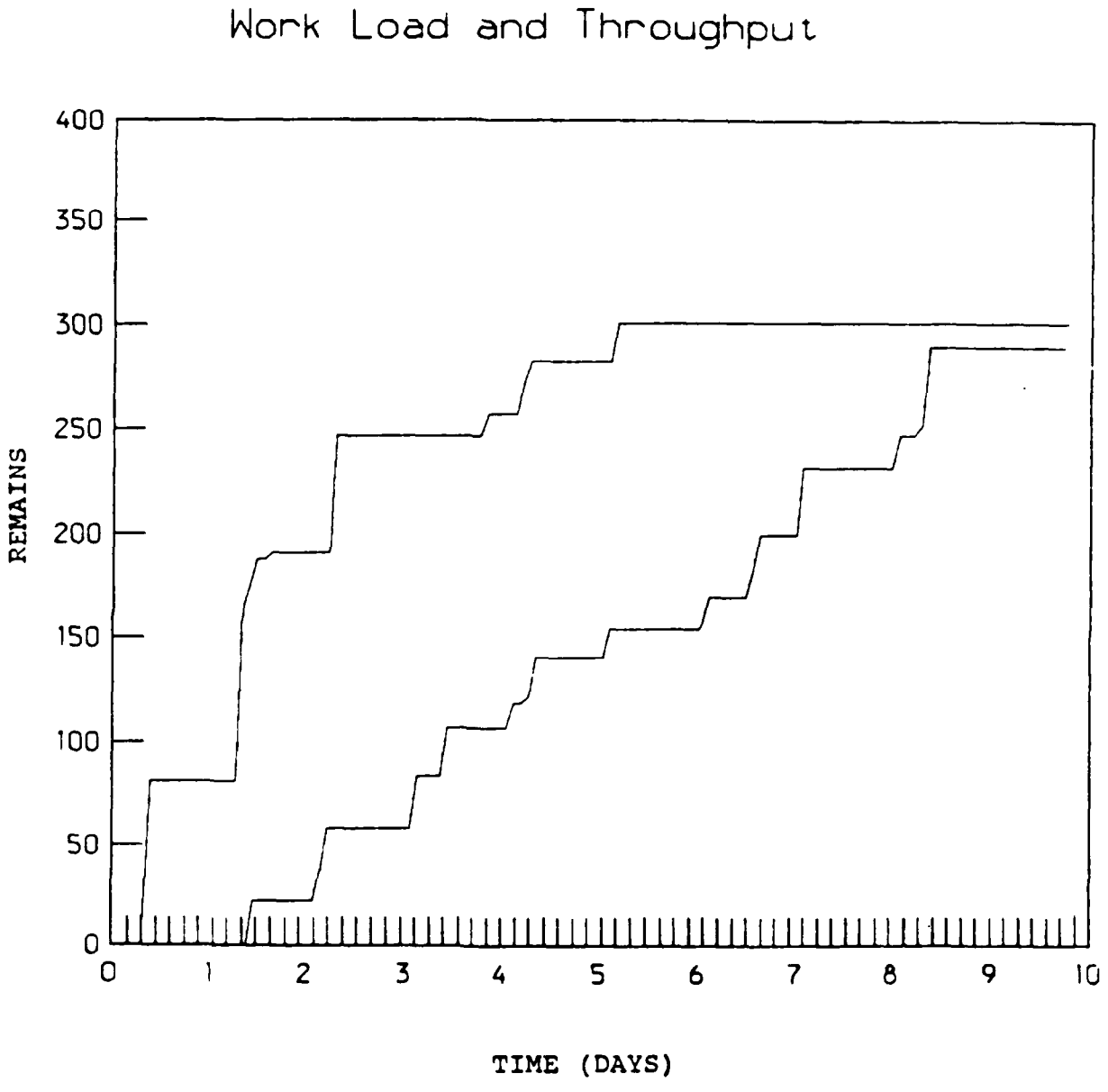

Figure 8. Collection Point 1, BDE, Div 1, Backlog

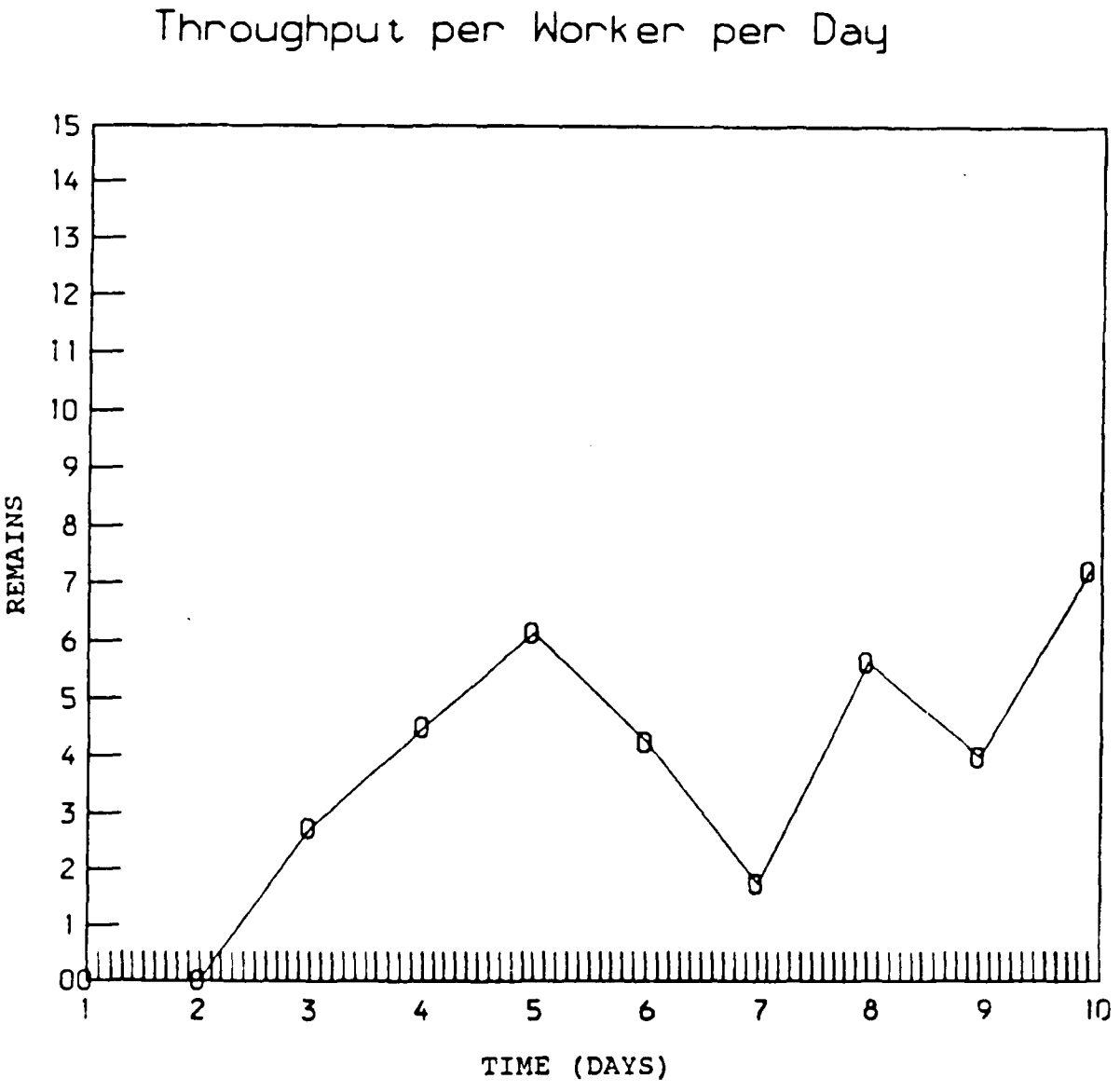

Figure 9. Collection Point 1, BDE, Div 1, Throughput

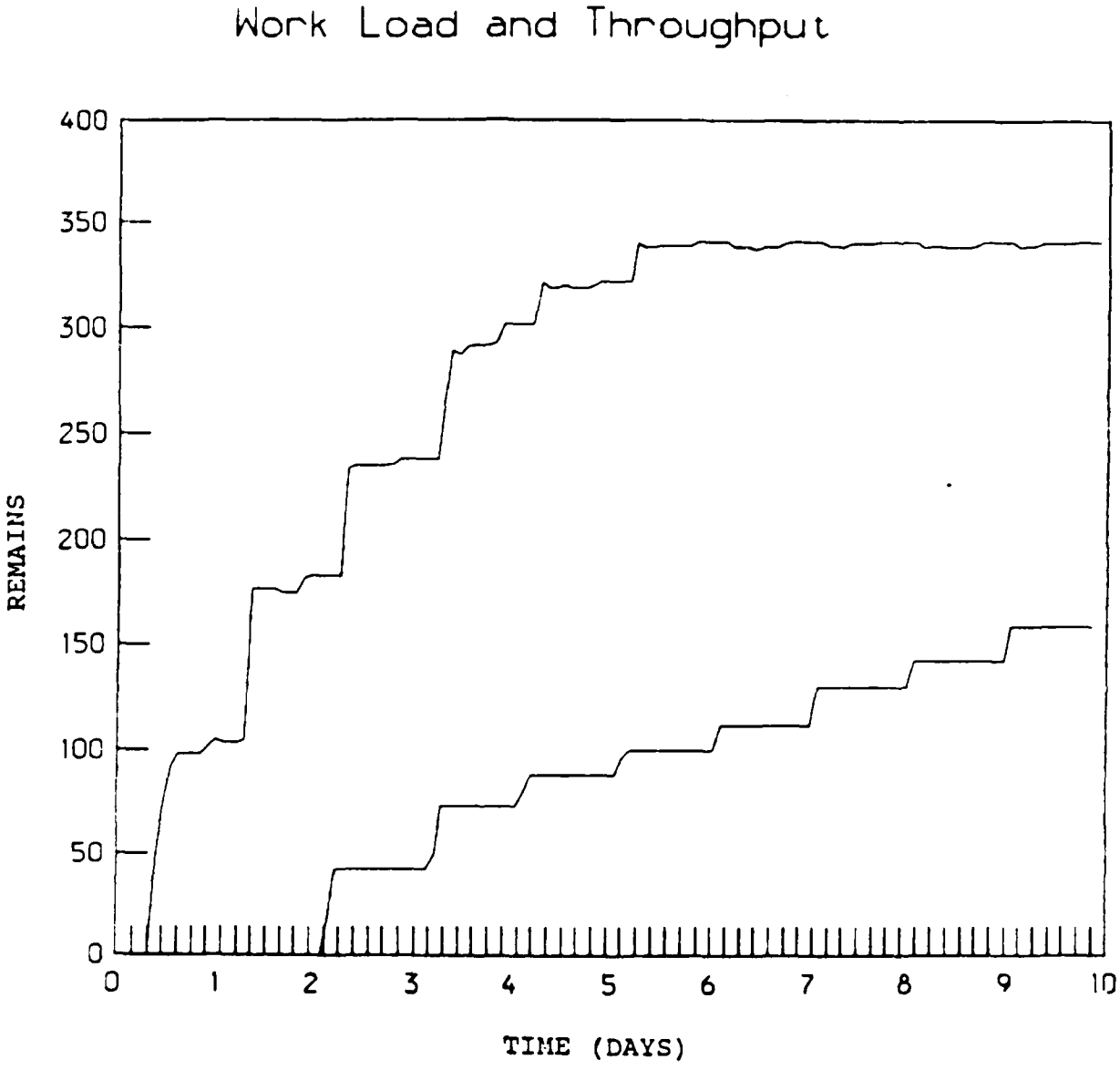

Figure 10. Collection Point 2, BDE, Div 1, Backlog

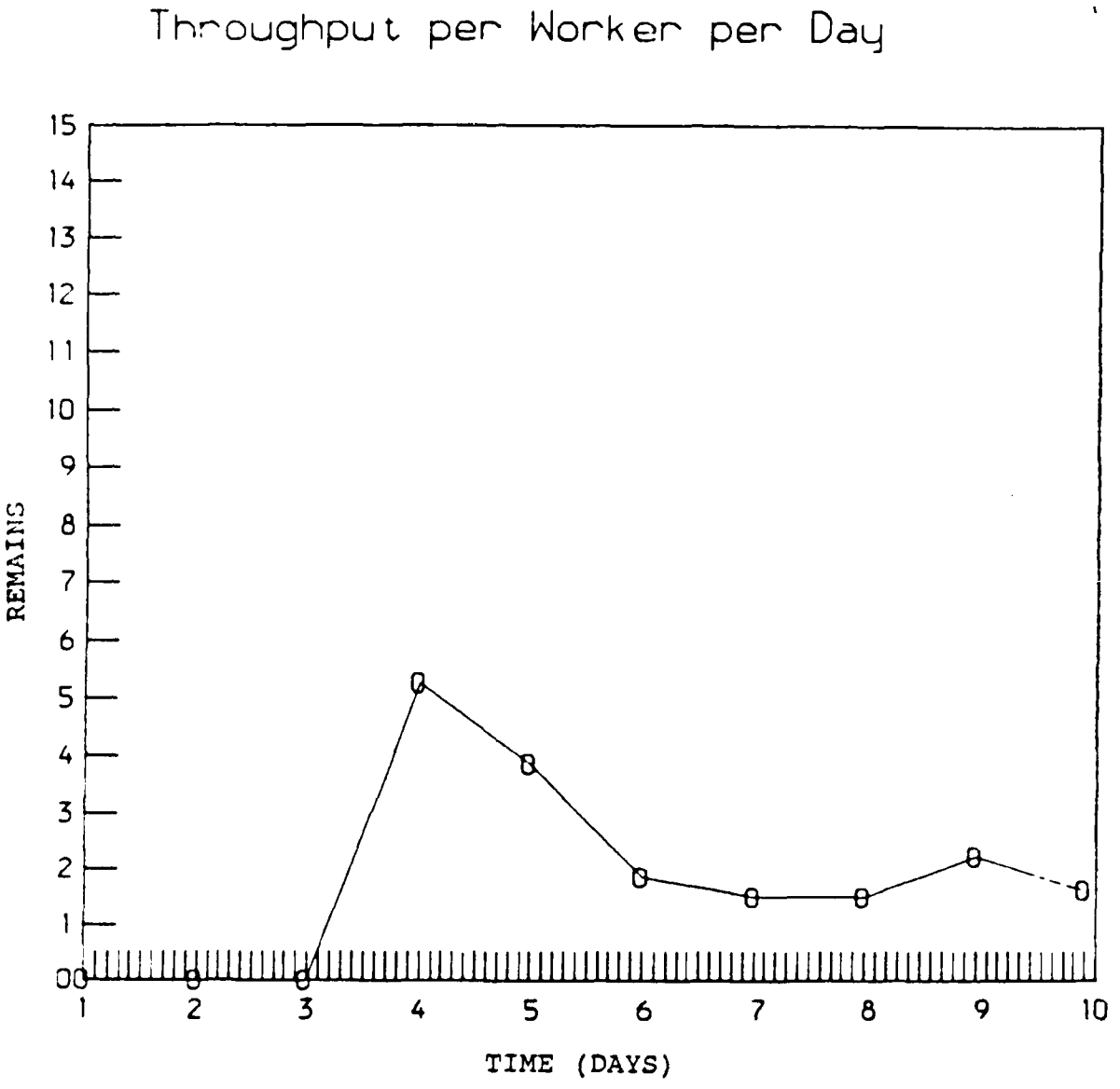

Figure 11. Collection Point 2, BDE, Div 1, Throughput

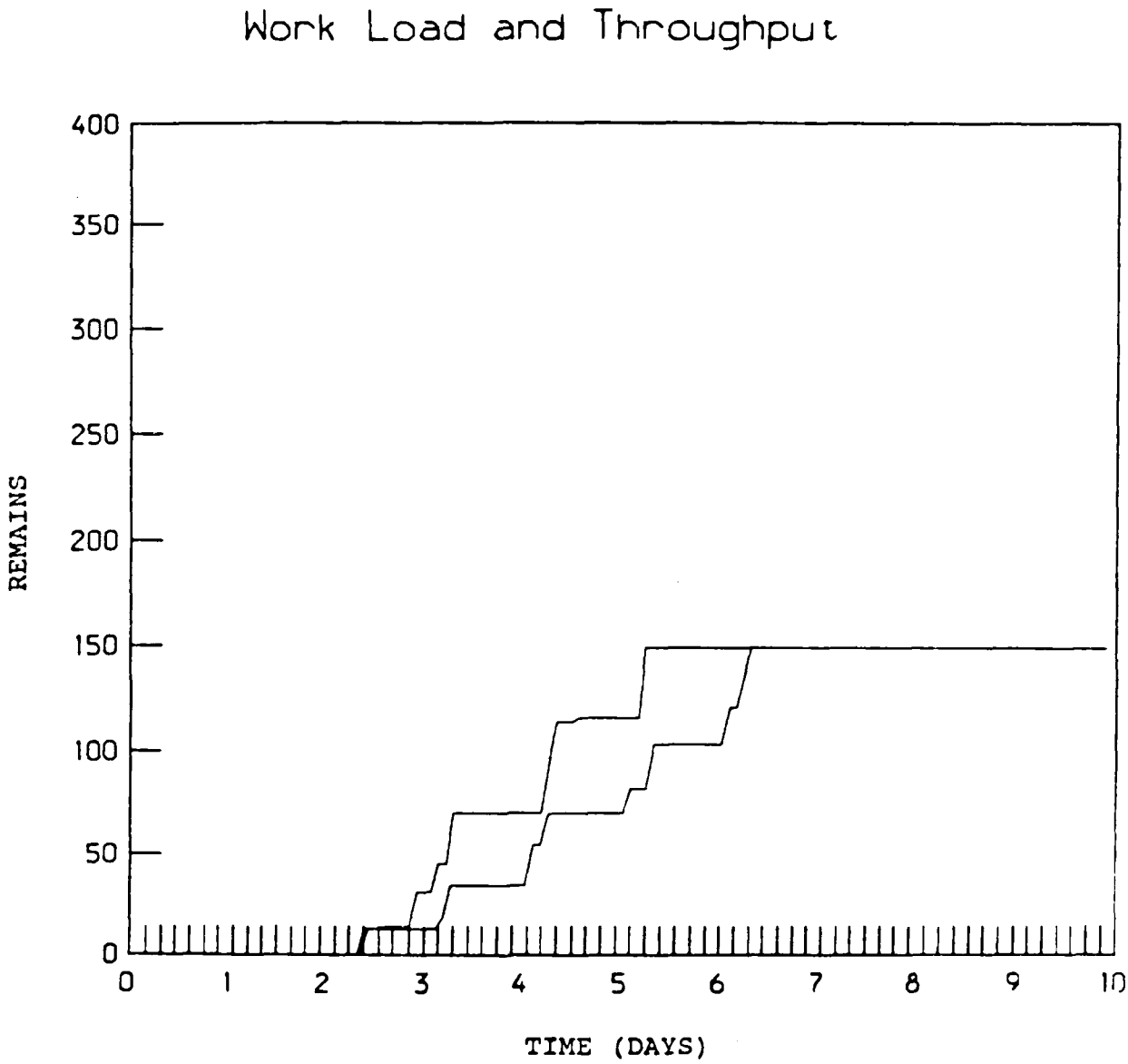

Figure 12. Collection Point 3, BDE, Div 1, Backlog

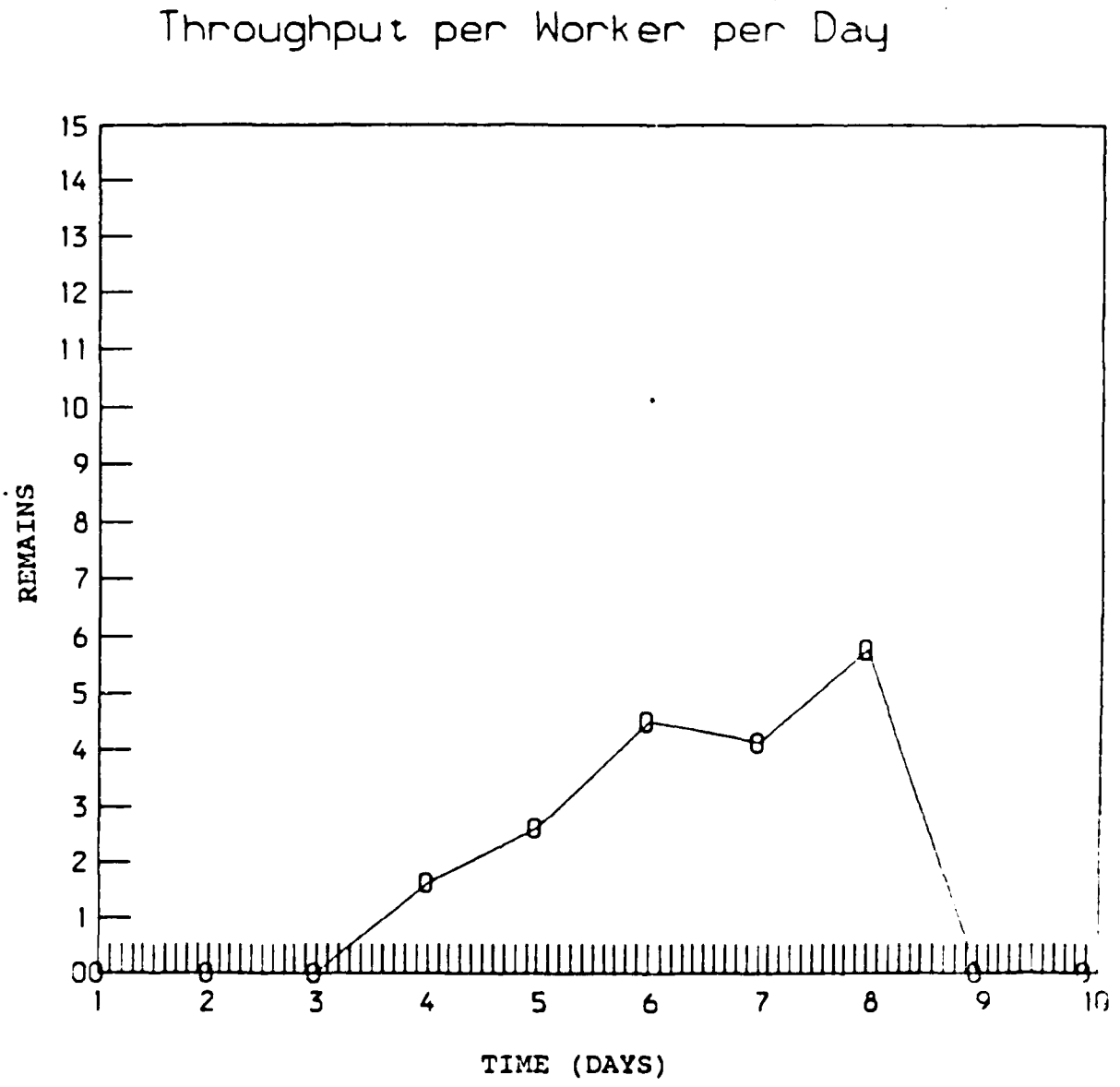

Figure 13. Collection Point 3, BDE, Div 1, Throughput

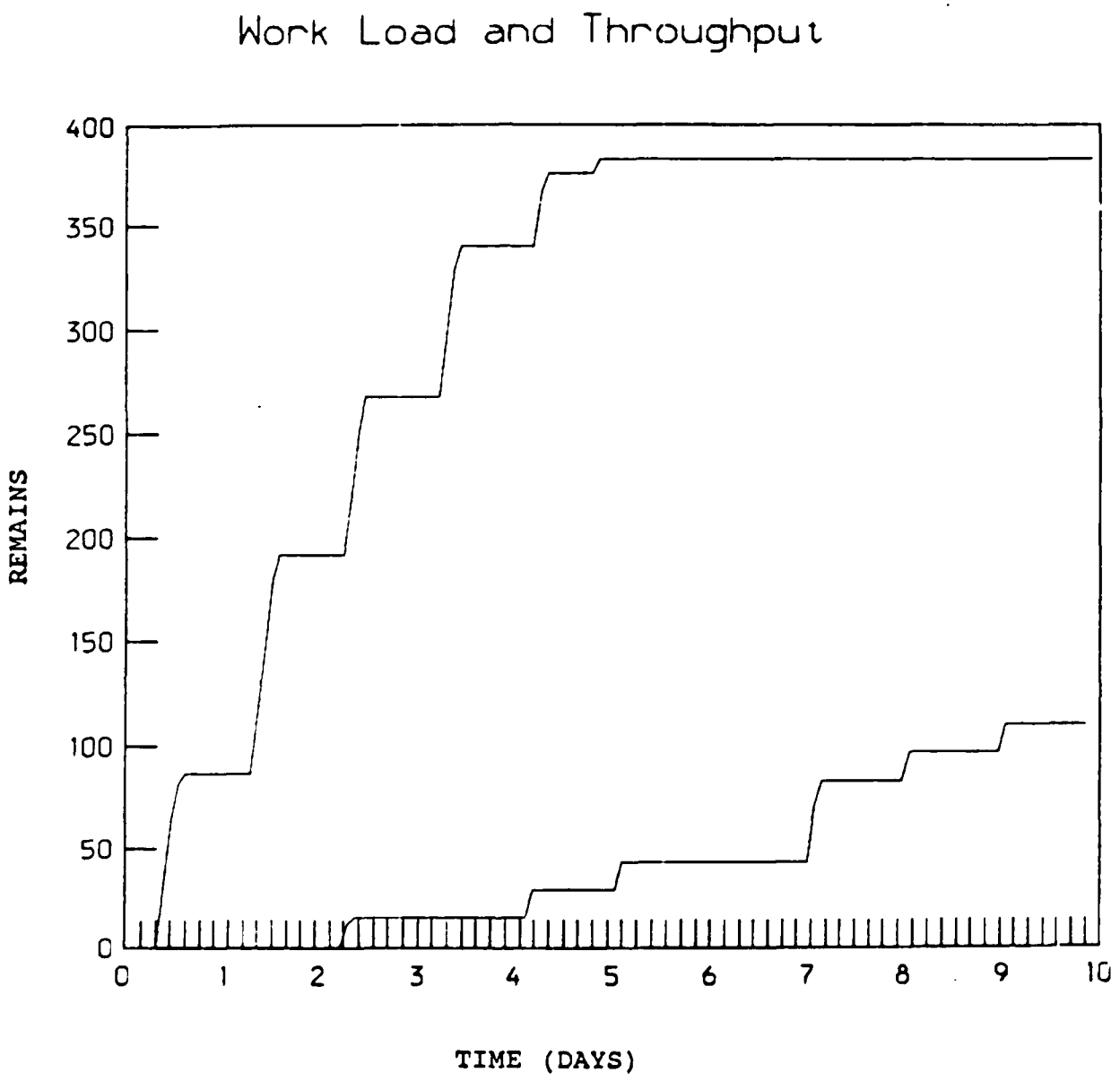

Figure 14. Collection Point 4, ACR, Div 1, Backlog

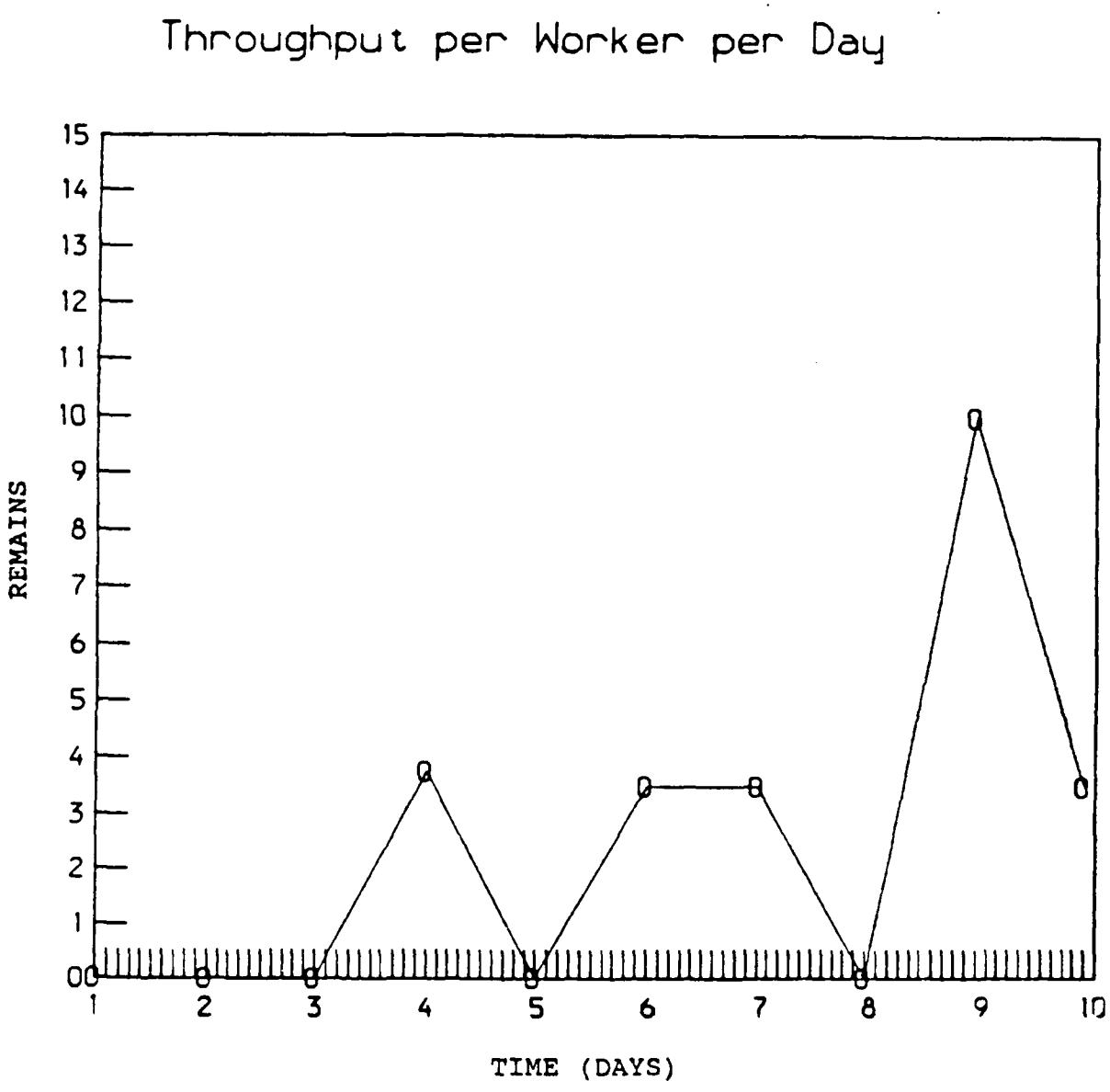

Figure 15. Collection Point 4, ACR, Div 1, Throughput

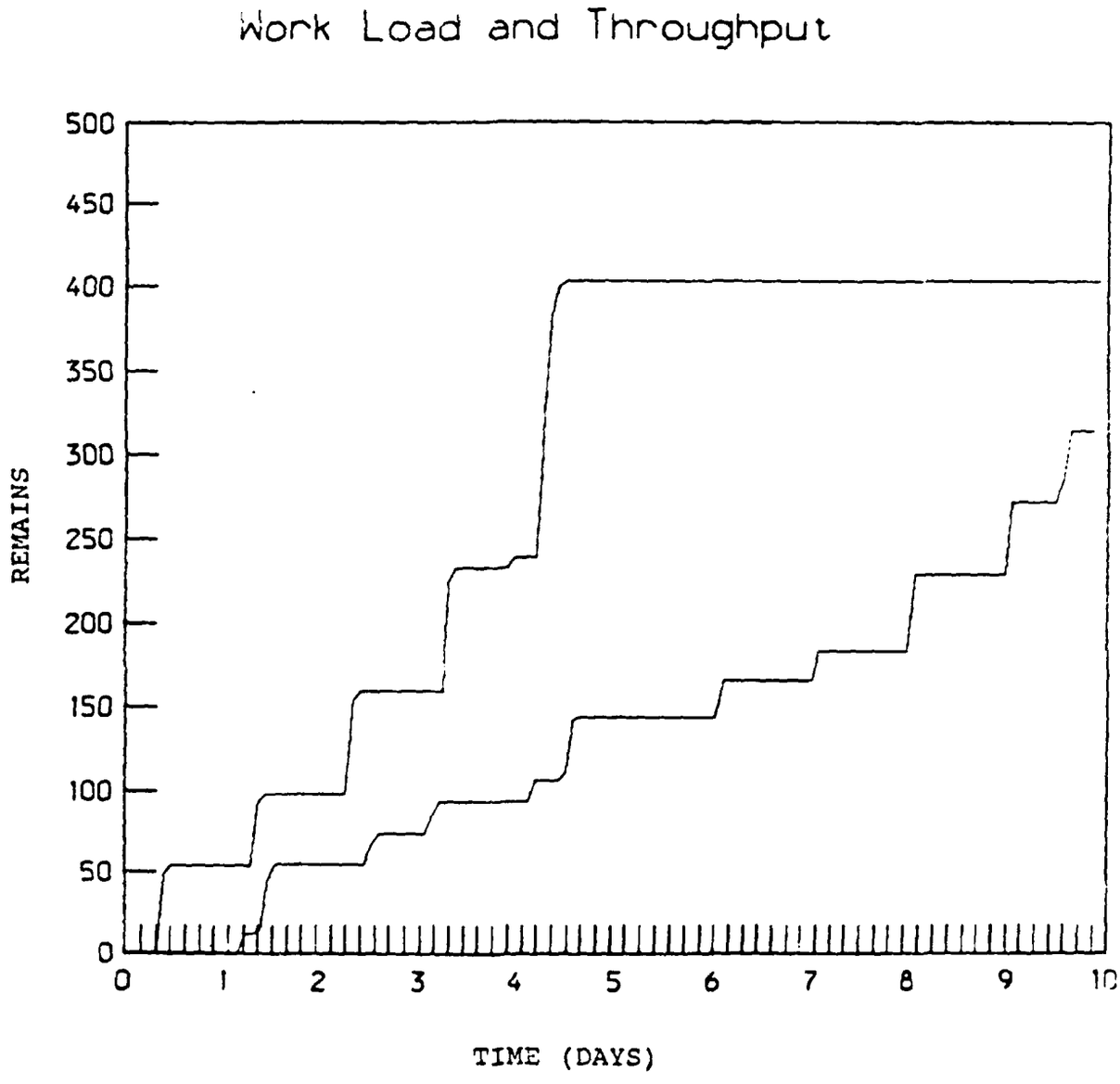

Figure 16. Collection Point 1, BDE, Div 3, Backlog

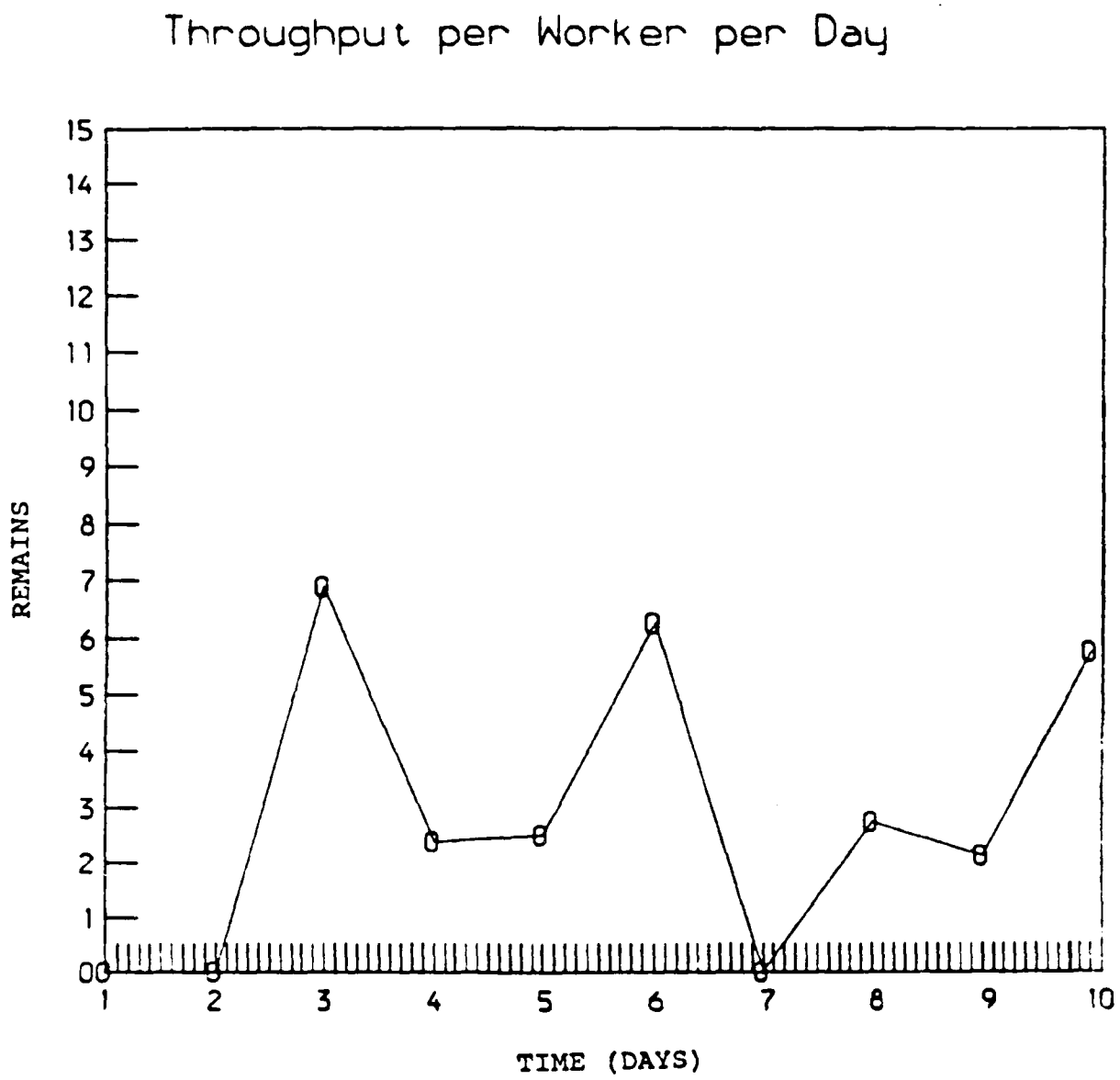

Figure 17. Collection Point 1, BDE, Div 3, Throughput

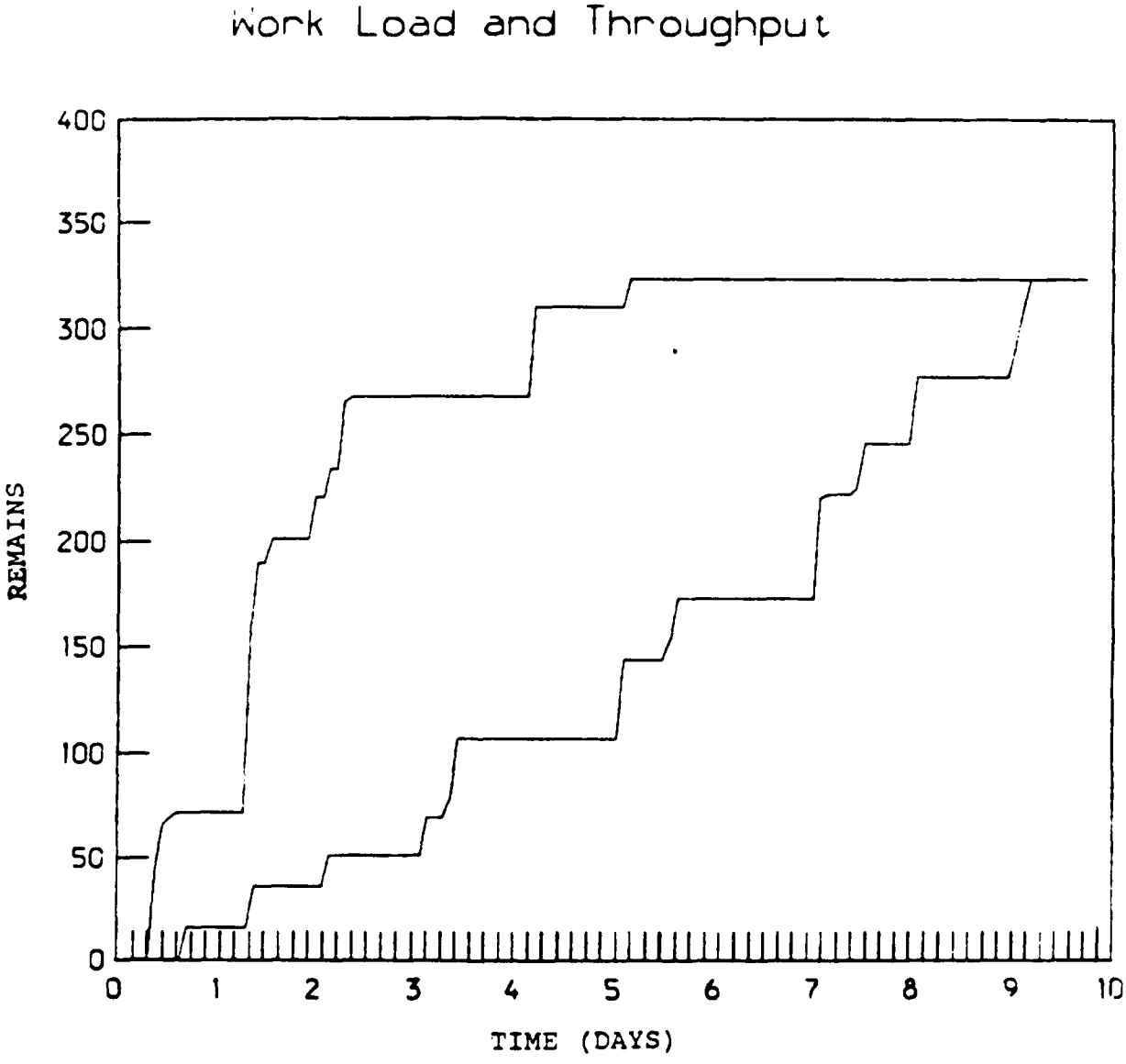

Figure 18. Collection Point 2, BDE, Div 3, Backlog

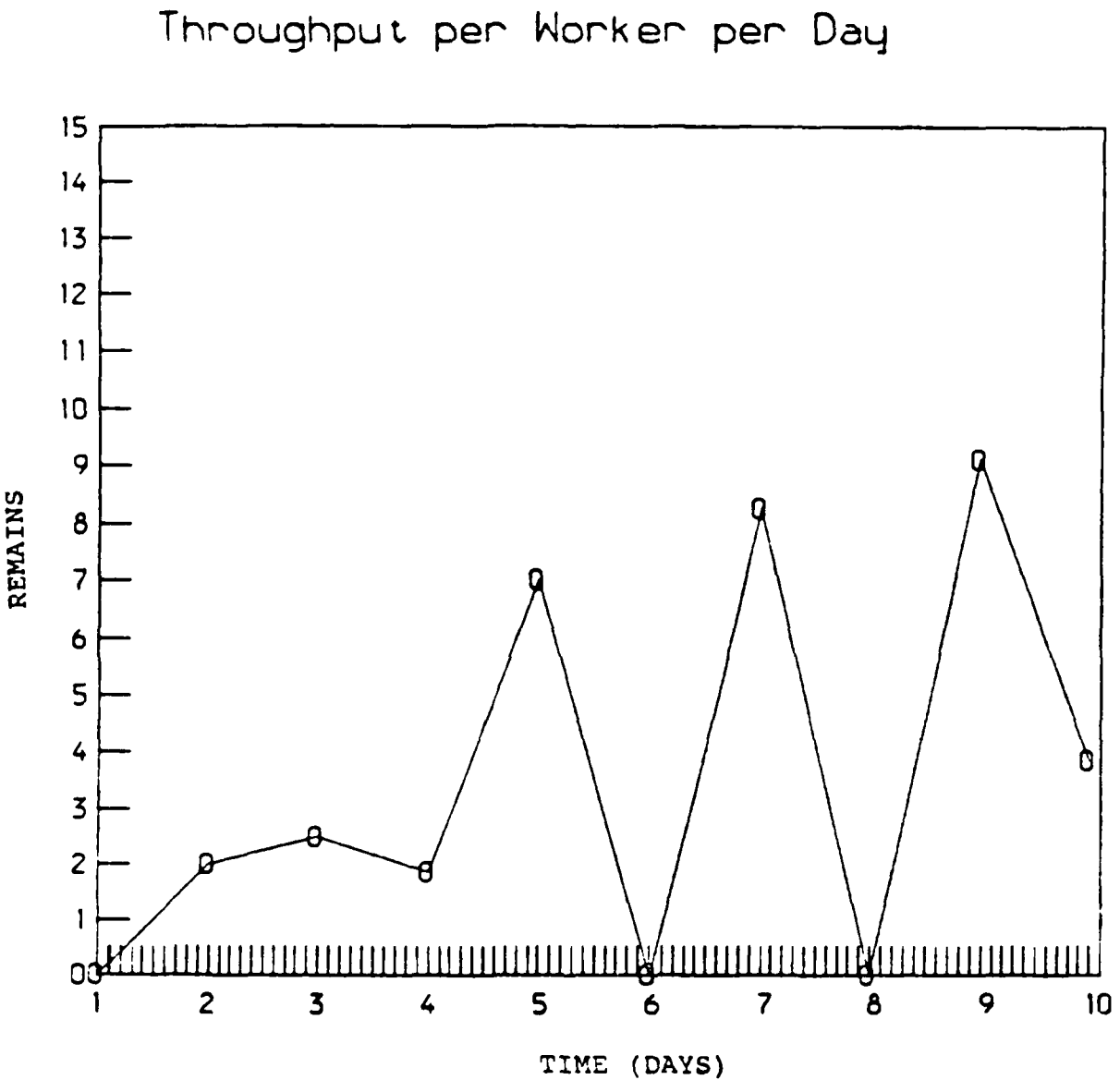

Figure 19. Collection Point 2, BDE, Div 3, Throughput

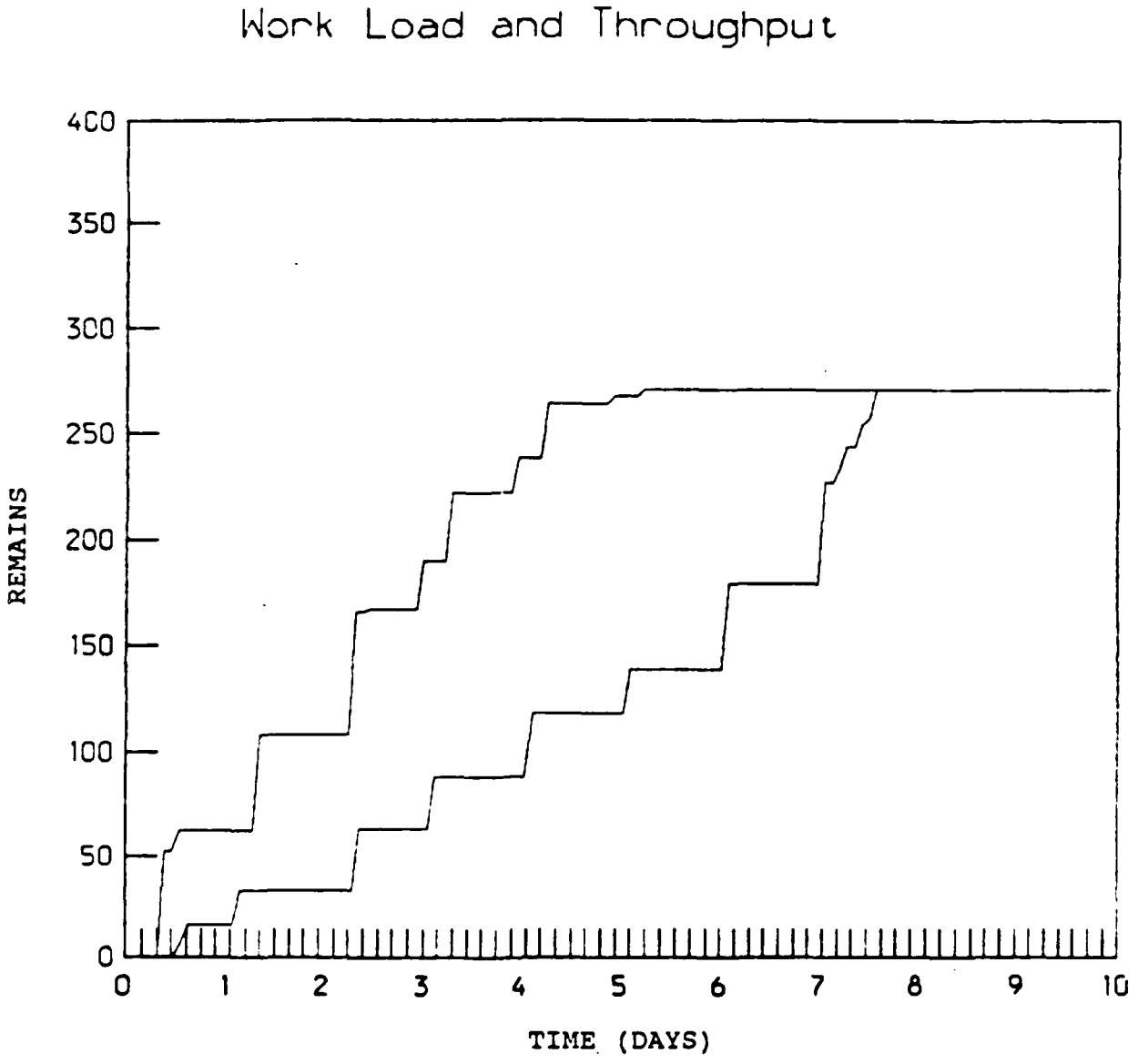

Figure 20. Collection Point 3, BDE, Div 3, Backlog

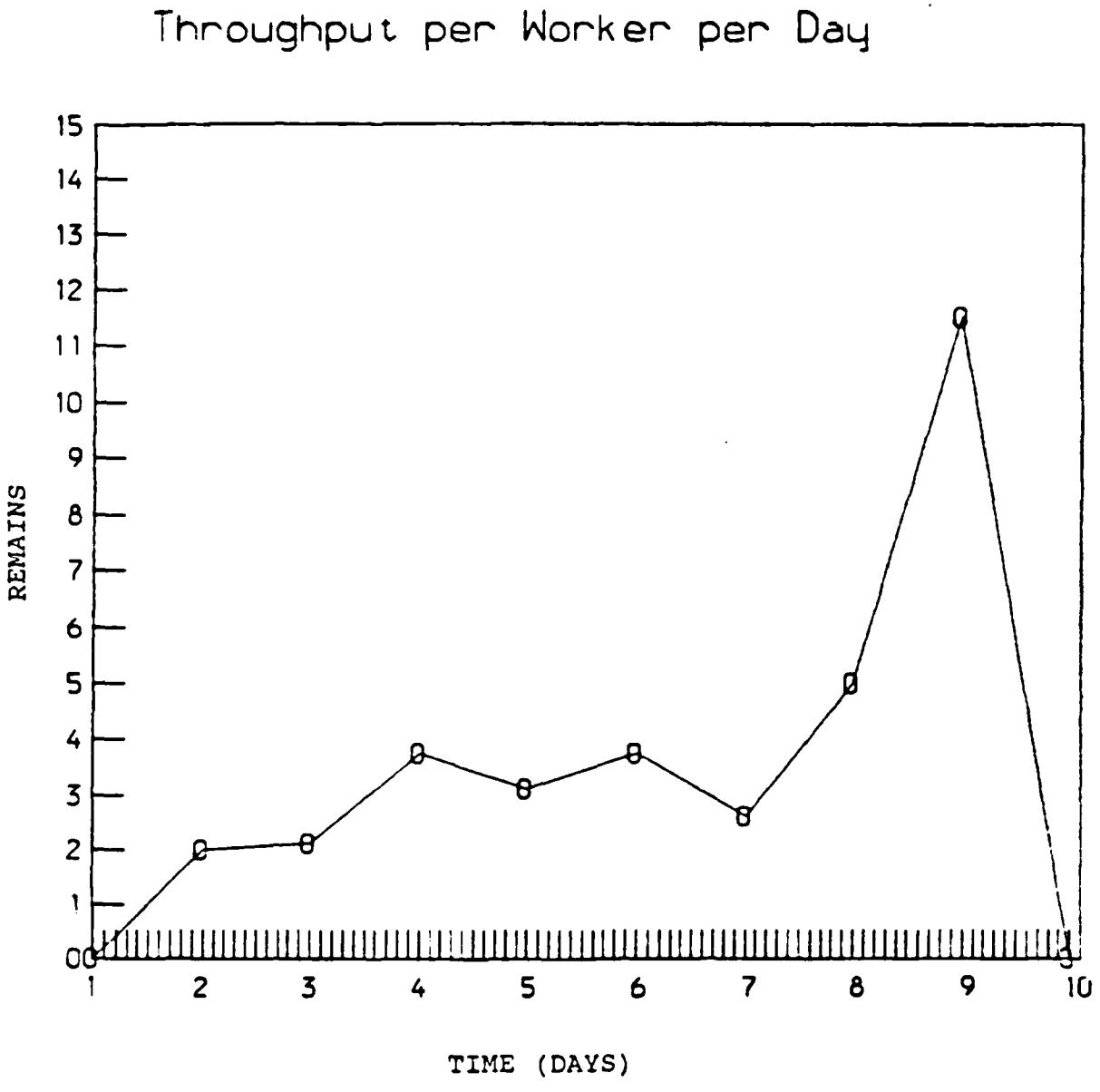

Figure 21. Collection Point 3, BDE, Div 3, Throughput

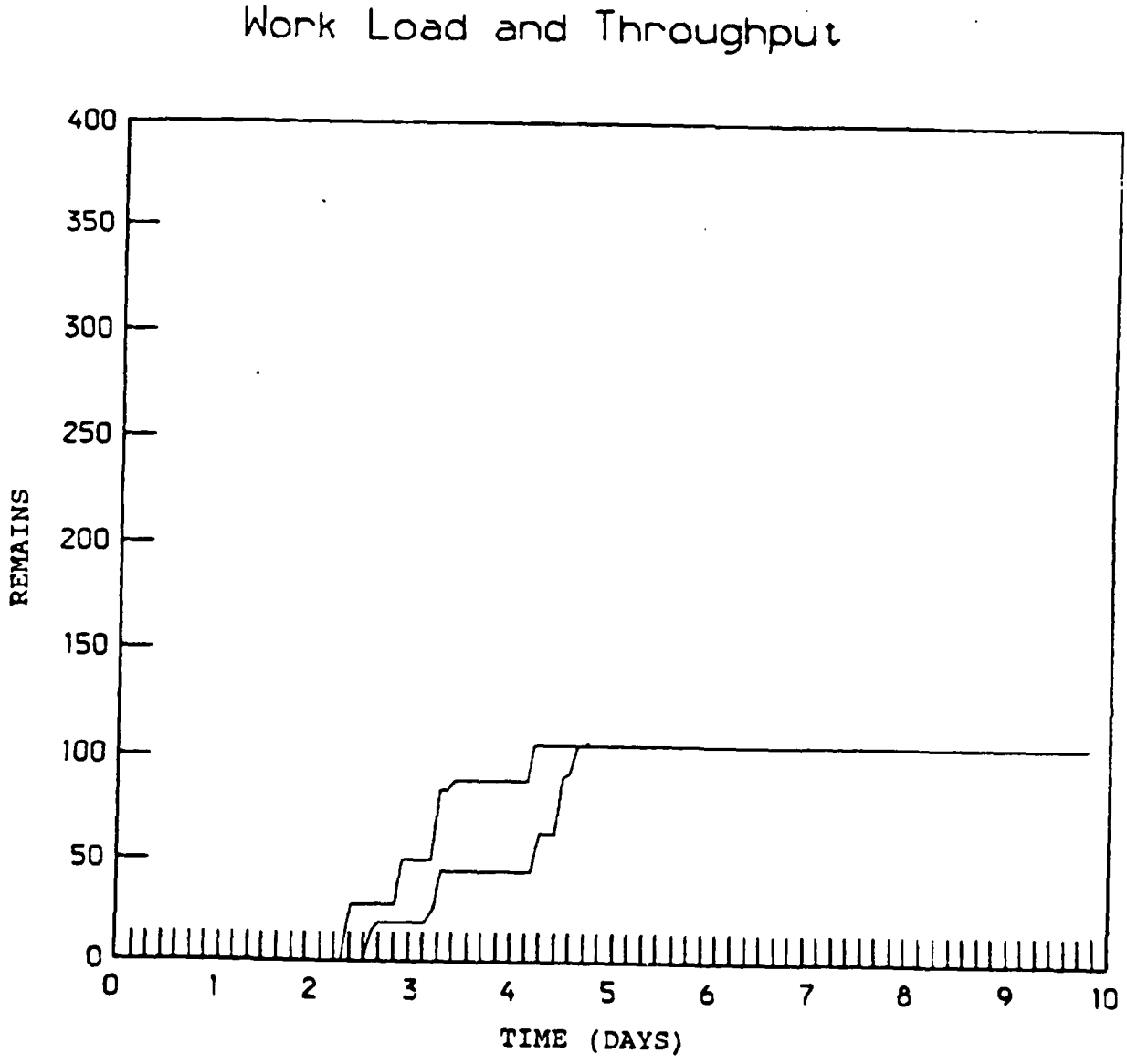

Figure 22. Collection Point 4, ACR, Div 3, Backlog

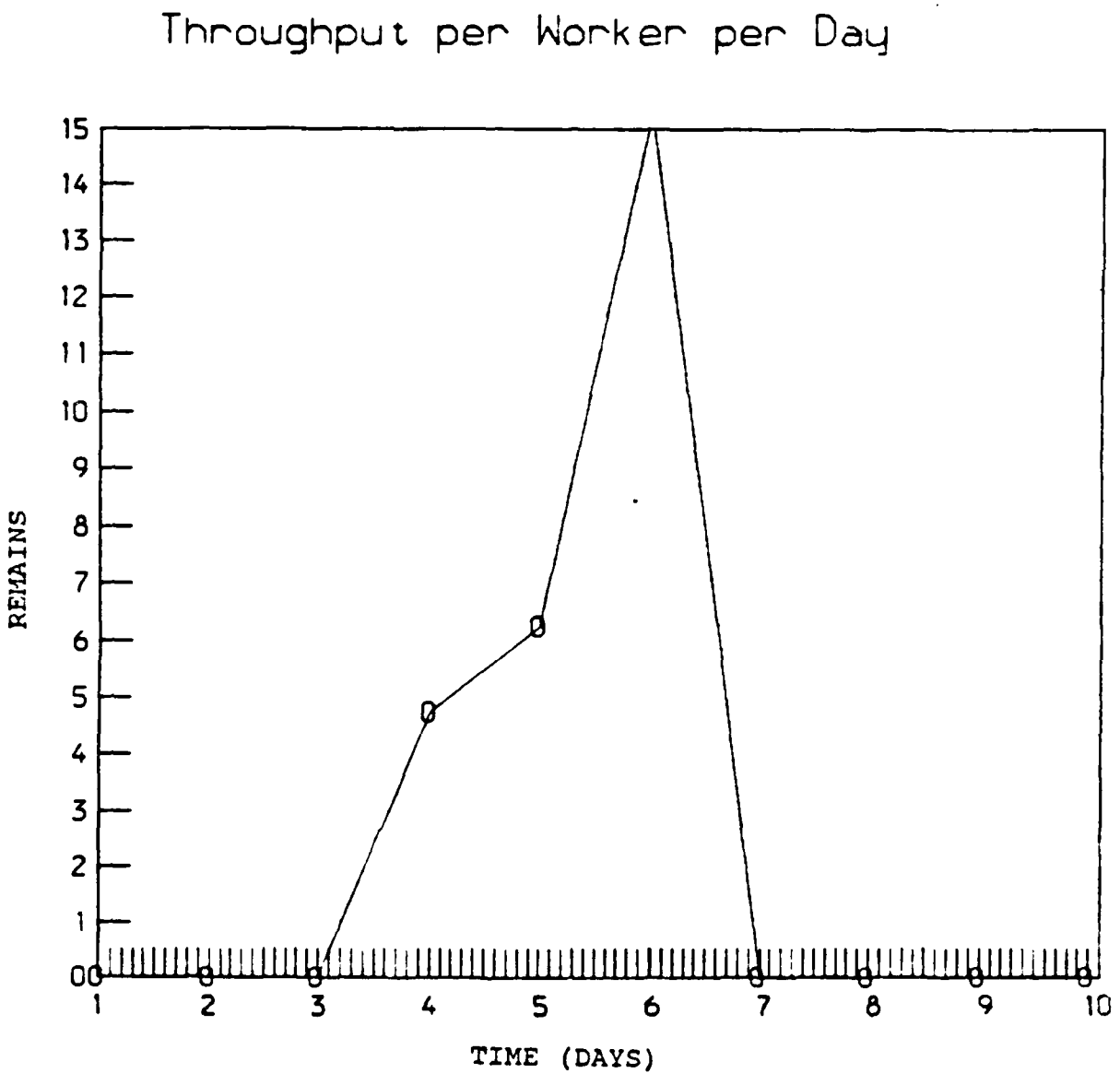

Figure 23. Collection Point 4, ACR, Div 3, Throughput

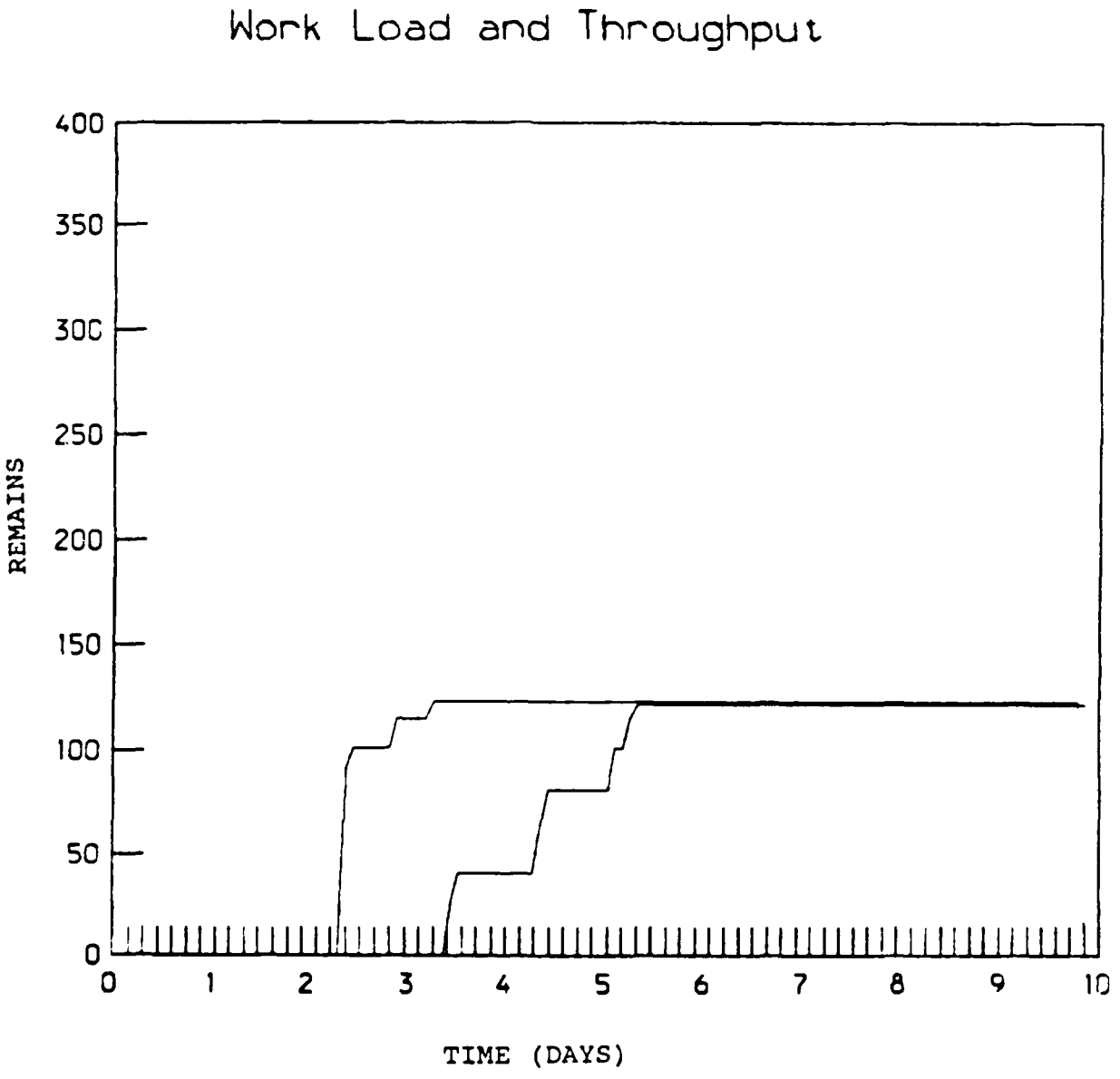

Figure 24. Collection Point 1, BDE, Div 4, Backlog

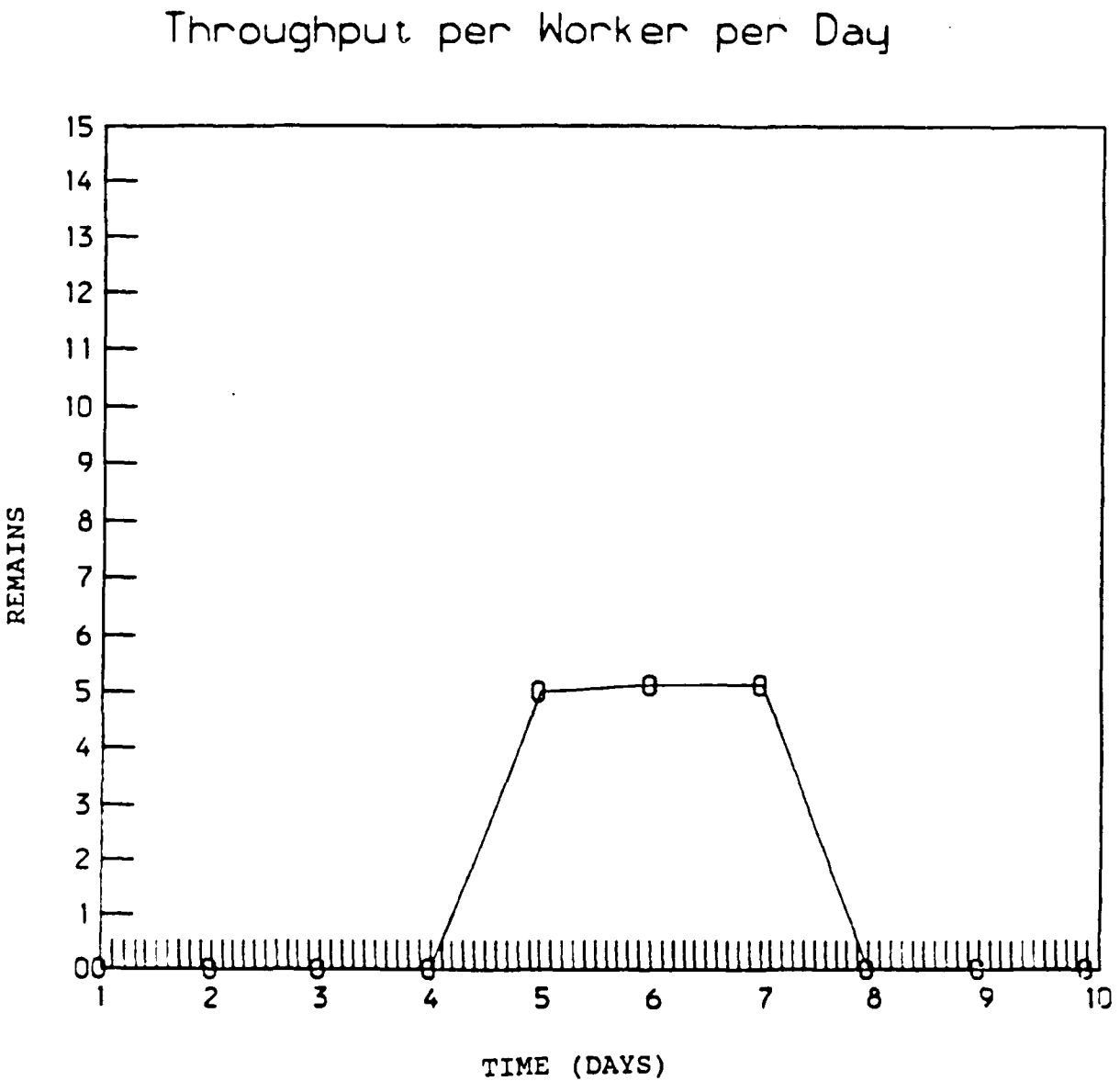

Figure 25. Collection Point 1, BDE, Div 4, Throughput

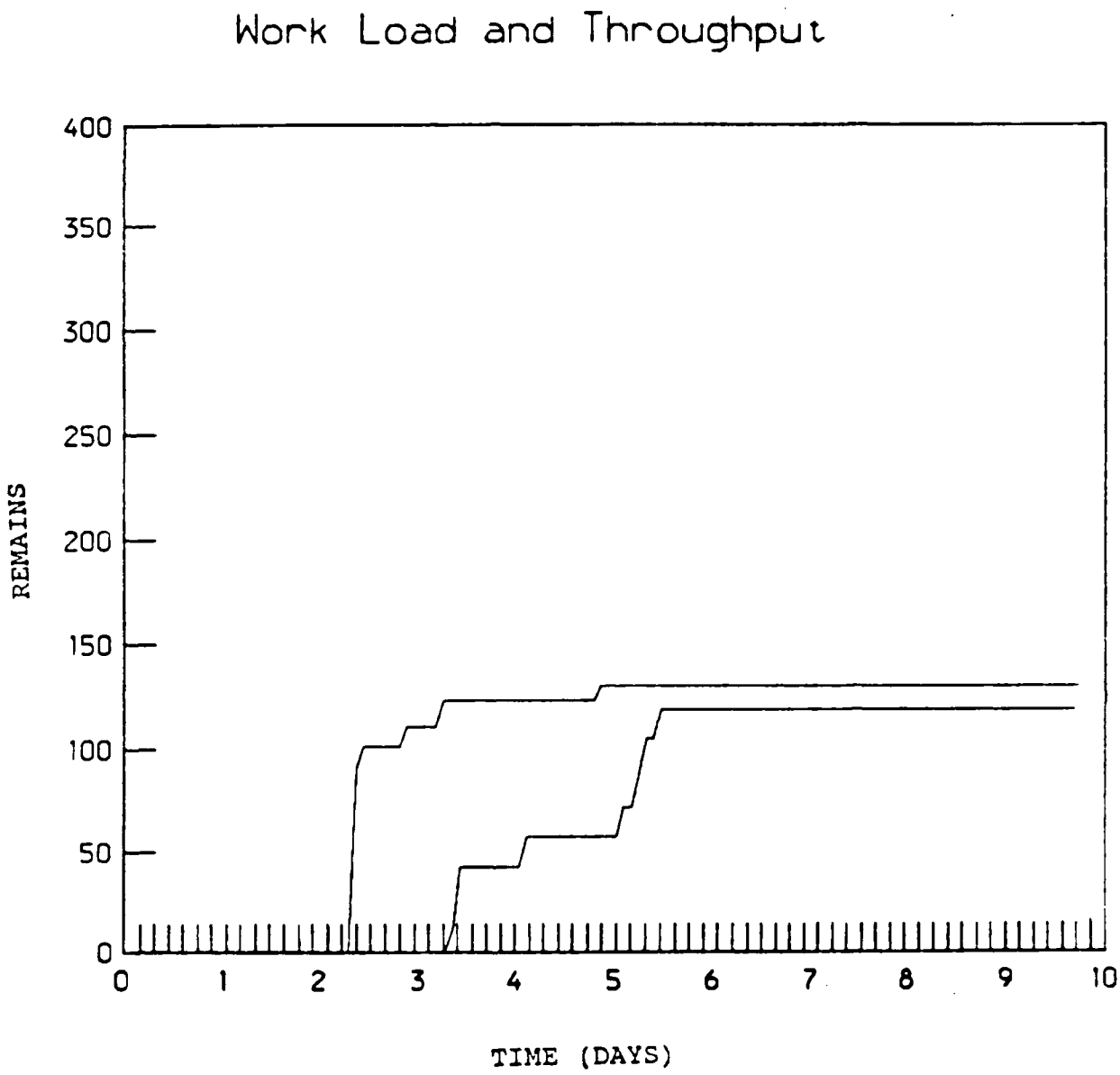

Figure 26. Collection Point 2, BDE, Div 4, Backlog

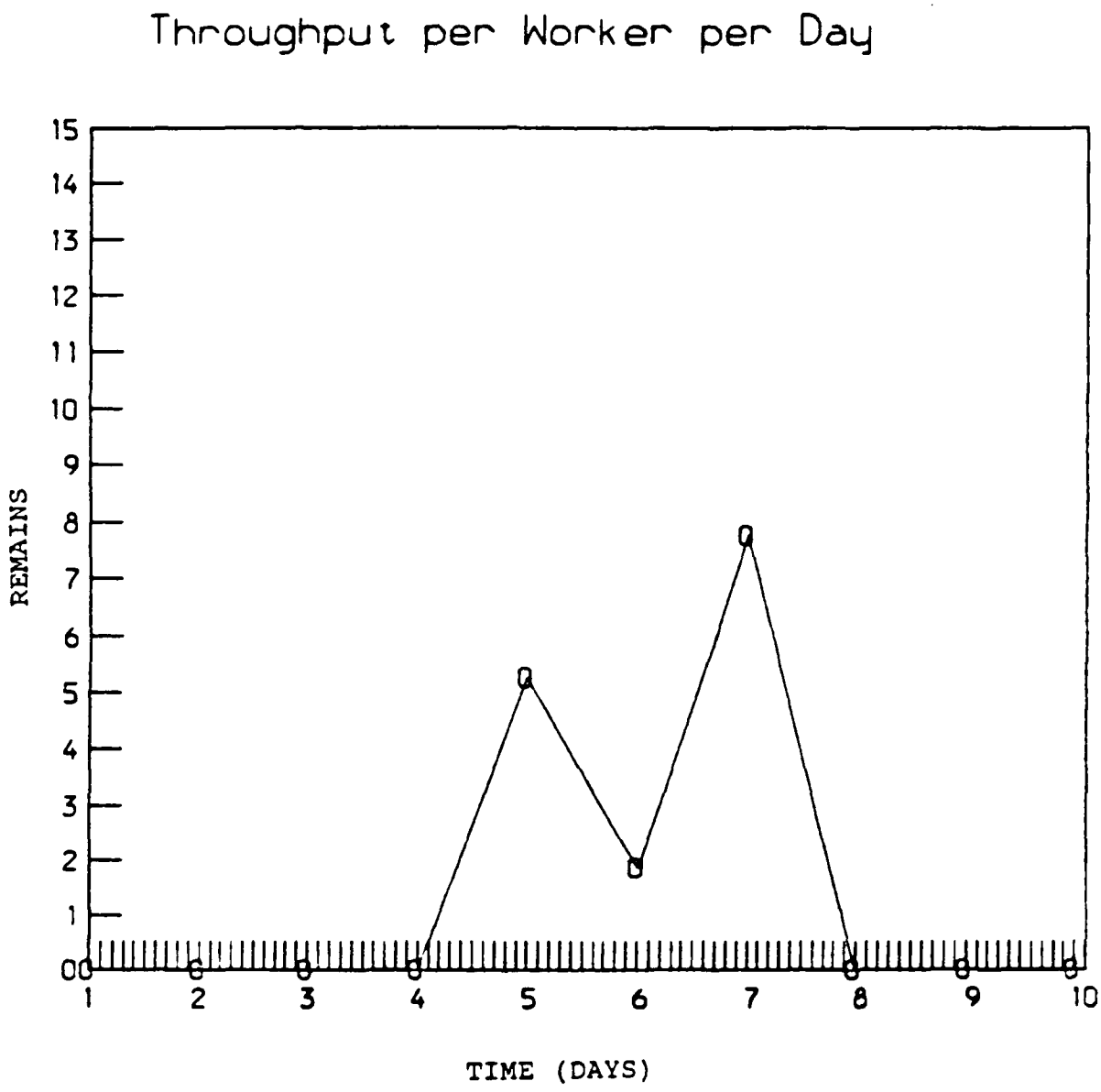

Figure 27. Collection Point 2, BDE, Div 4, Throughput

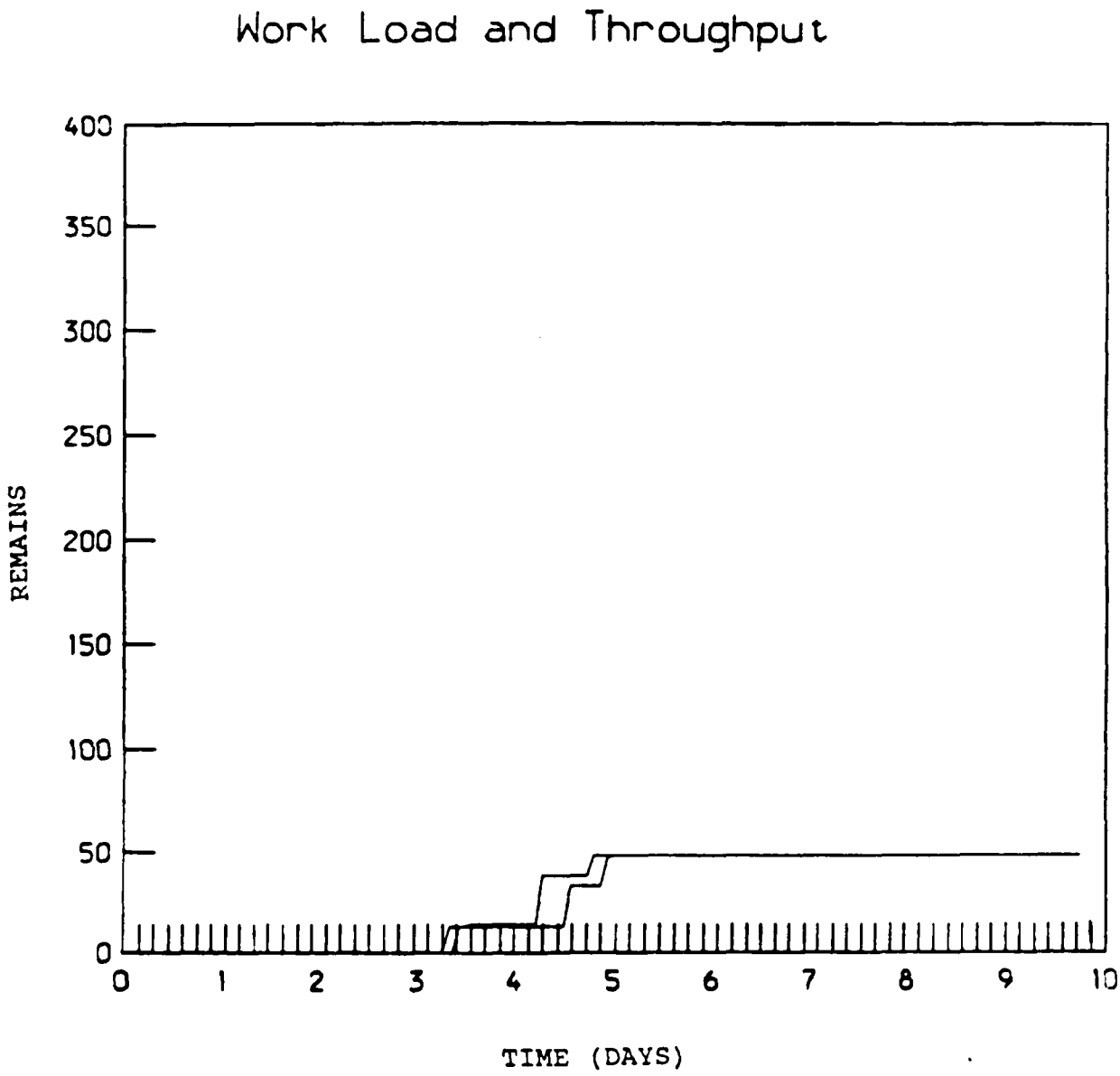

Figure 28. Collection Point 3, BDE, Div 4, Backlog

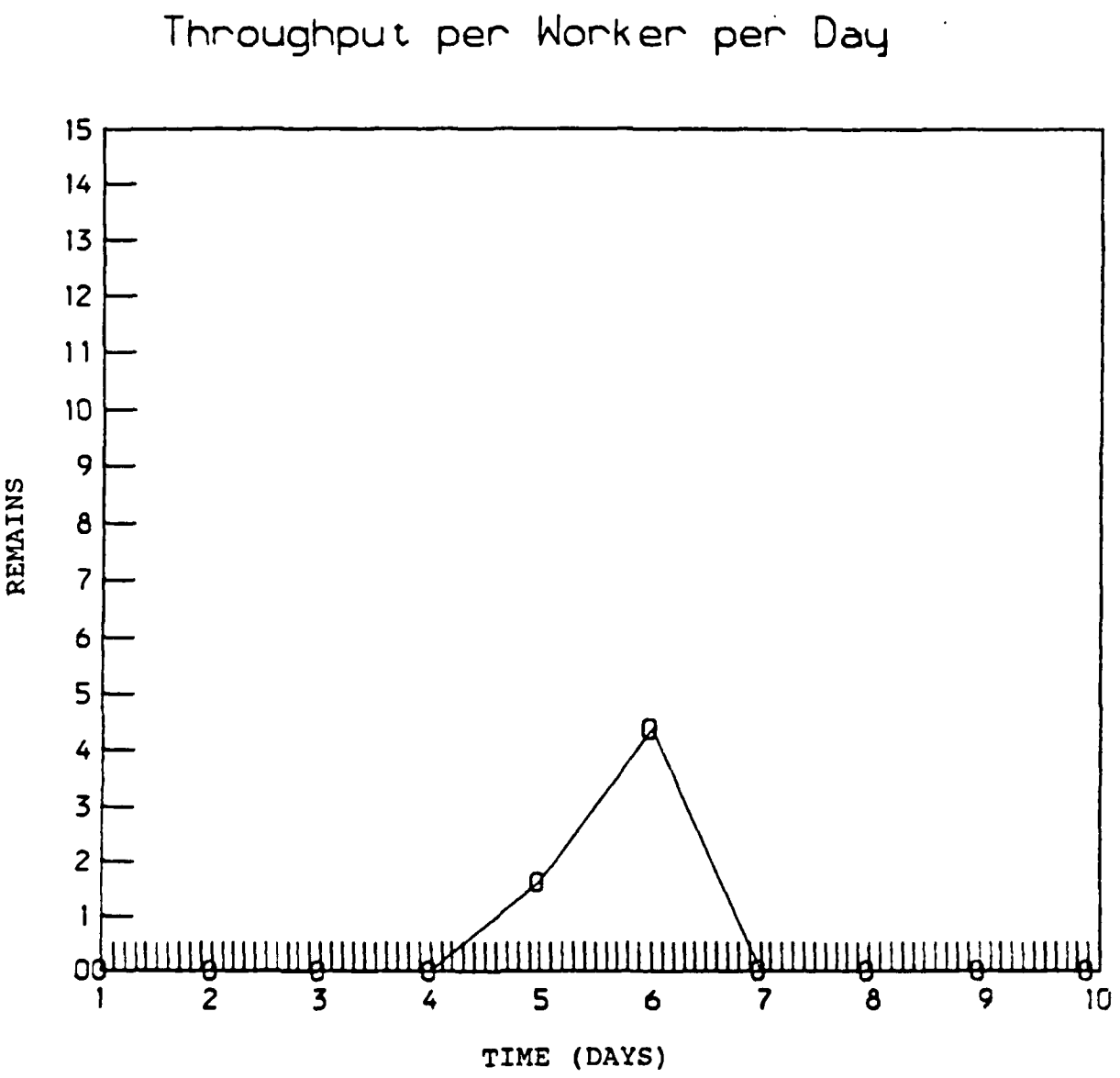

Figure 29. Collection Point 3, BDE, Div 4, Throughput

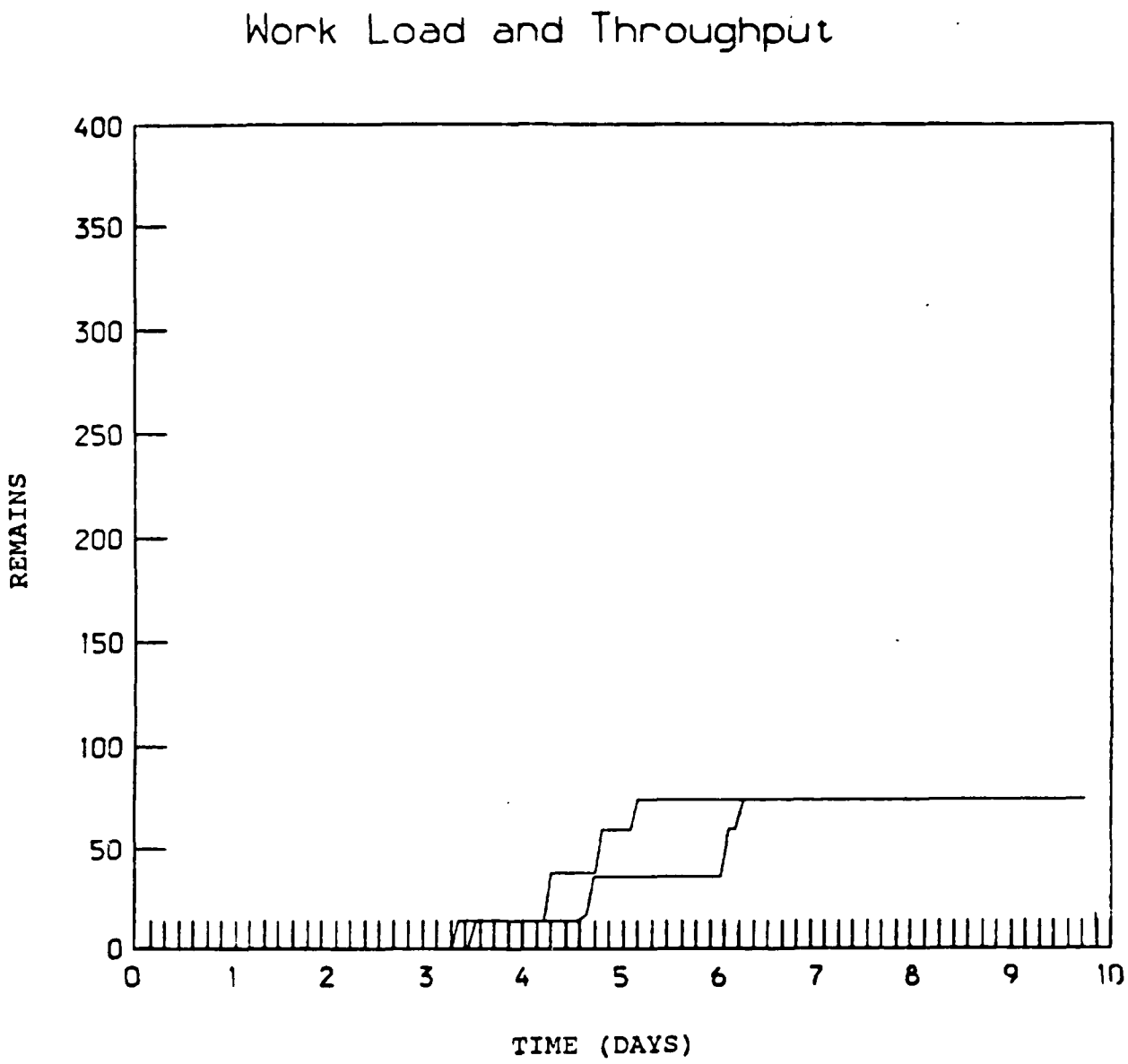

Figure 30. Collection Point 4, SEP BDE, Div 4, Backlog

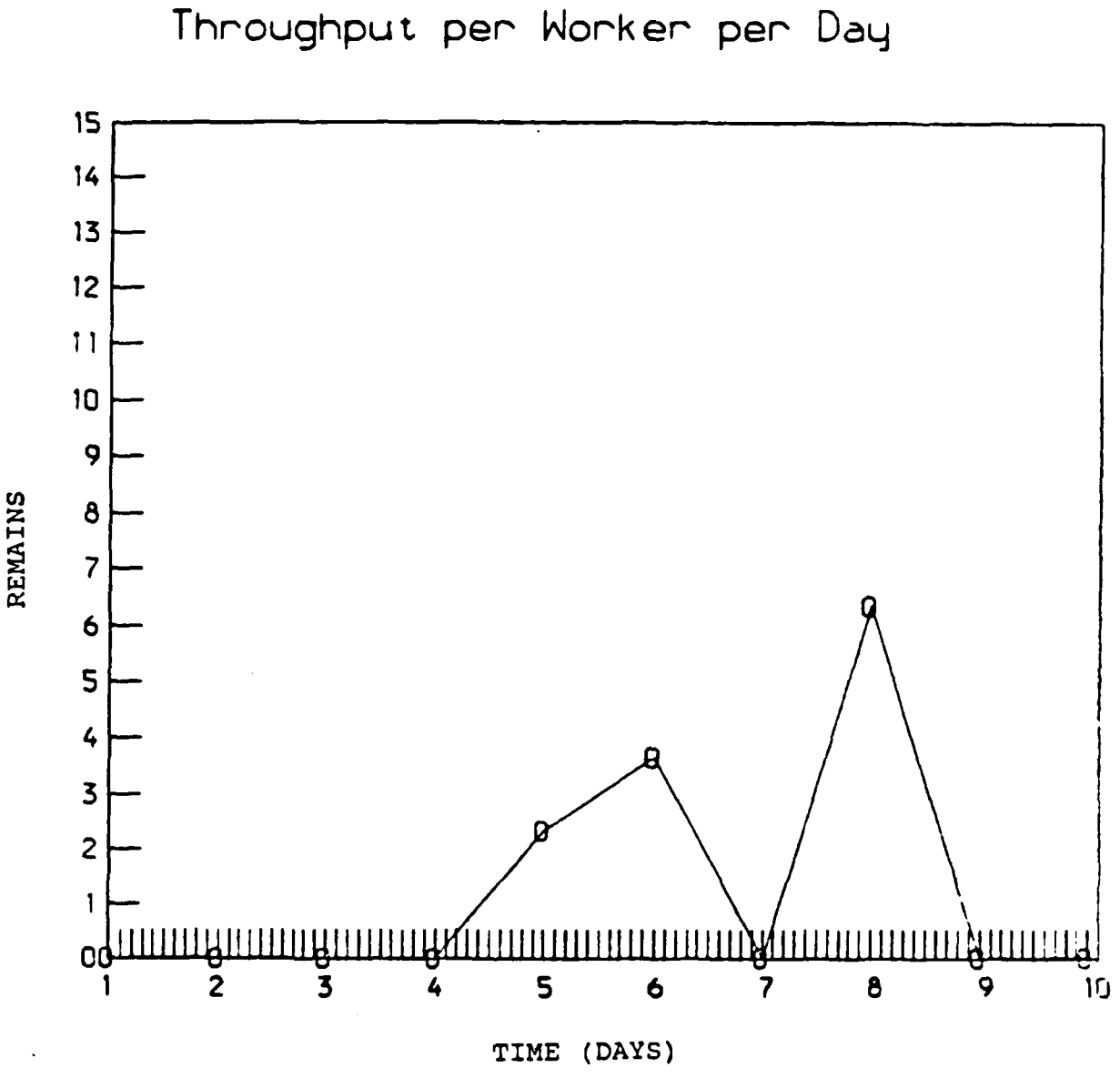

Figure 31. Collection Point 4, SEP BDE, Div 4, Throughput

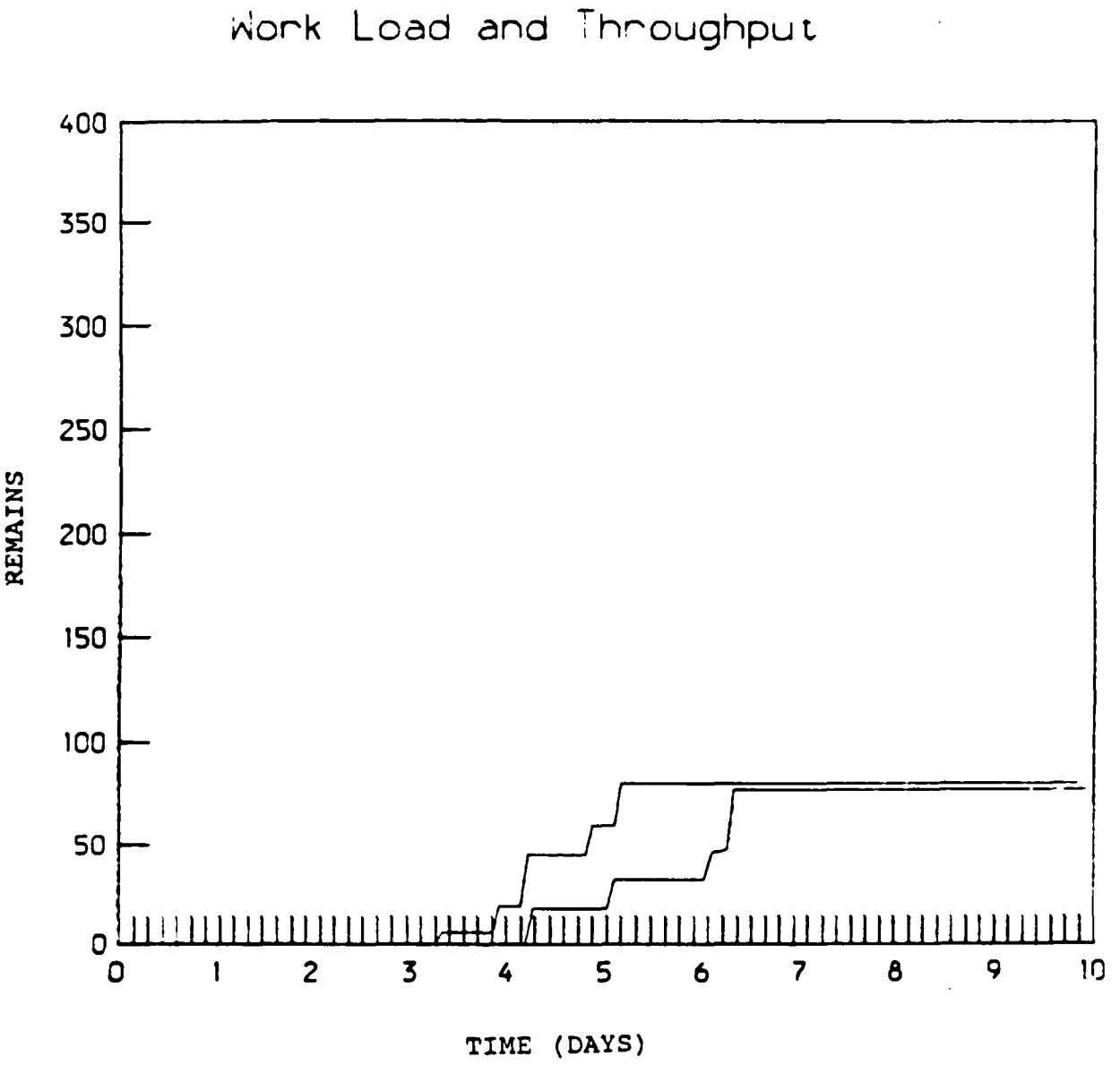

Figure 32. Collection Point 1, BDE, Div 5, Backlog

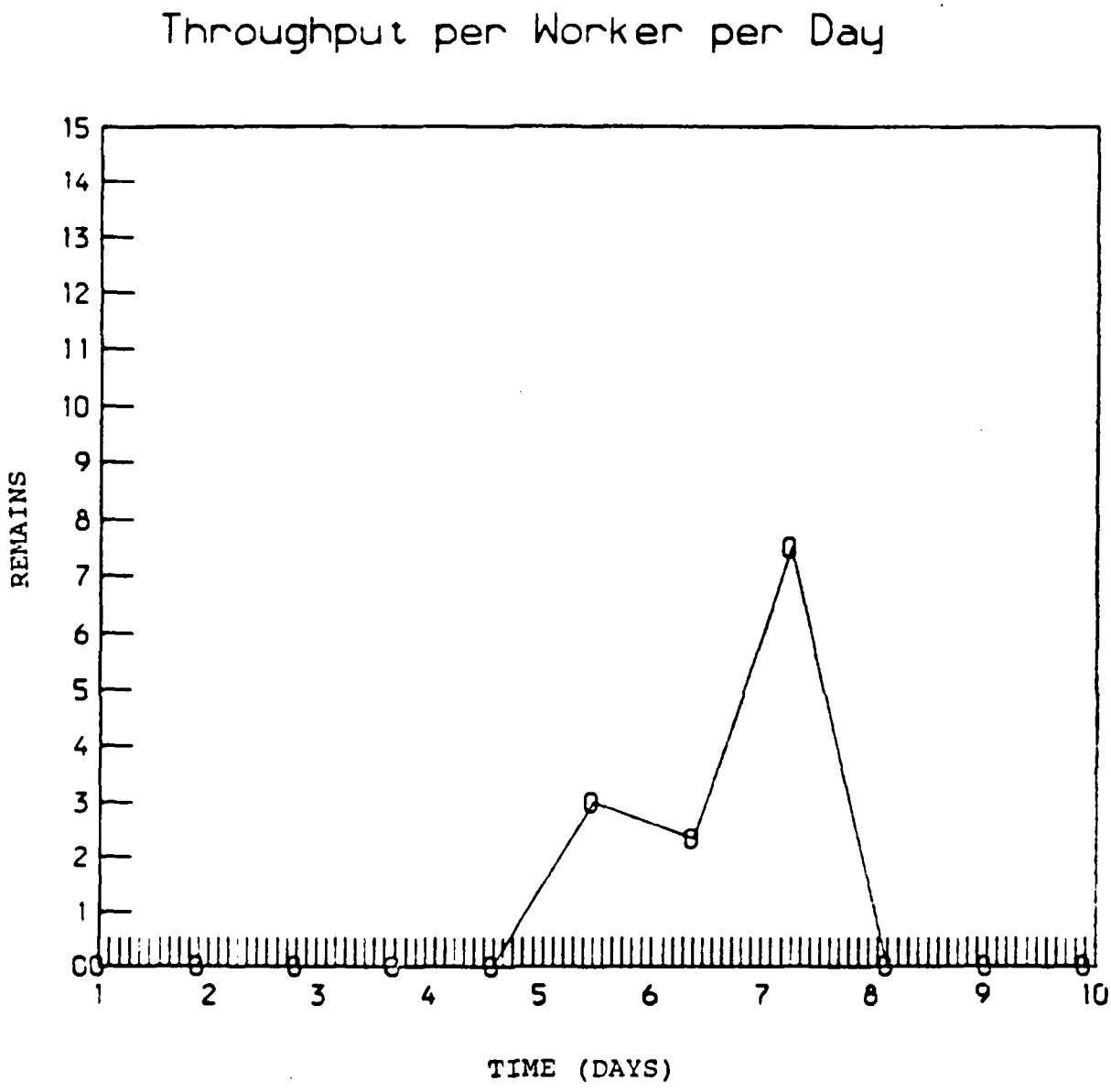

Figure 33. Collection Point 1, BDE, Div 5, Throughput

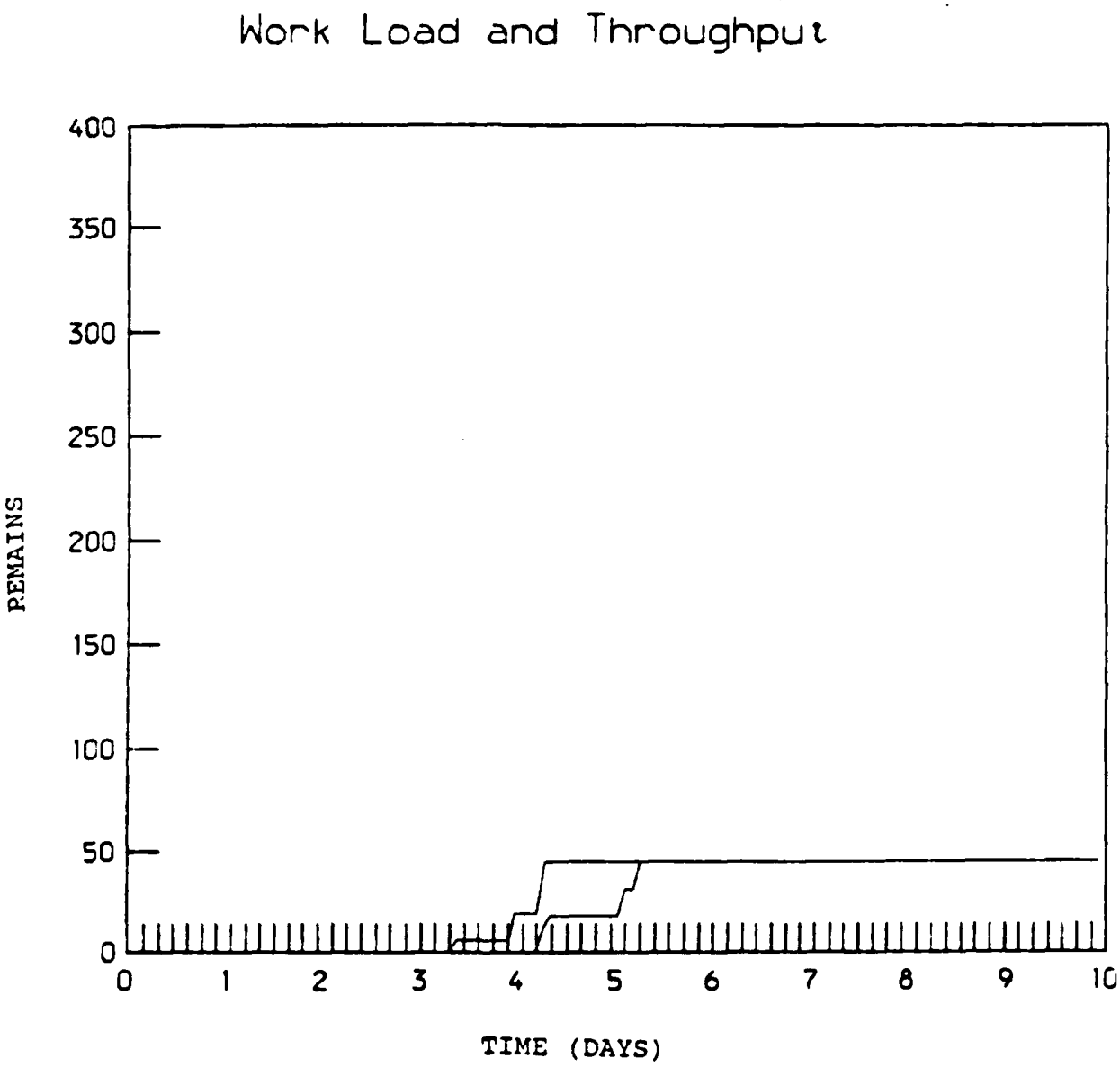

Figure 34. Collection Point 2, BDE, Div 5, Backlog

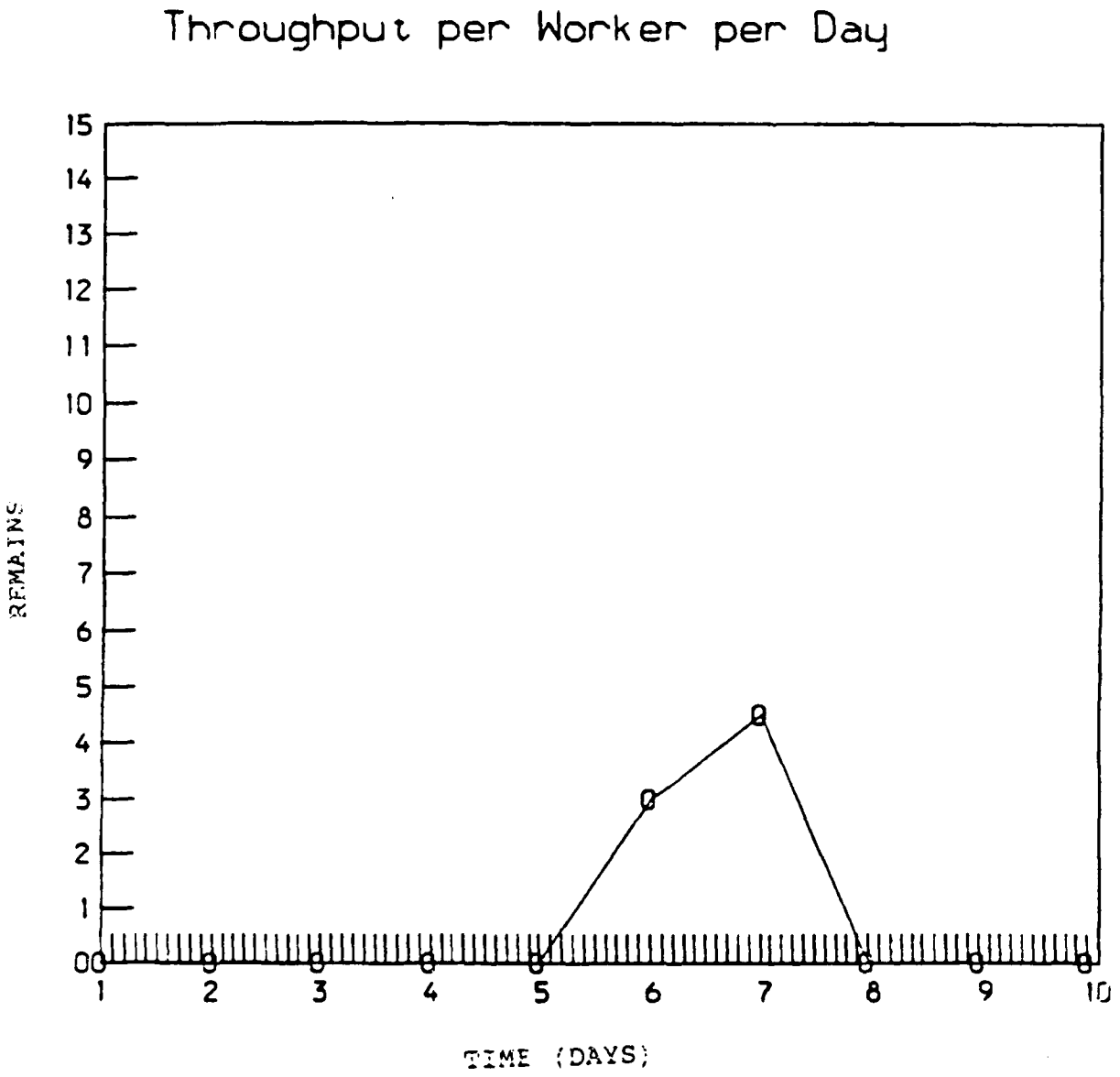

Figure 35. Collection Point 2, BDE, Div 5, Throughput

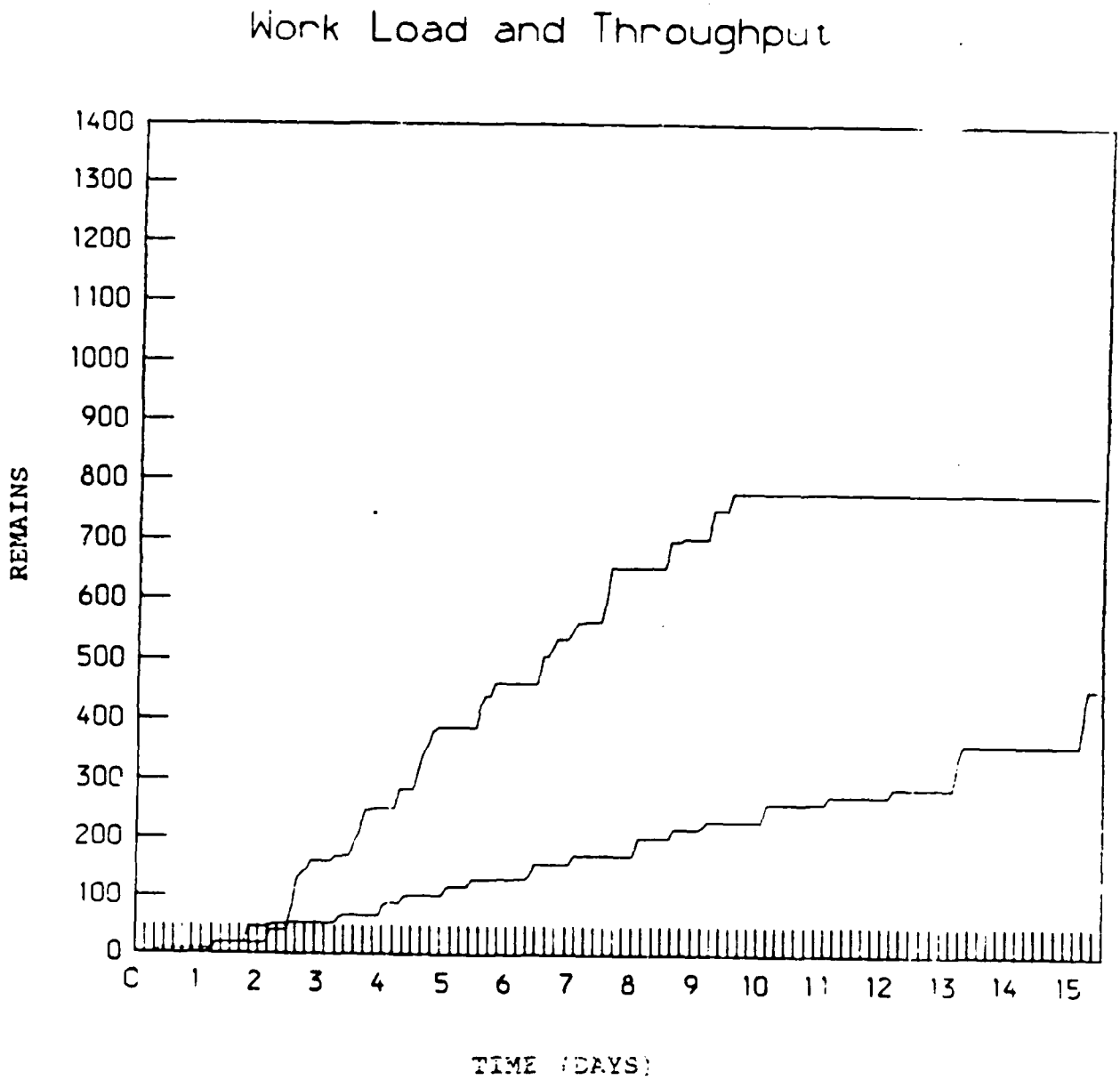

Figure 36. Division Collection Point 1, Backlog

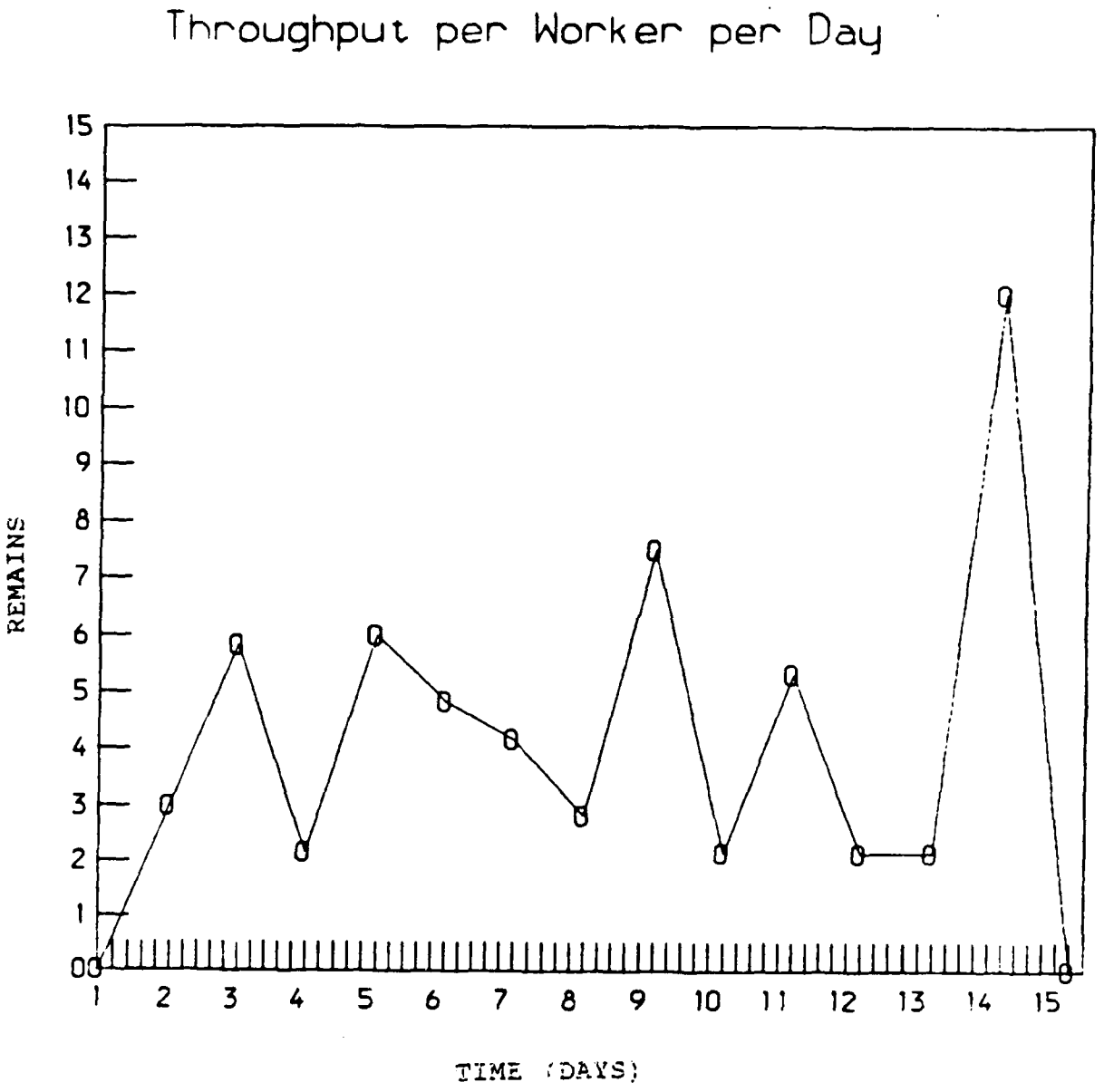

Figure 37. Division Collection Point 1, Throughput

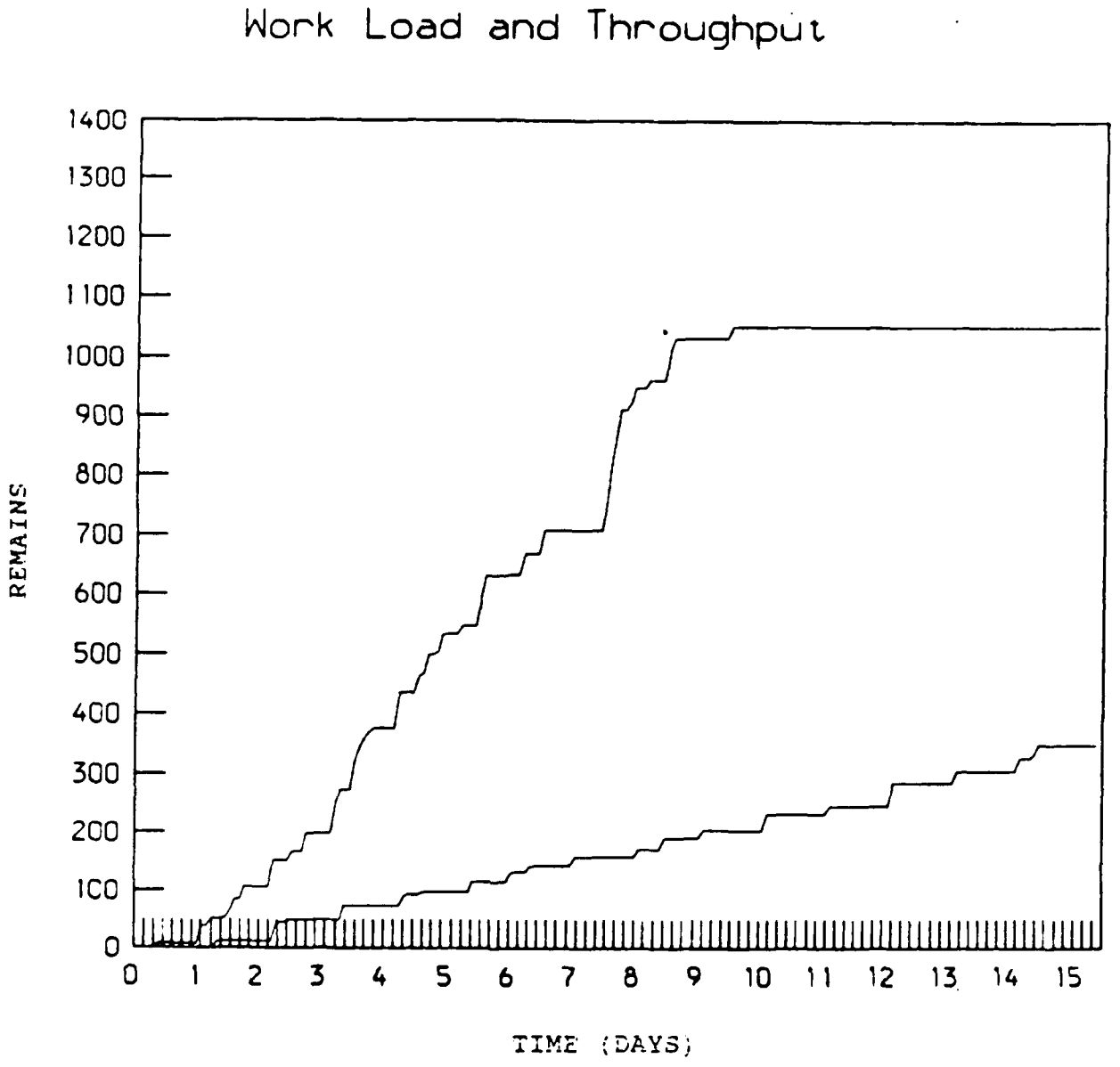

Figure 38. Division Collection Point 3, Backlog

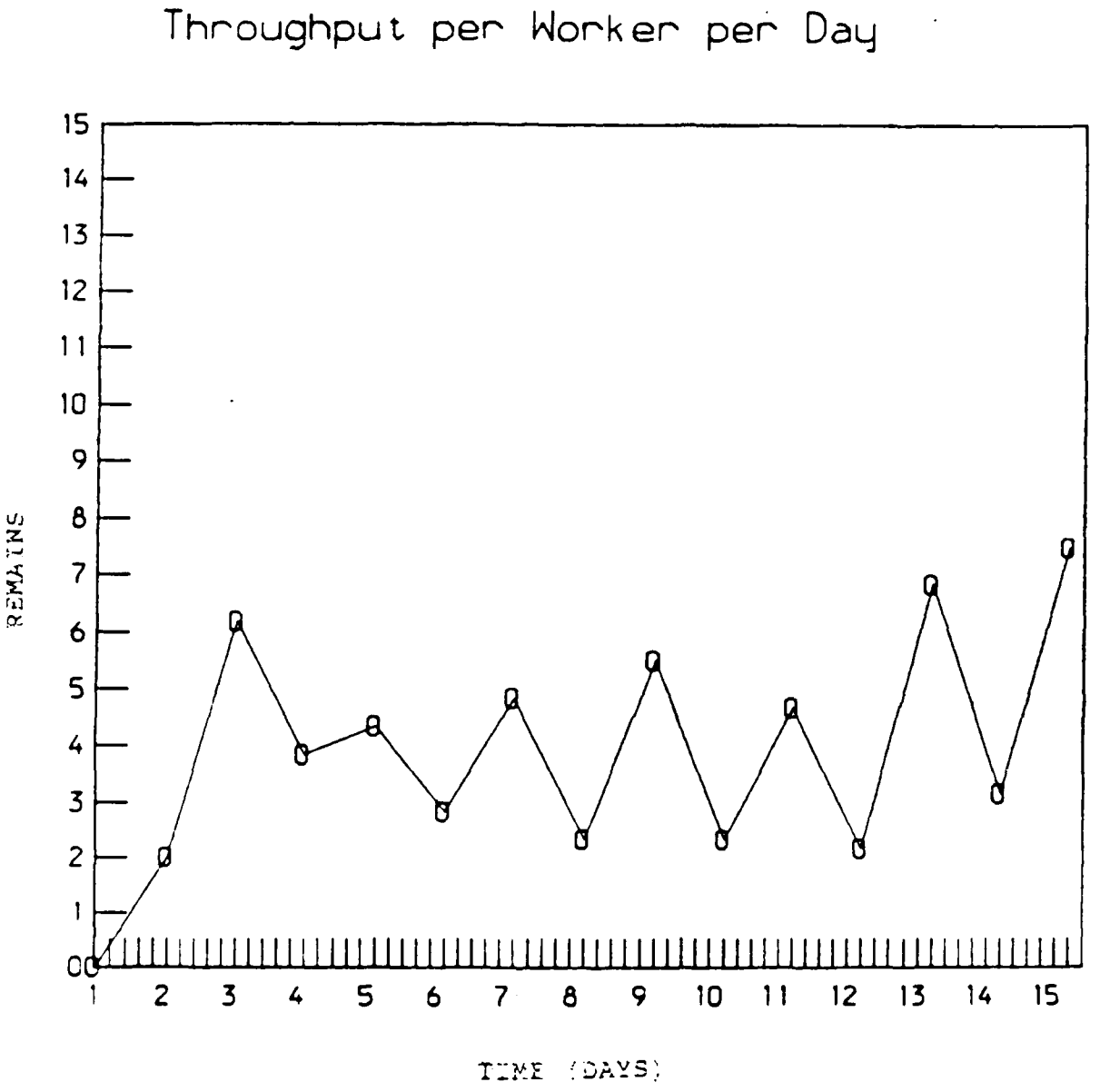

Figure 39. Division Collection Point 3, Throughput

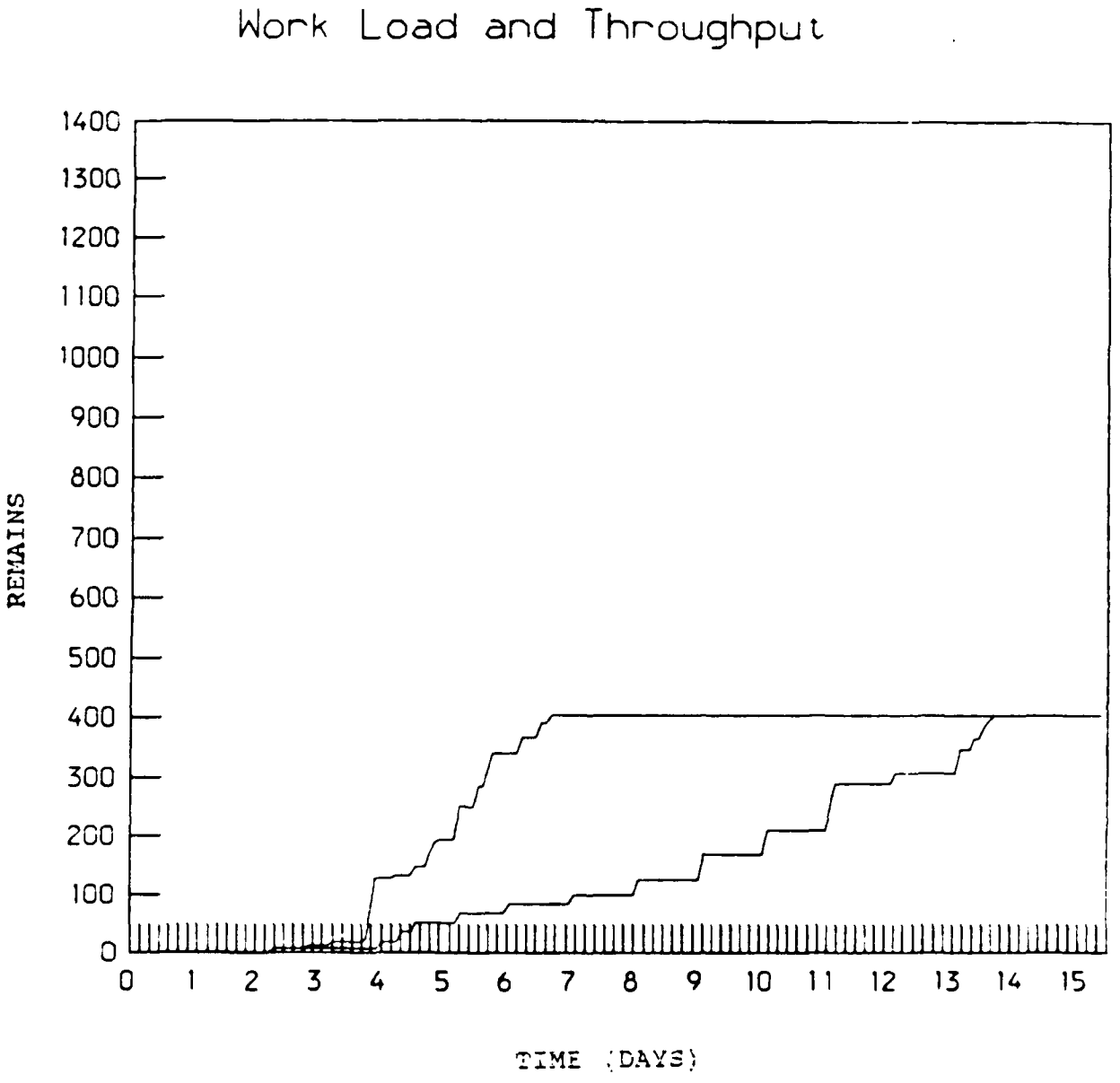

Figure 40. Division Collection Point 4, Backlog

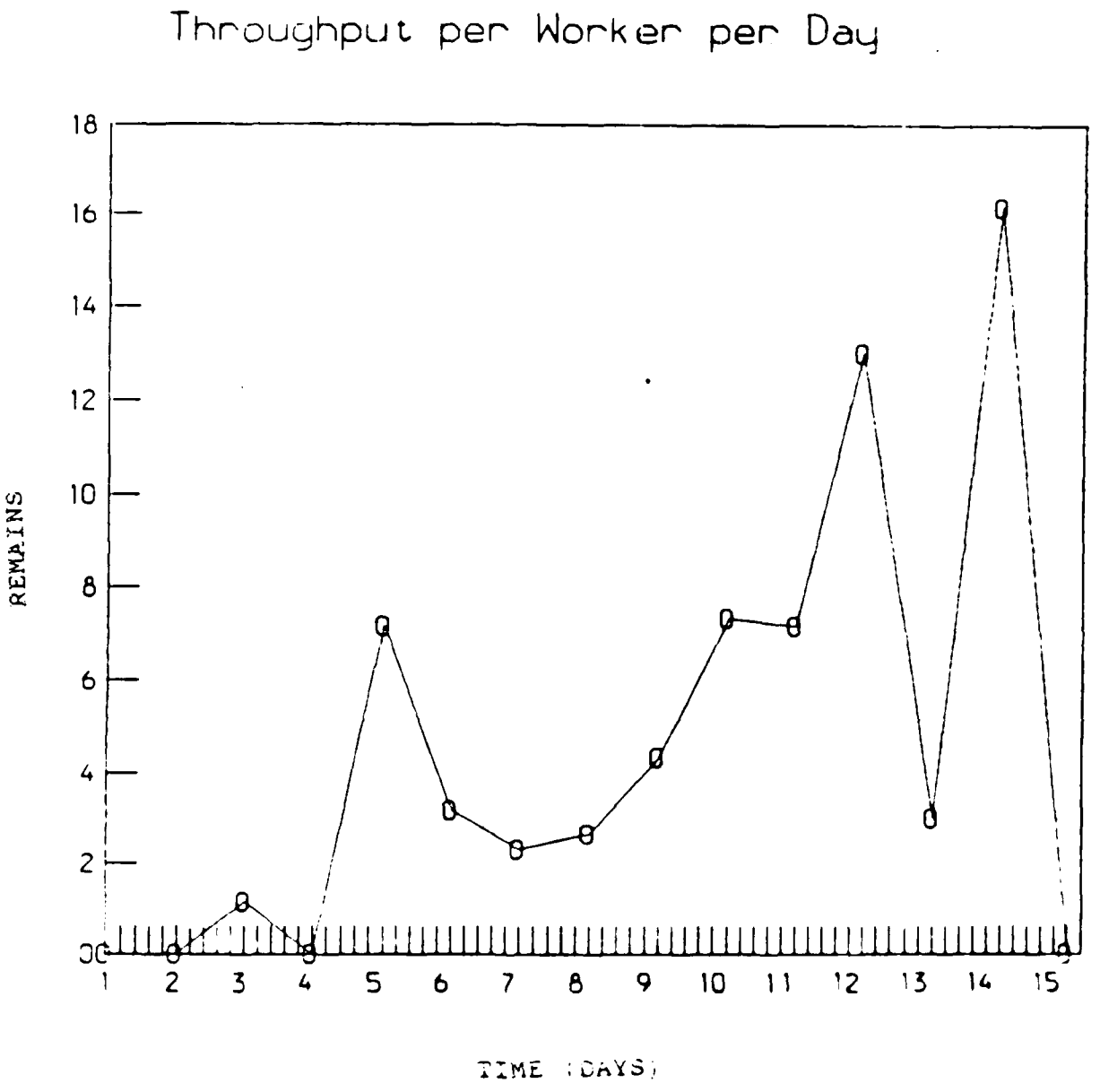

Figure 41. Division Collection Point 4, Throughput

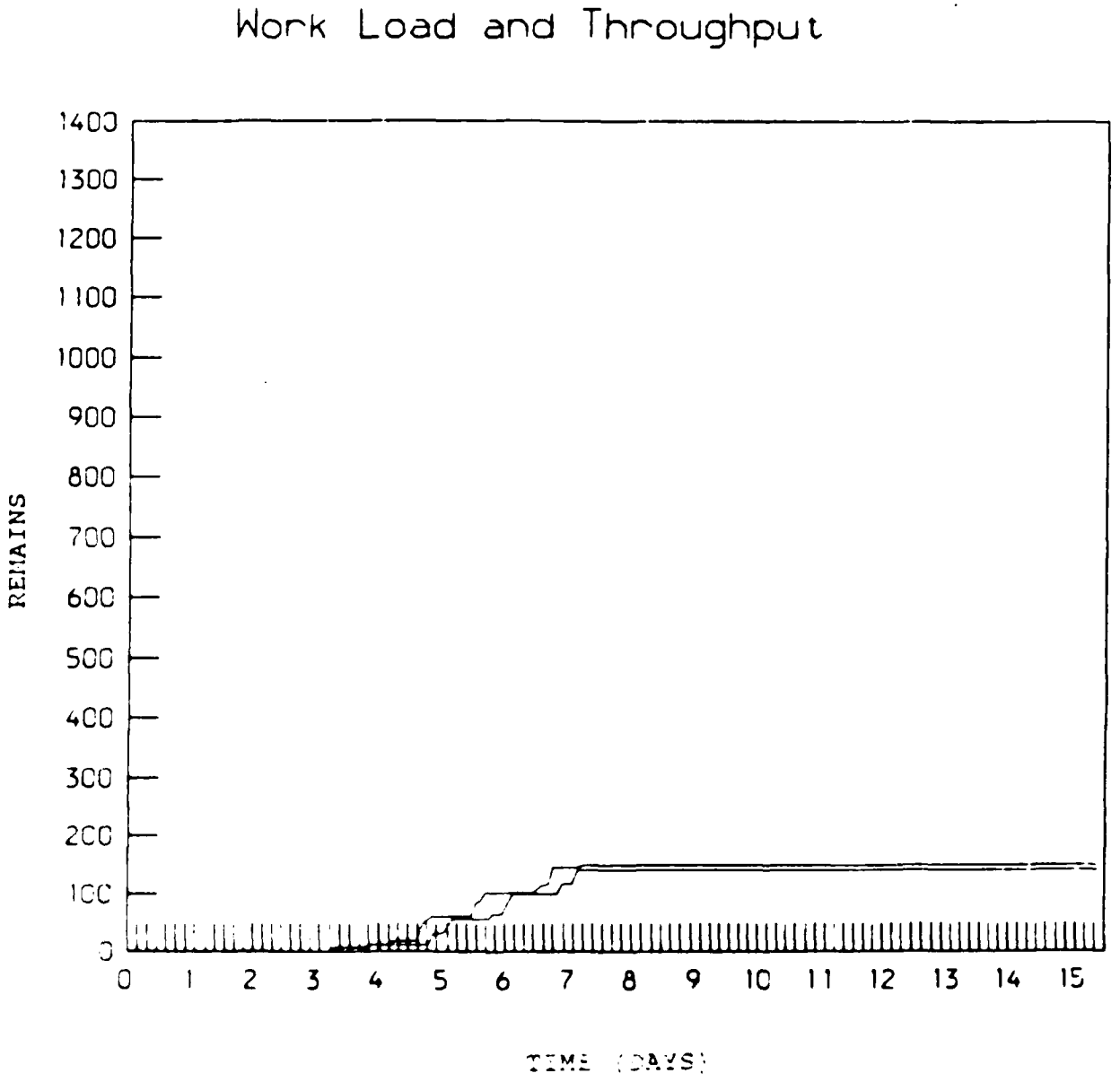

Figure 42. Division Collection Point 5, Backlog

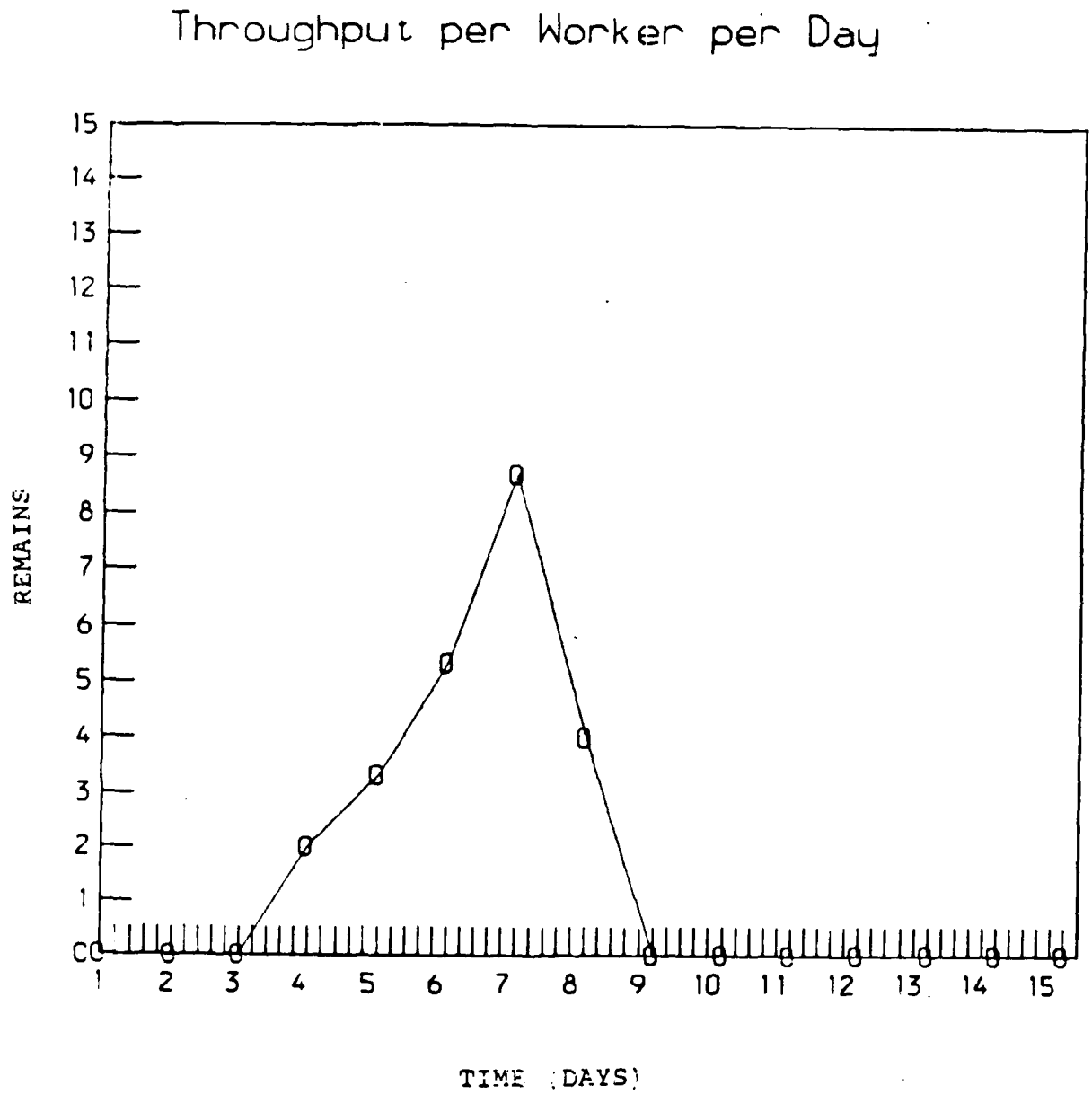

Figure 43. Division Collection Point 5, Throughput

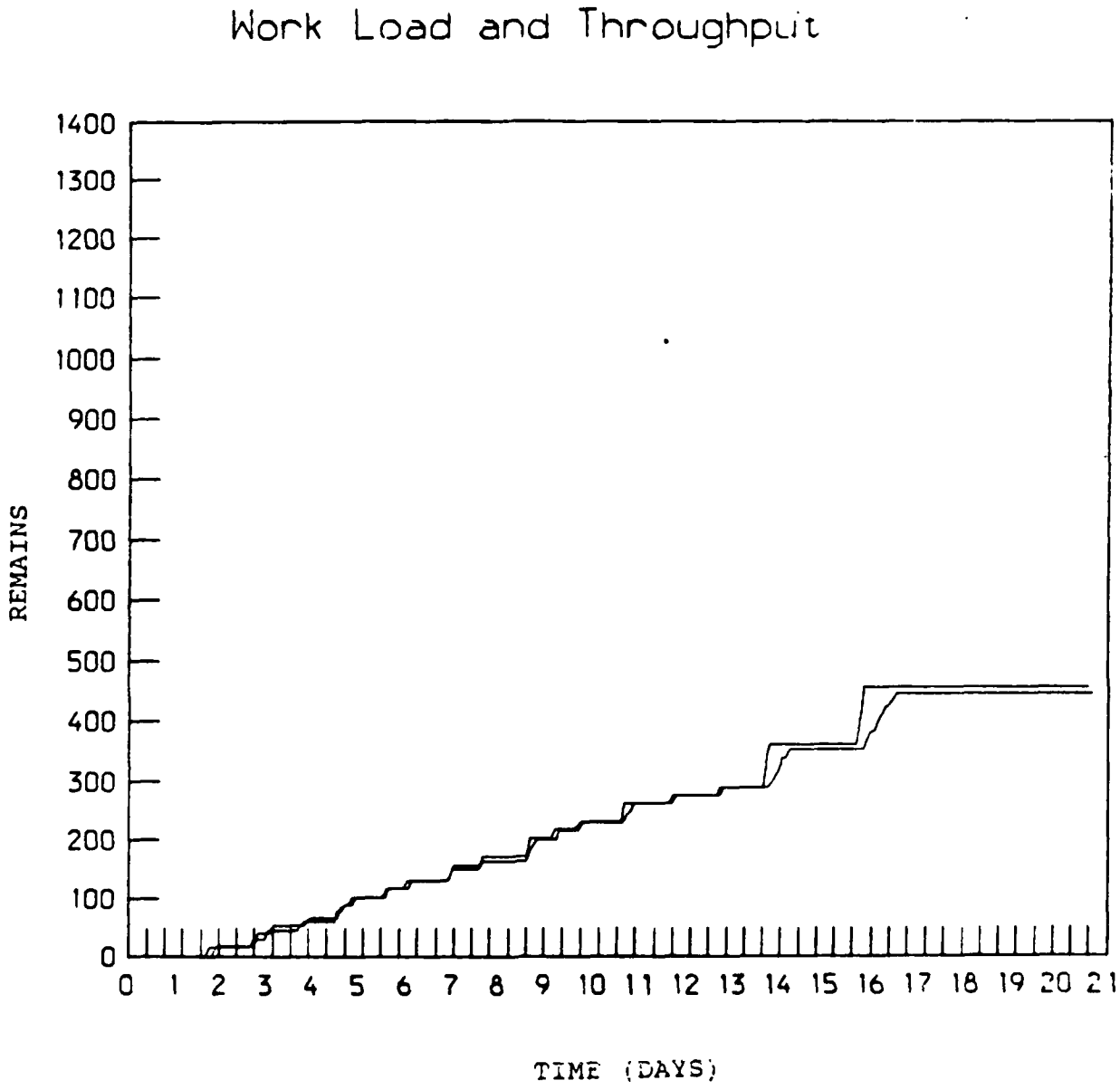

Figure 44. Corps Collection Point 1, Backlog

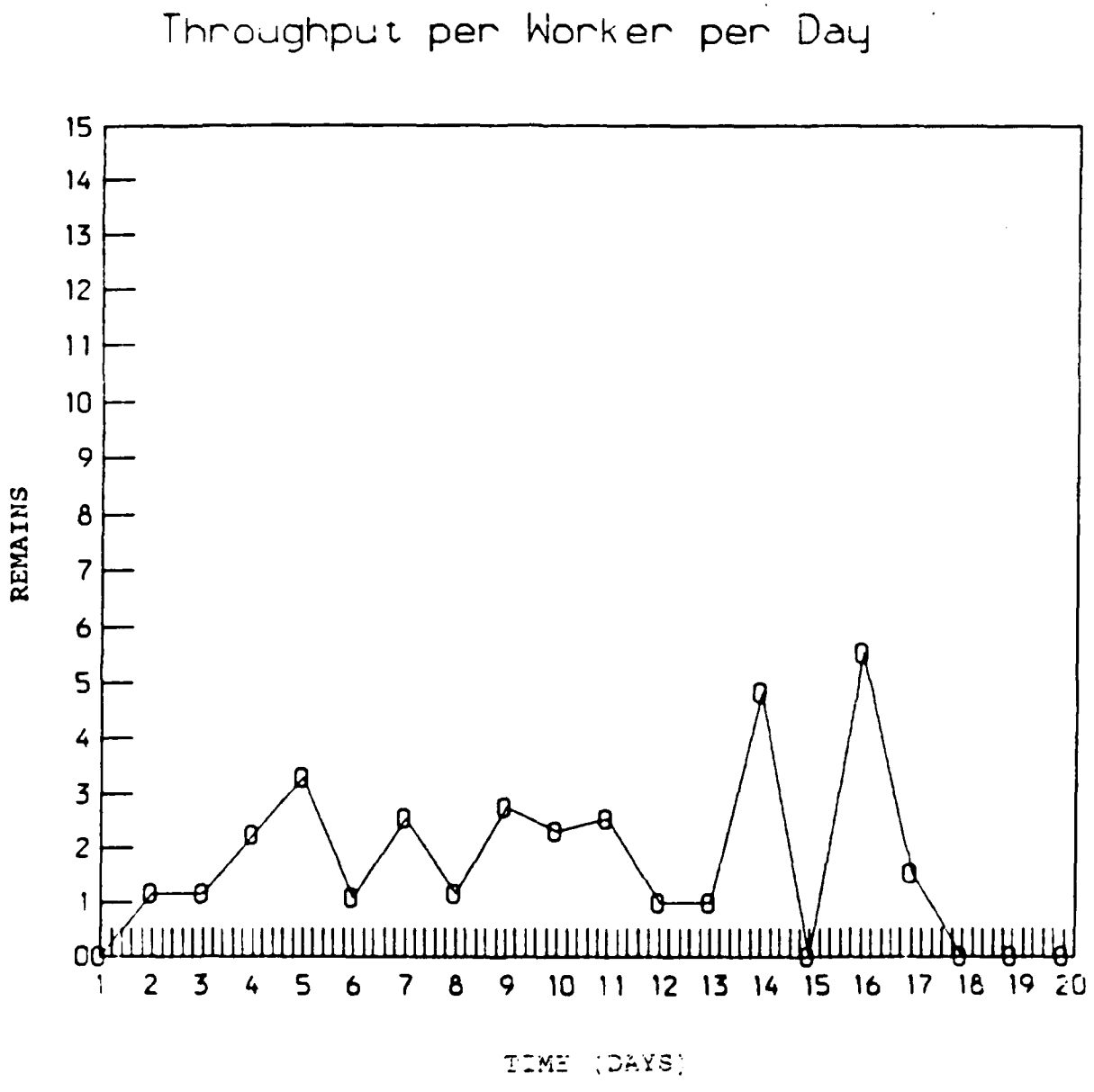

Figure 45. Corps Collection Point 1, Throughput

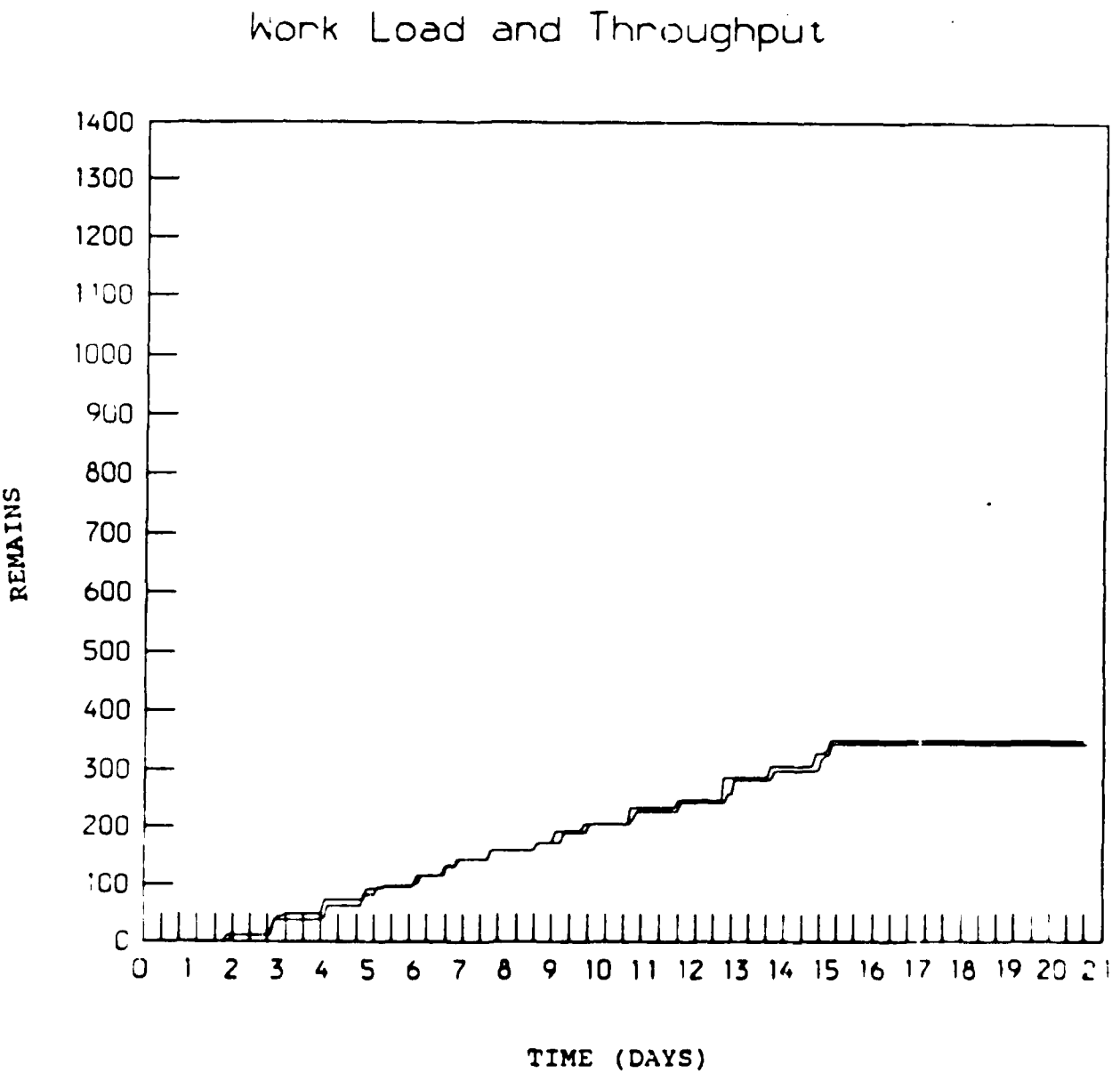

Figure 46. Corps Collection Point 2, Backlog

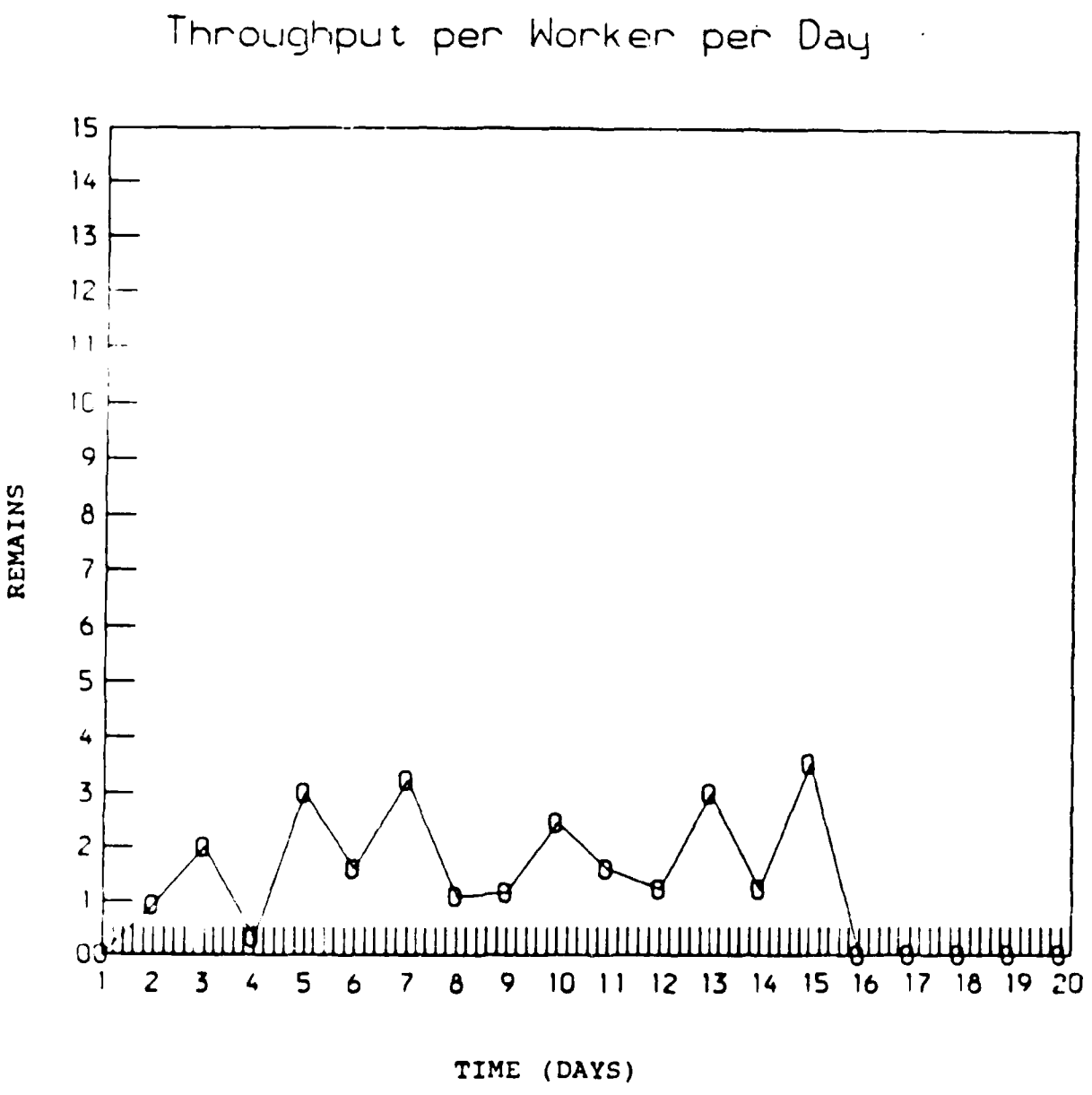

Figure 47. Corps Collection Point 2, Throughput

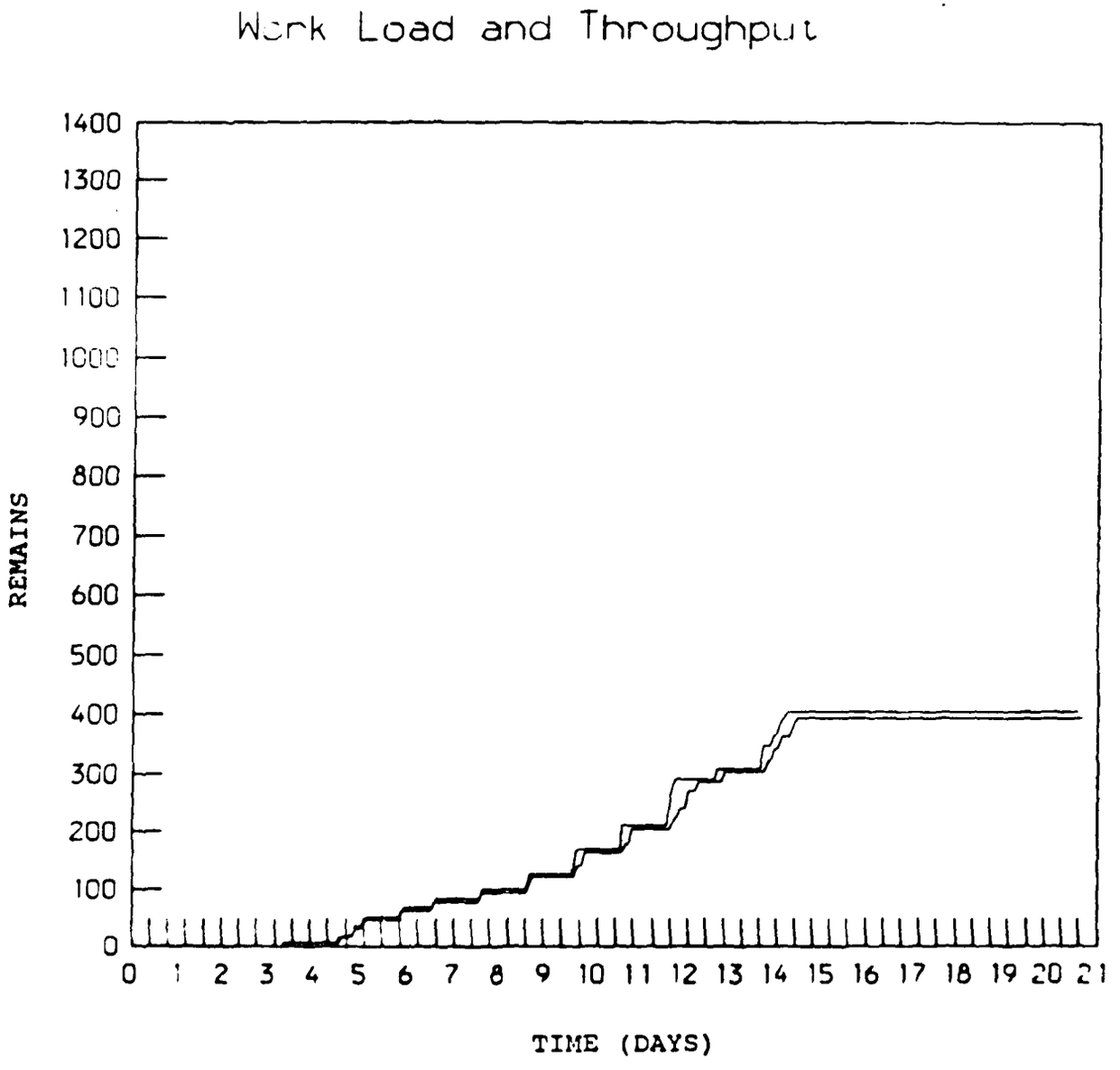

Figure 48. Corps Collection Point 3, Backlog

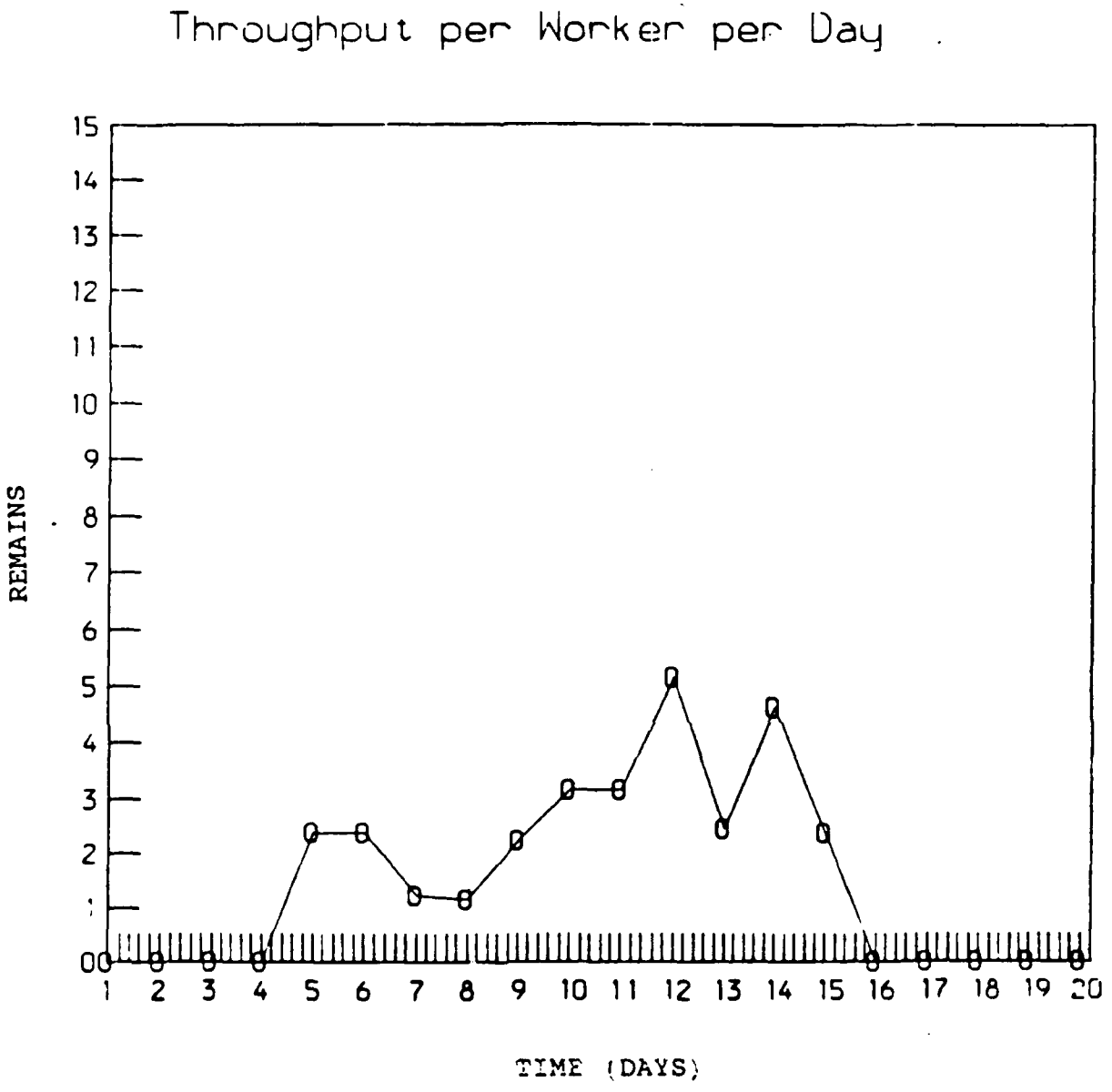

Figure 49. Corps Collection Point 3, Throughput

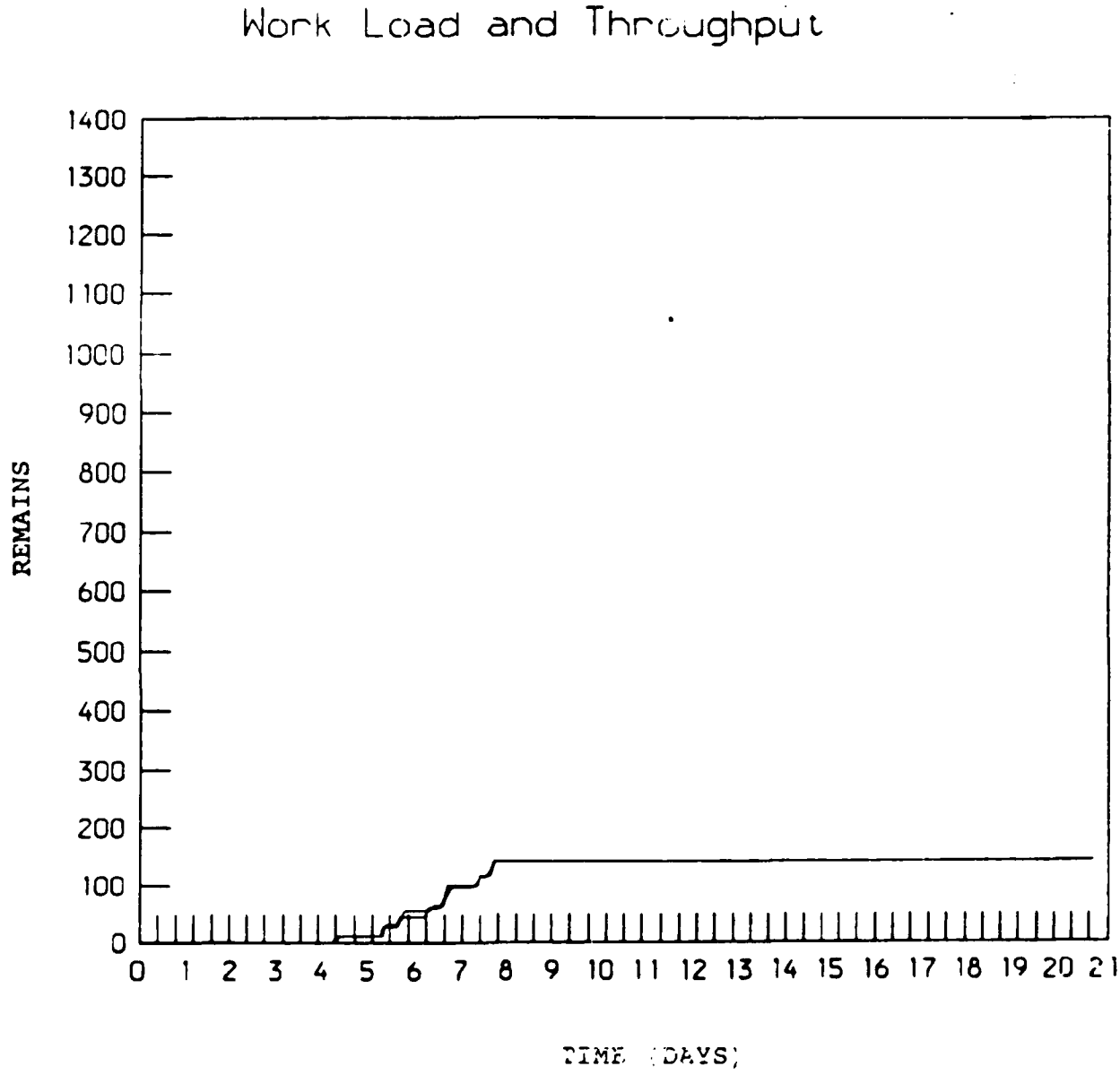

Figure 50. Corps Collection Point 4, Backlog

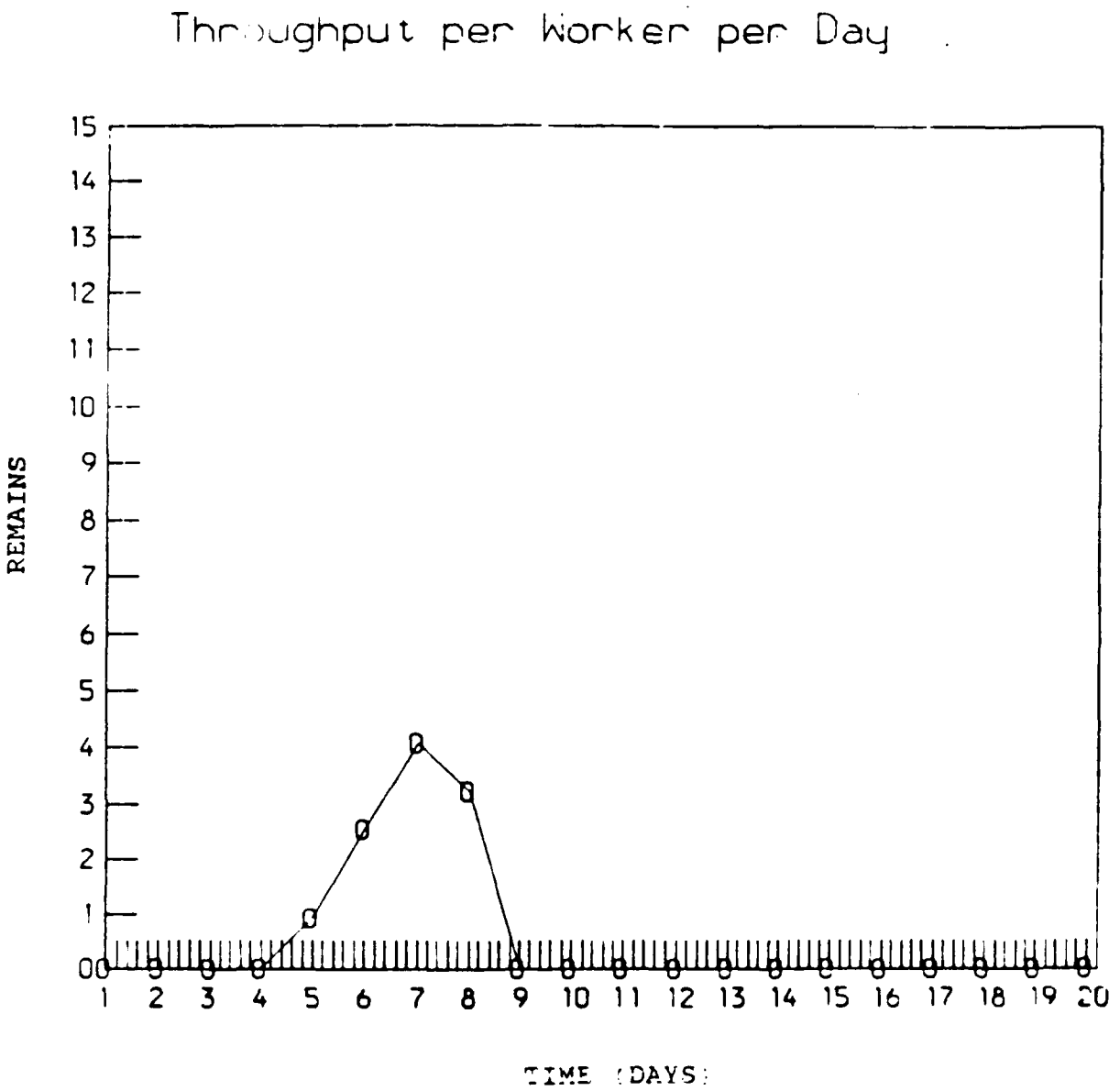

Figure 51. Corps Collection Point 4, Throughput

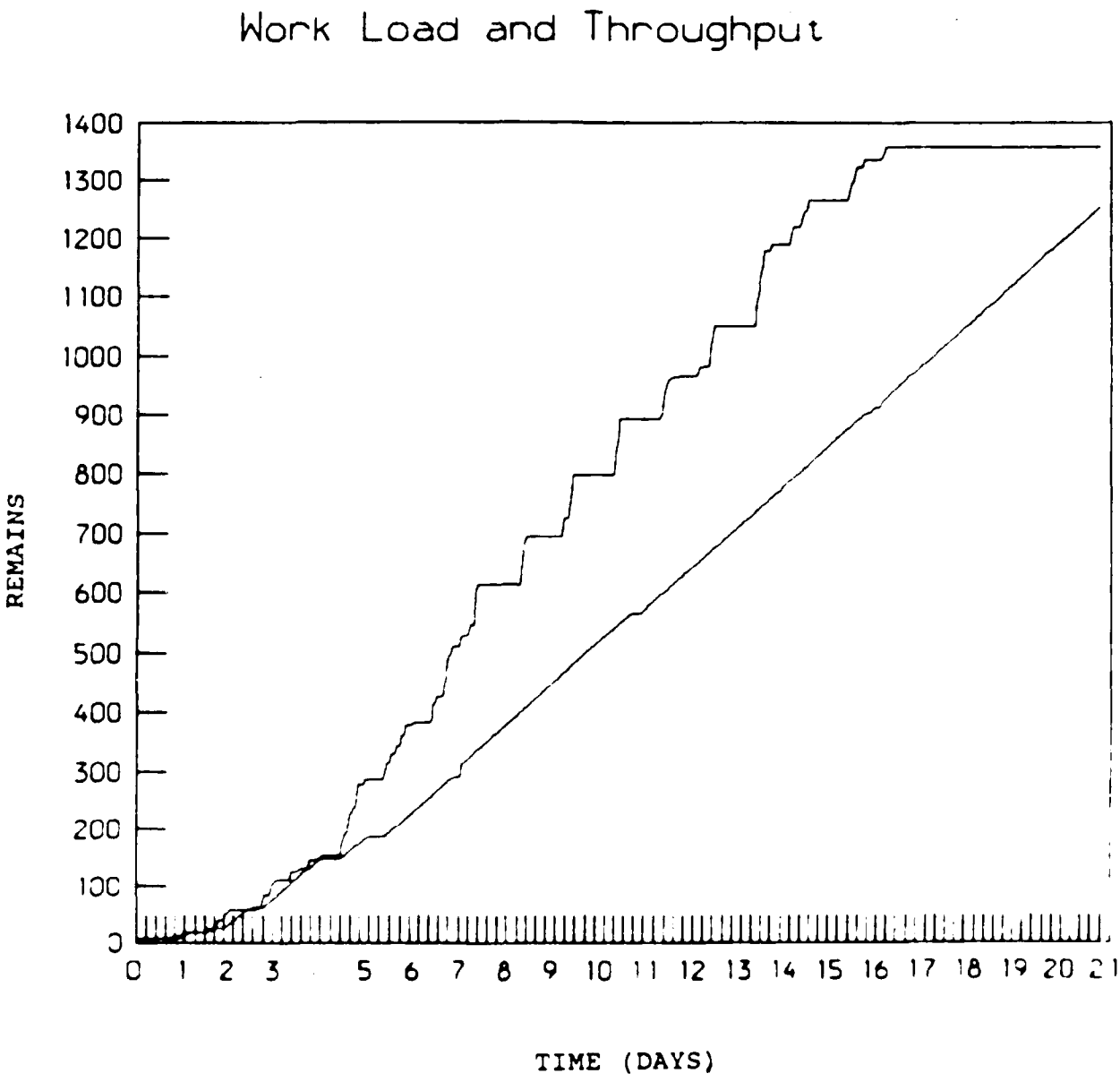

Figure 52. Temporary Cemetery, Backlog

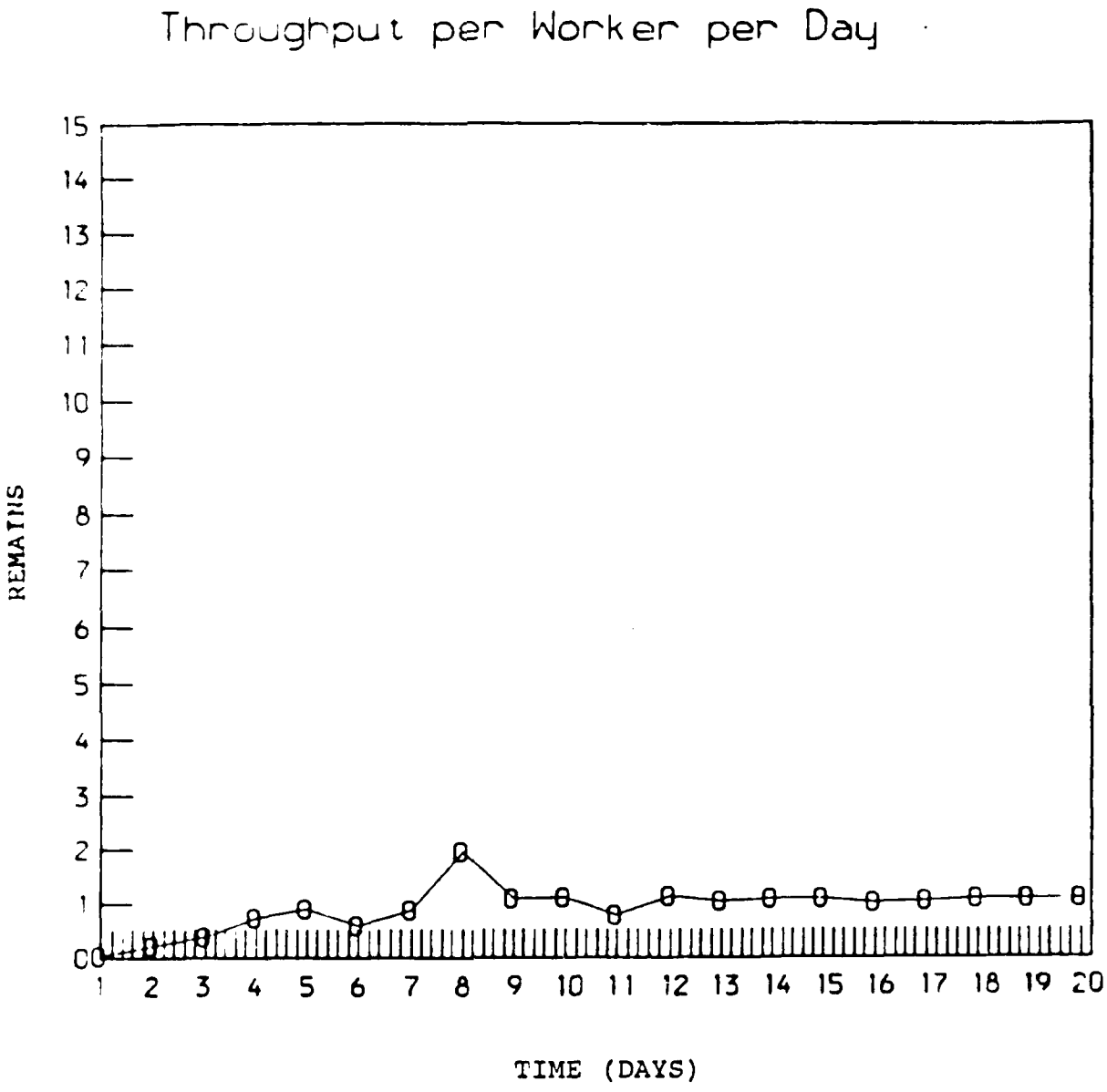

Figure 53. Temporary Cemetery, Throughput

AD-A191 872 GRAVES REGISTRATION SIMULATION(U) ARMY BALLISTIC RESEARCH LAB ABERDEEN PROVING GROUND MD R A HELFMAN ET AL NOV 87 BRL-TR-2865 2/2

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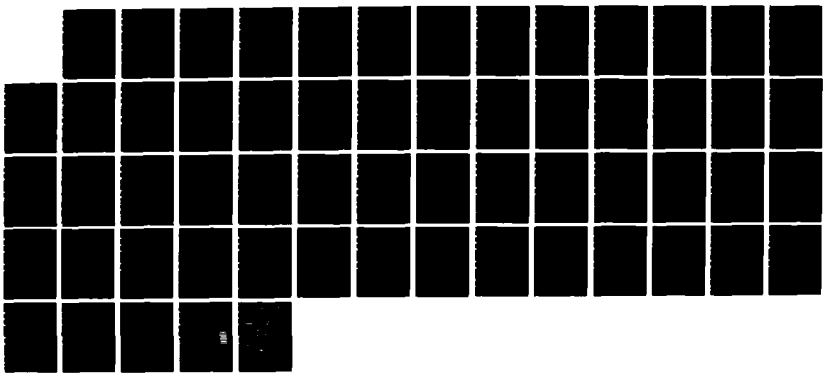
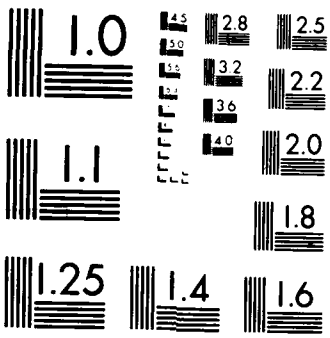



1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

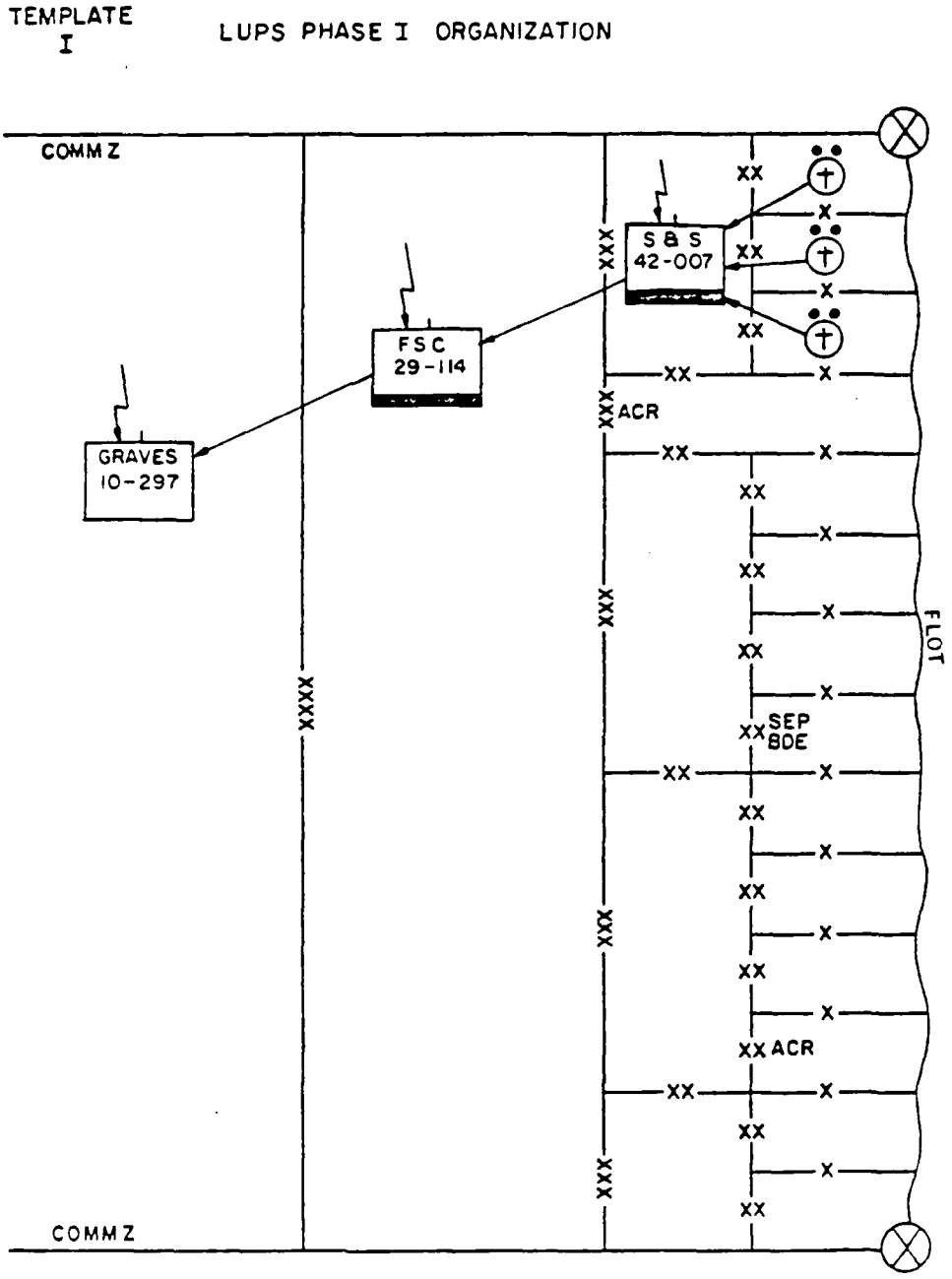


Figure 54. LUPS I Organization

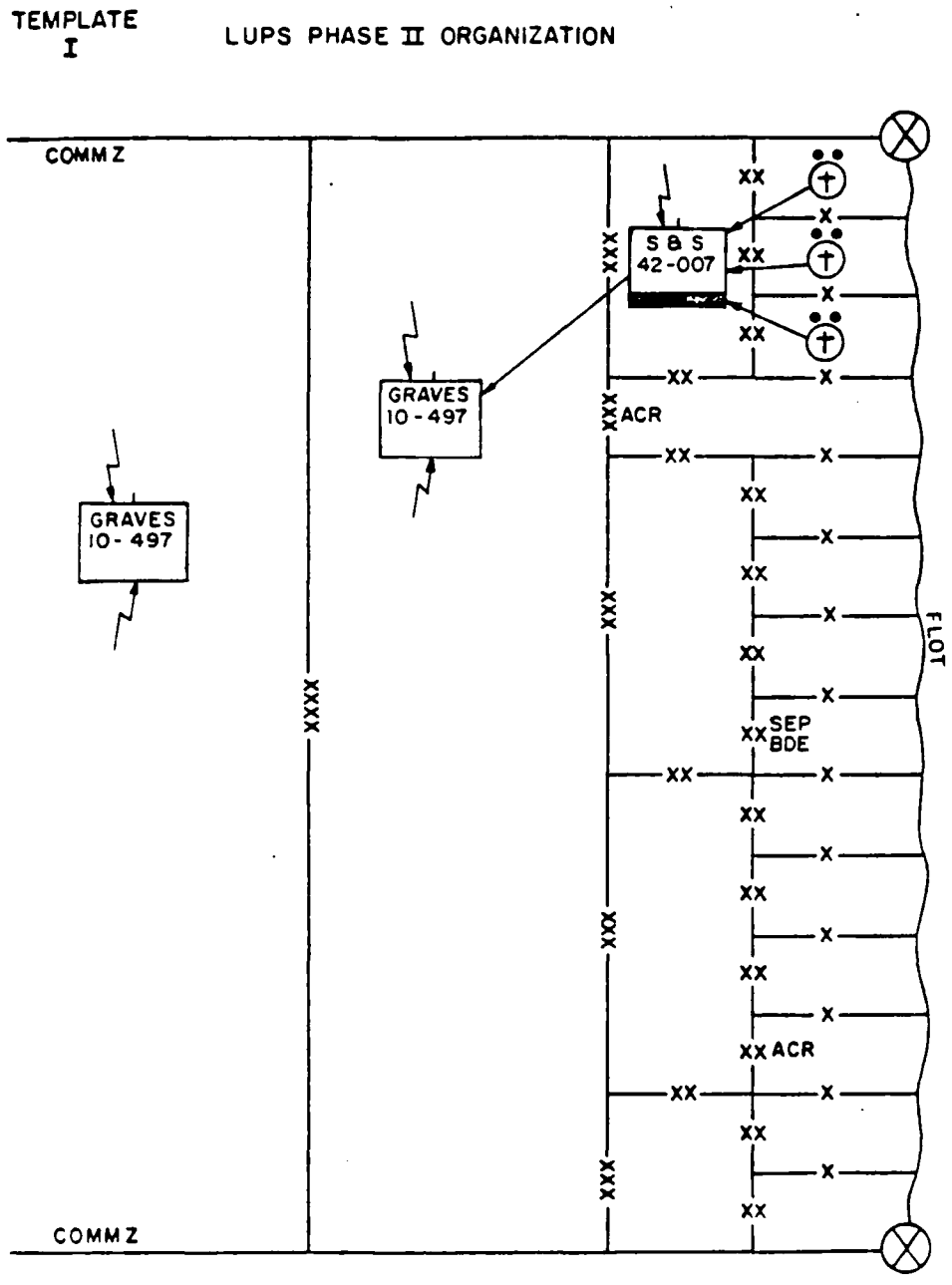


Figure 55. LUPS II Organization

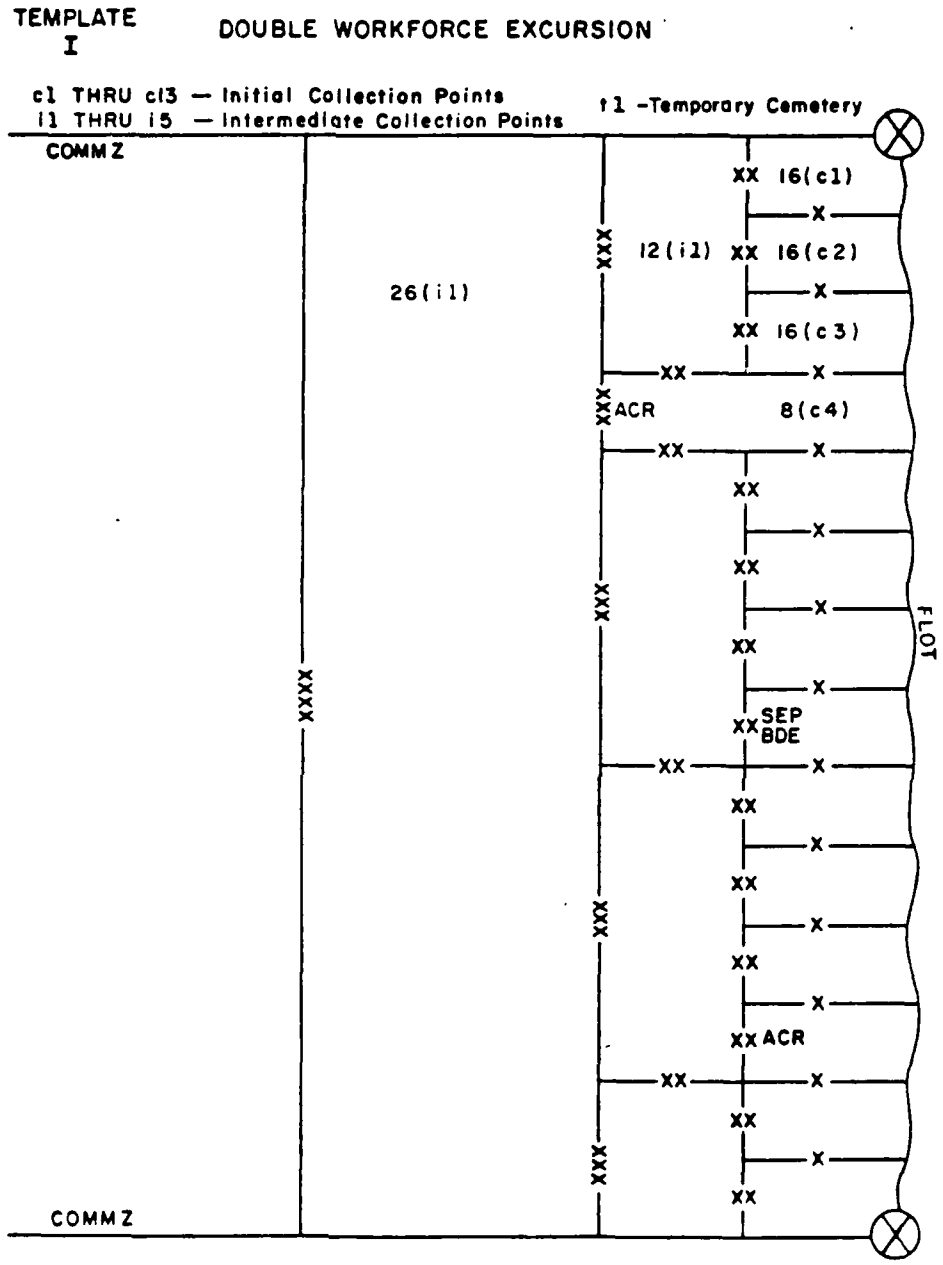


Figure 56. Double the Workforce Organization

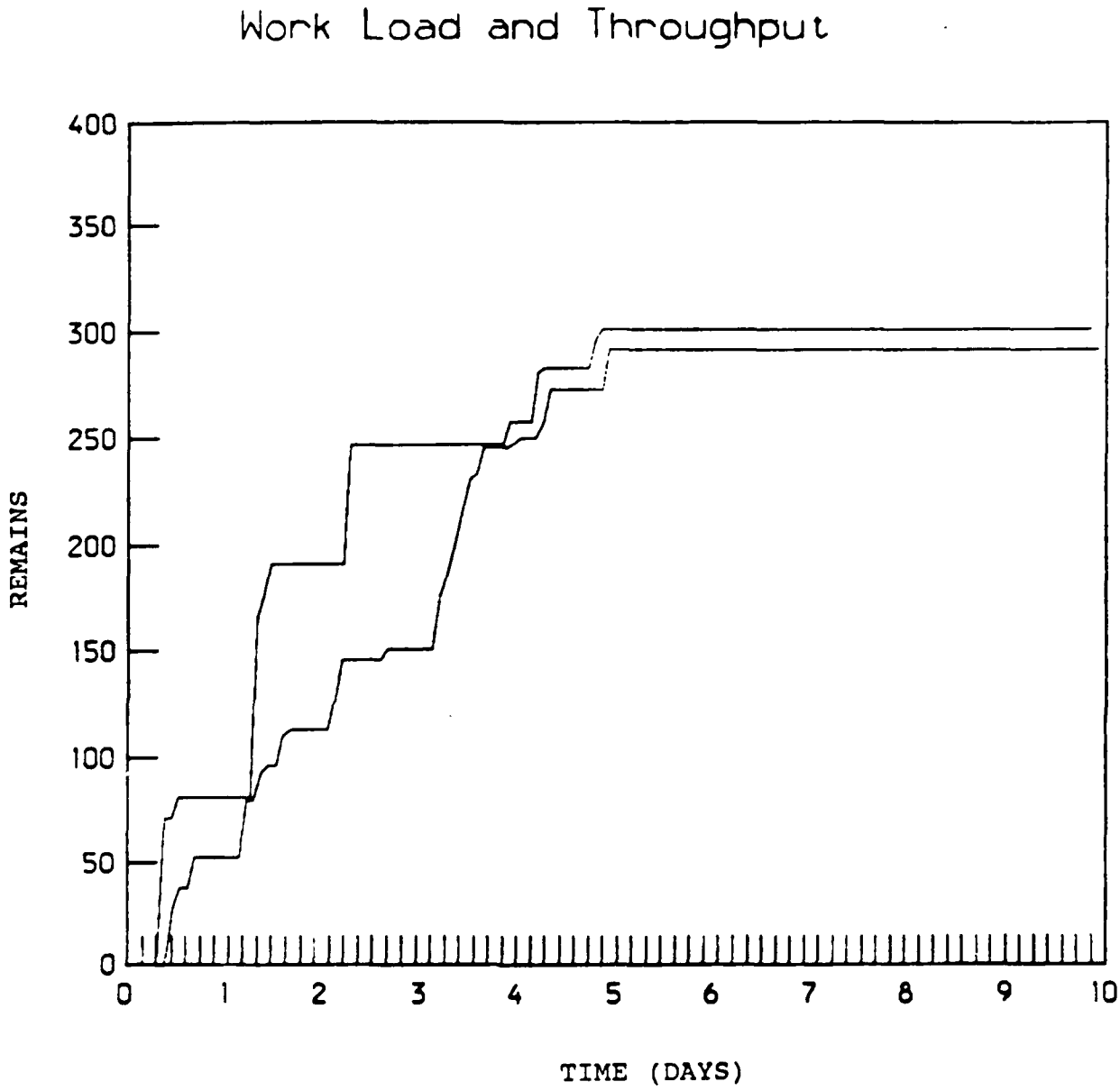


Figure 57. Collection Point 1, BDE, Backlog, Double Workforce

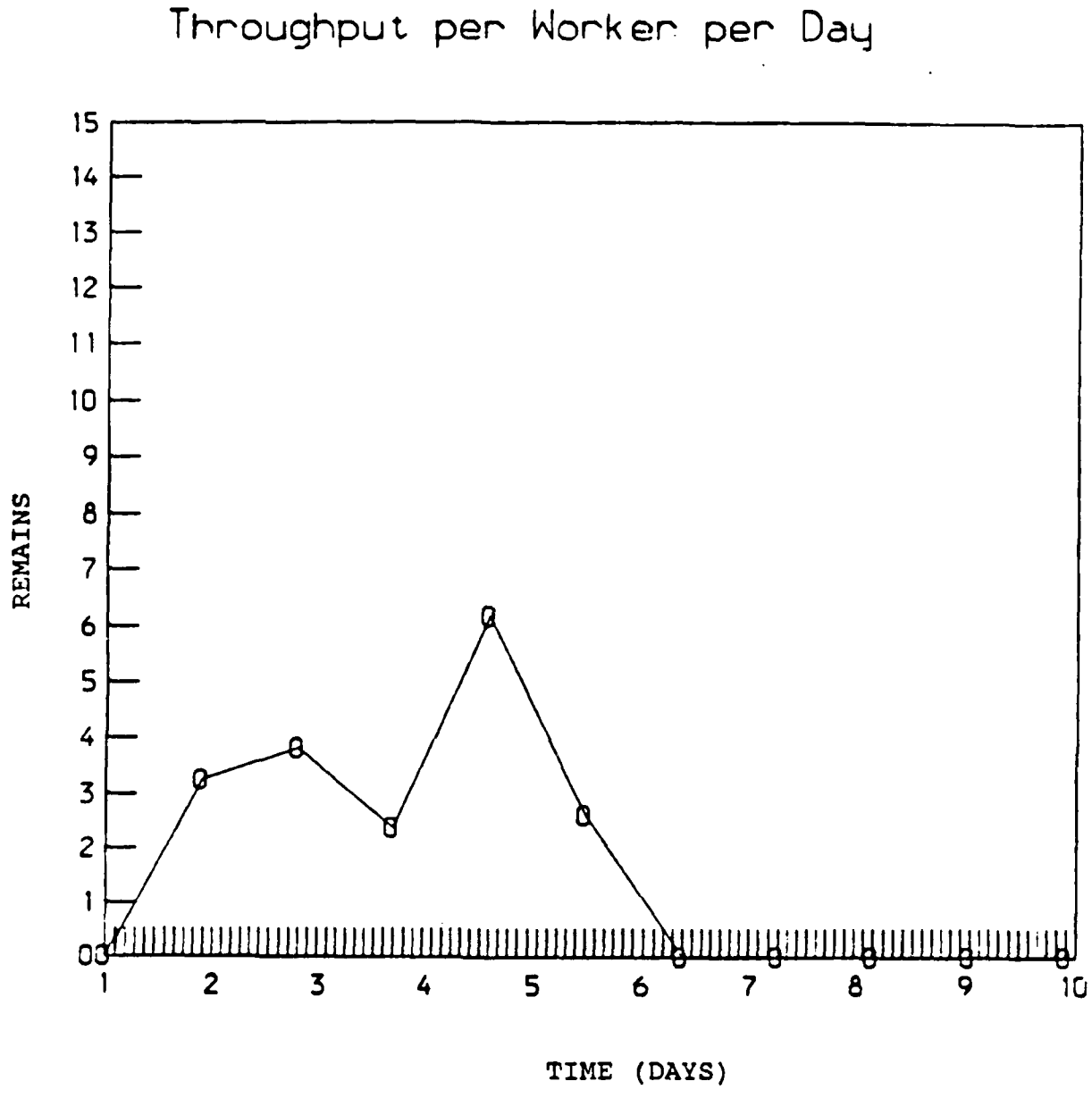


Figure 58. Collection Point 1, BDE, Throughput, Double Workforce

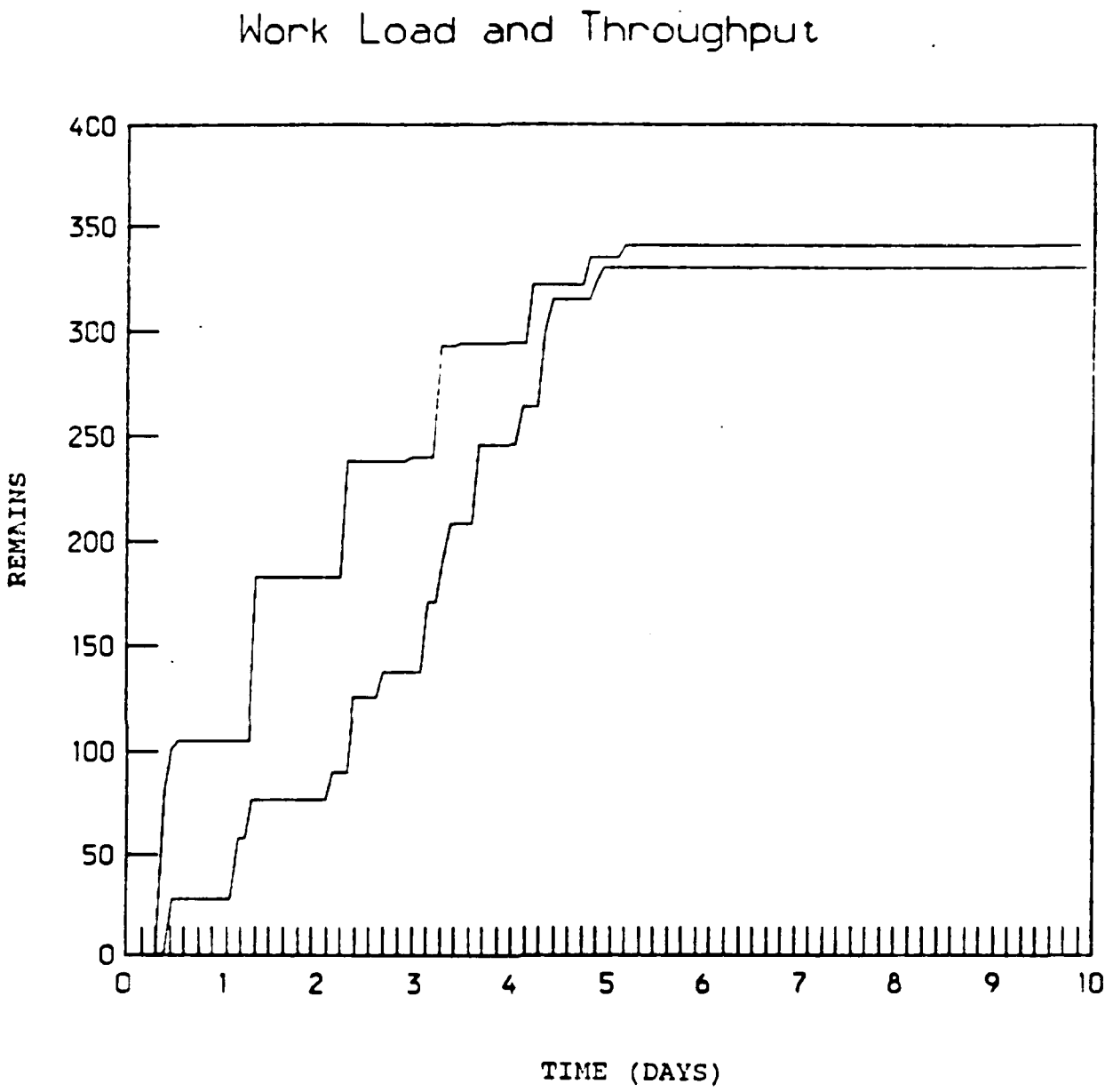


Figure 59. Collection Point 2, BDE, Backlog, Double Workforce

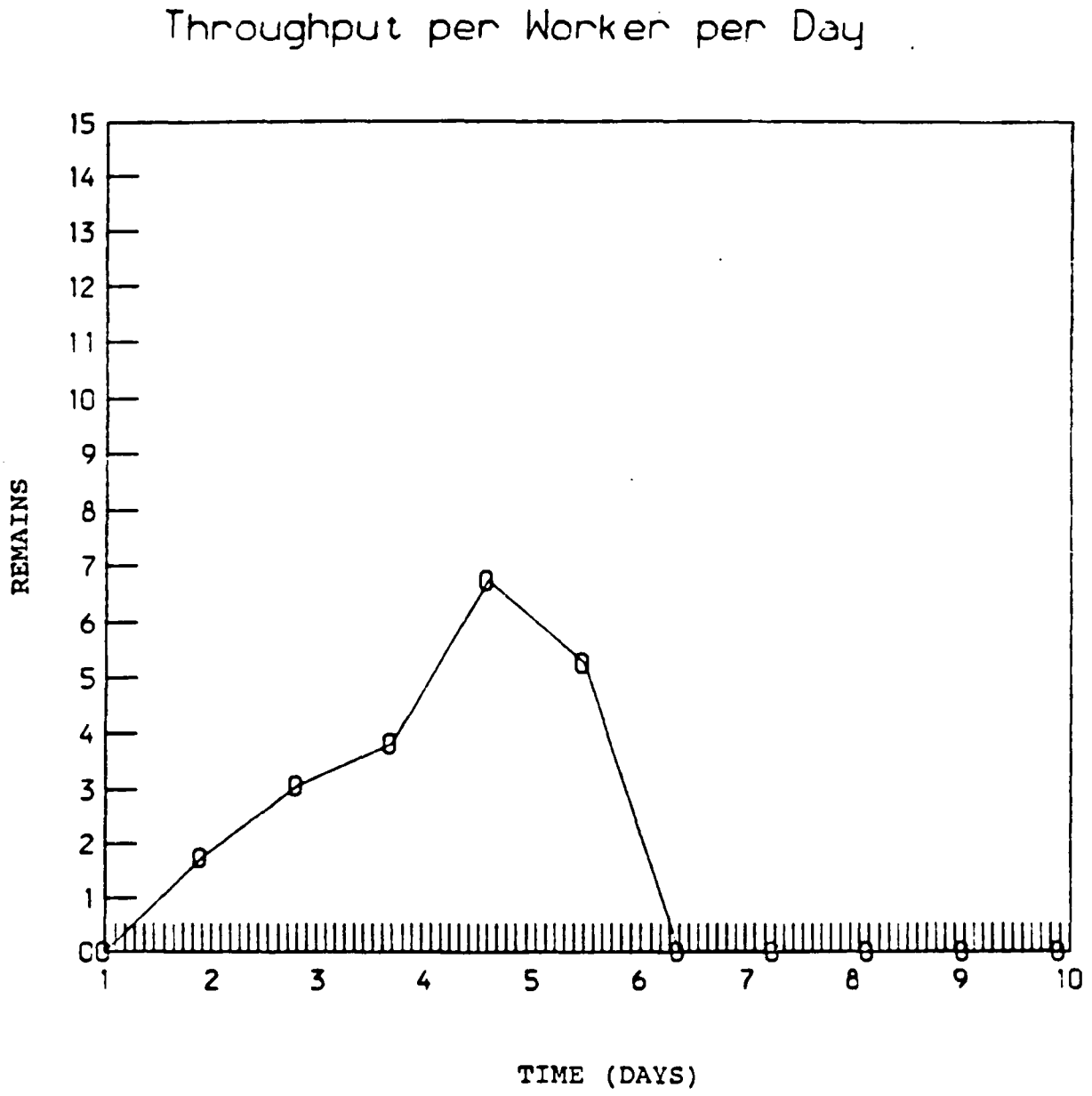


Figure 60. Collection Point 2, BDE, Throughput, Double Workforce

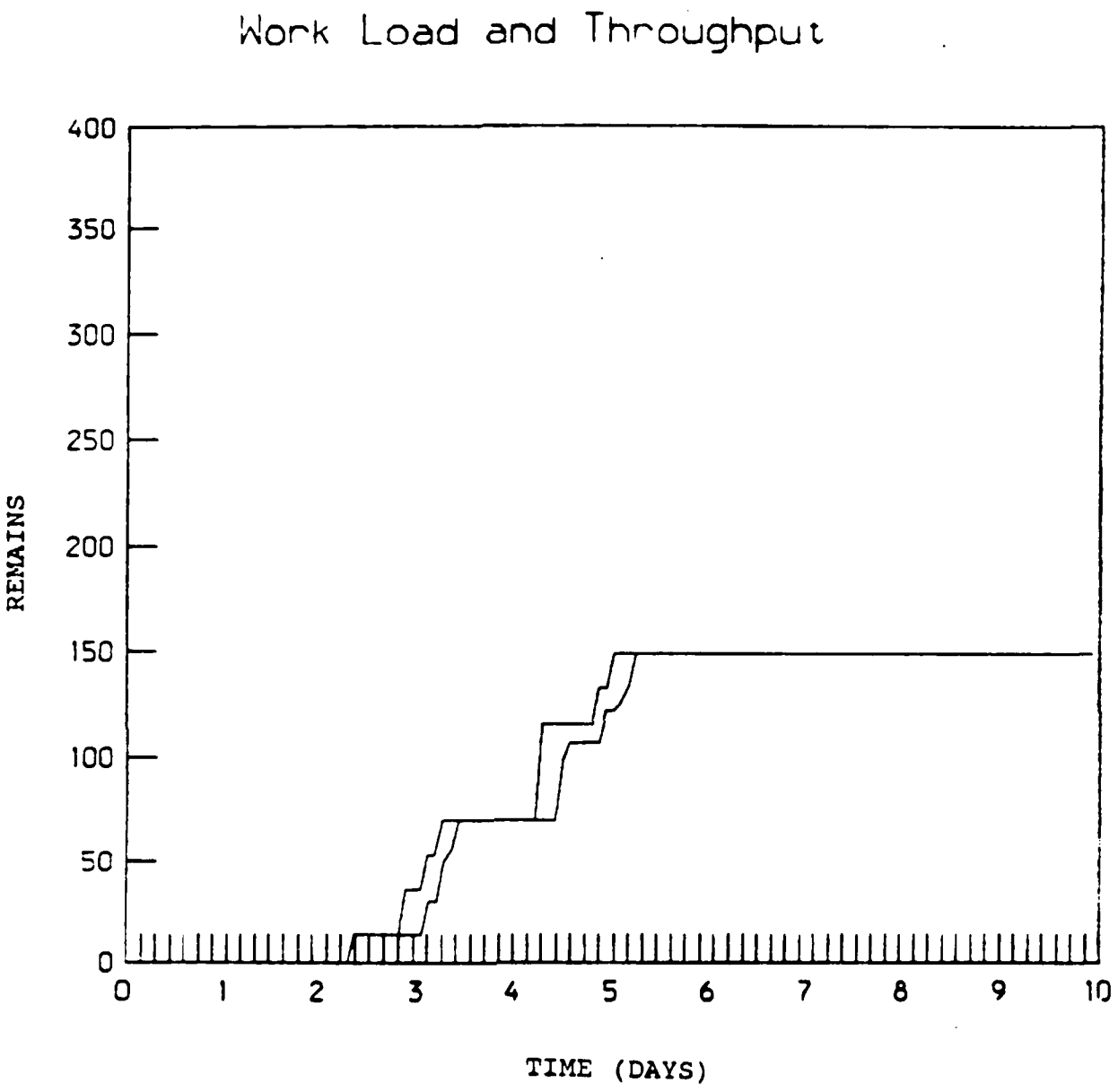


Figure 61. Collection Point 3, BDE, Backlog, Double Workforce

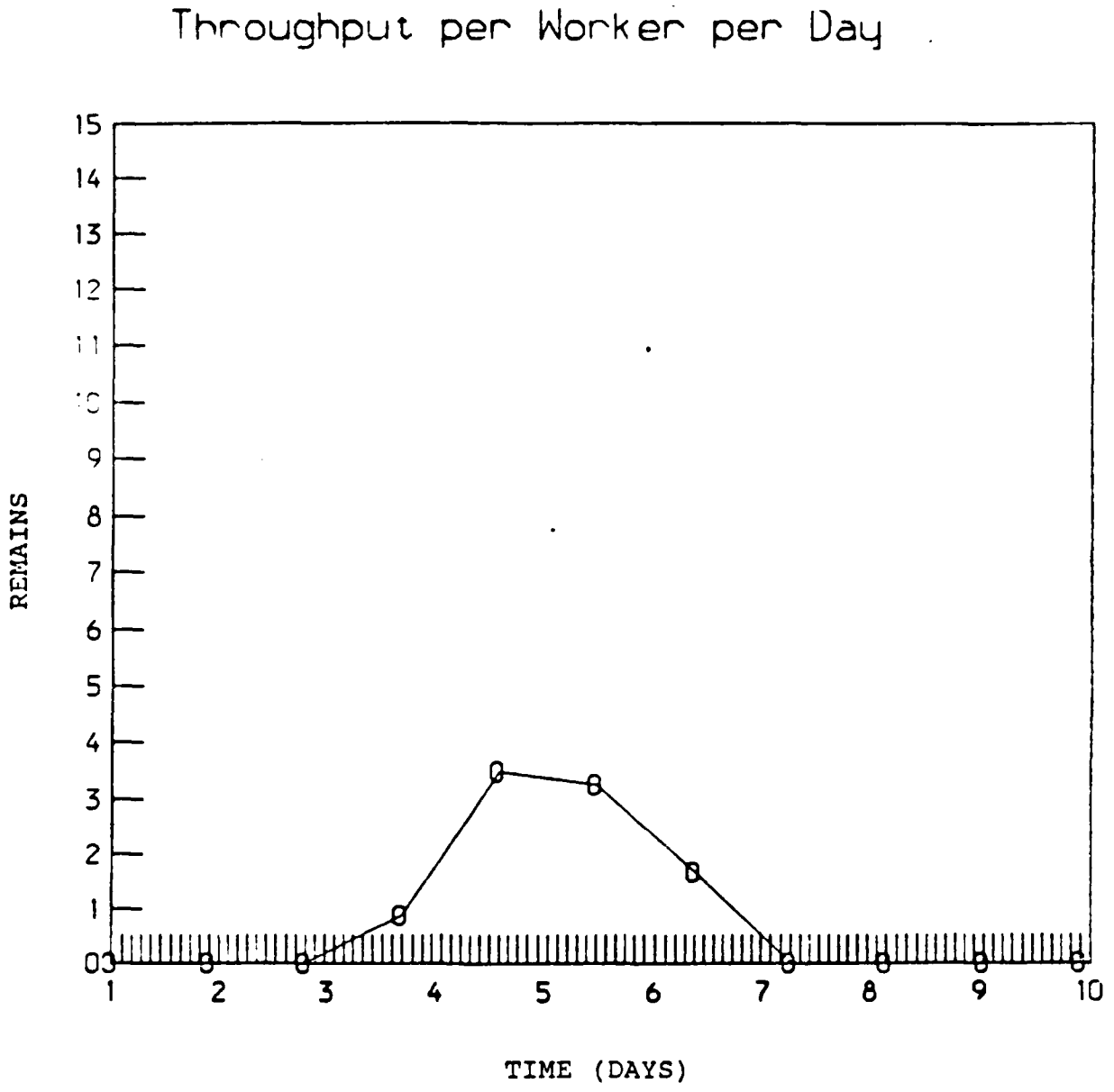


Figure 62. Collection Point 3, BDE, Throughput, Double Workforce

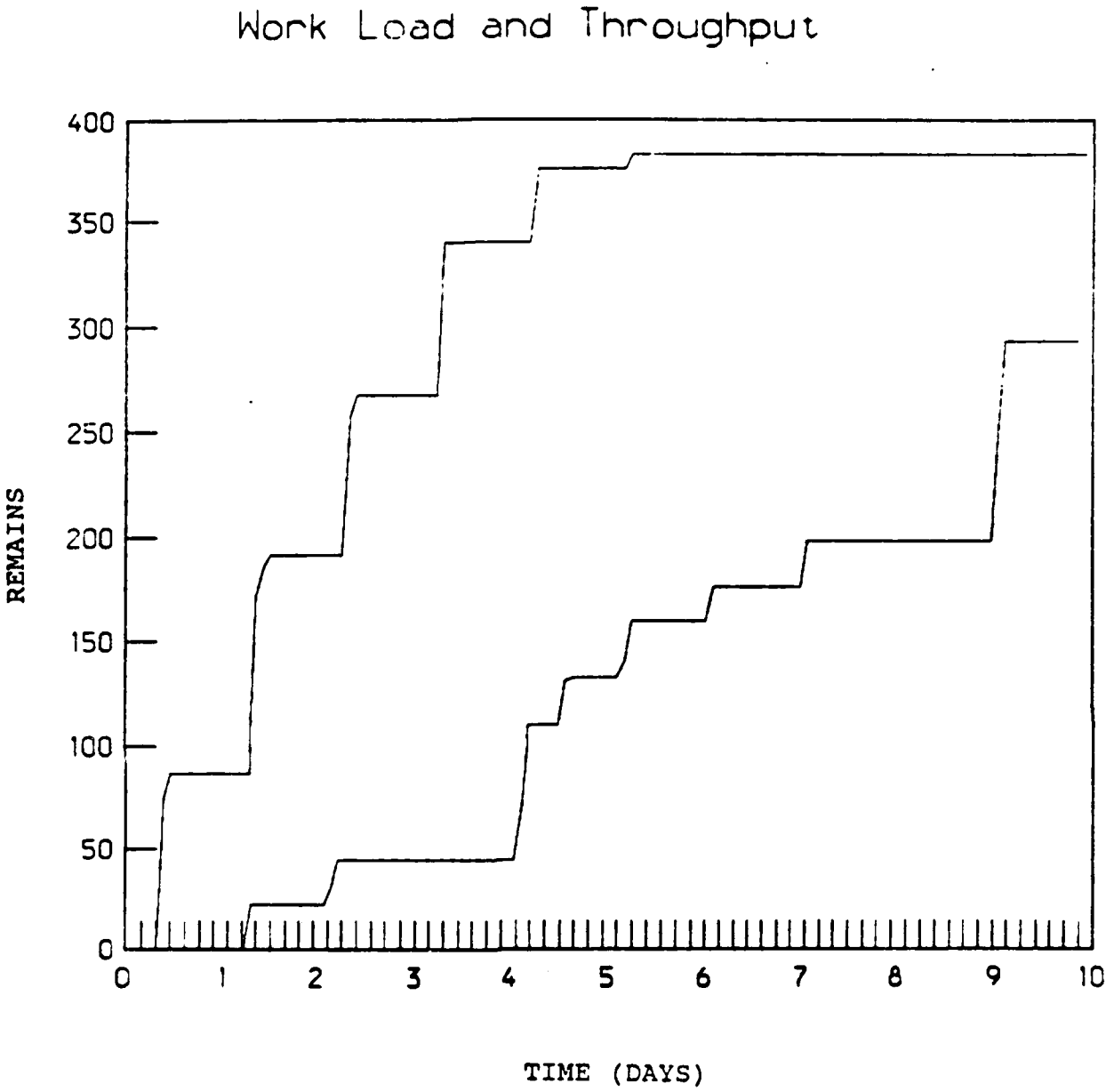


Figure 63. Collection Point 4, ACR, Backlog, Double Workforce

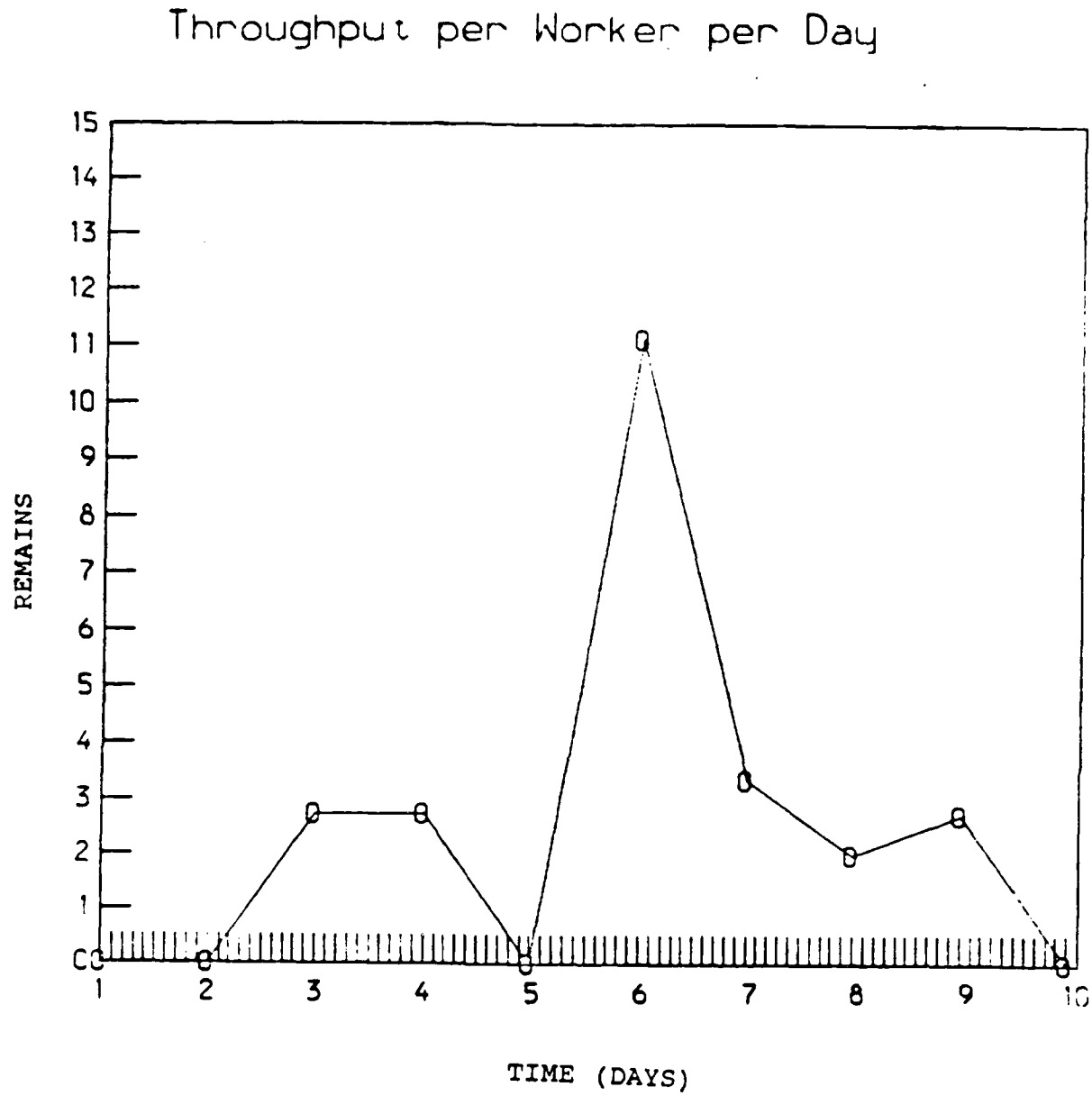


Figure 64. Collection Point 4, ACR, Throughput, Double Workforce

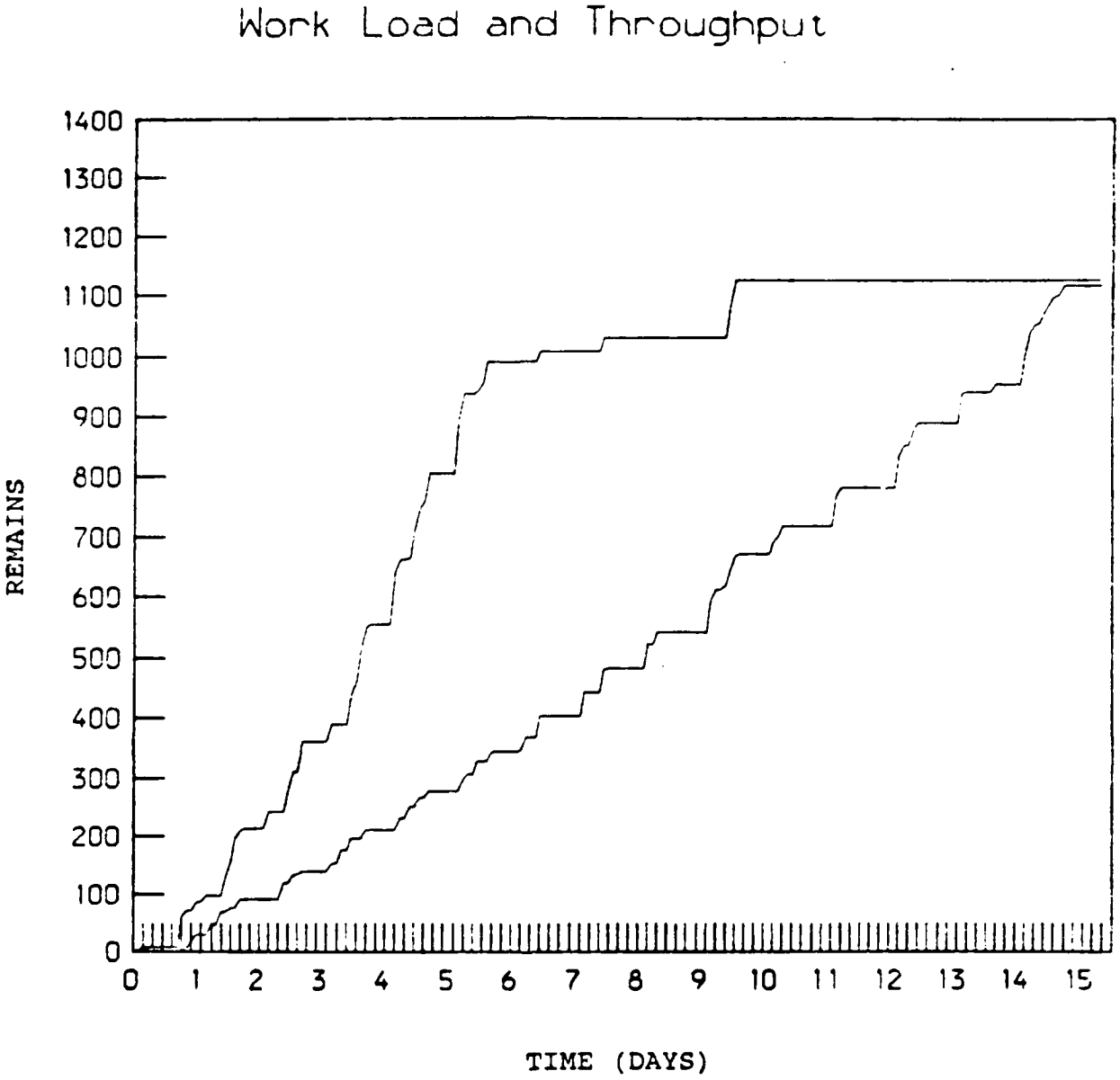


Figure 65. Division Collection Point 1, Backlog, Double Workforce

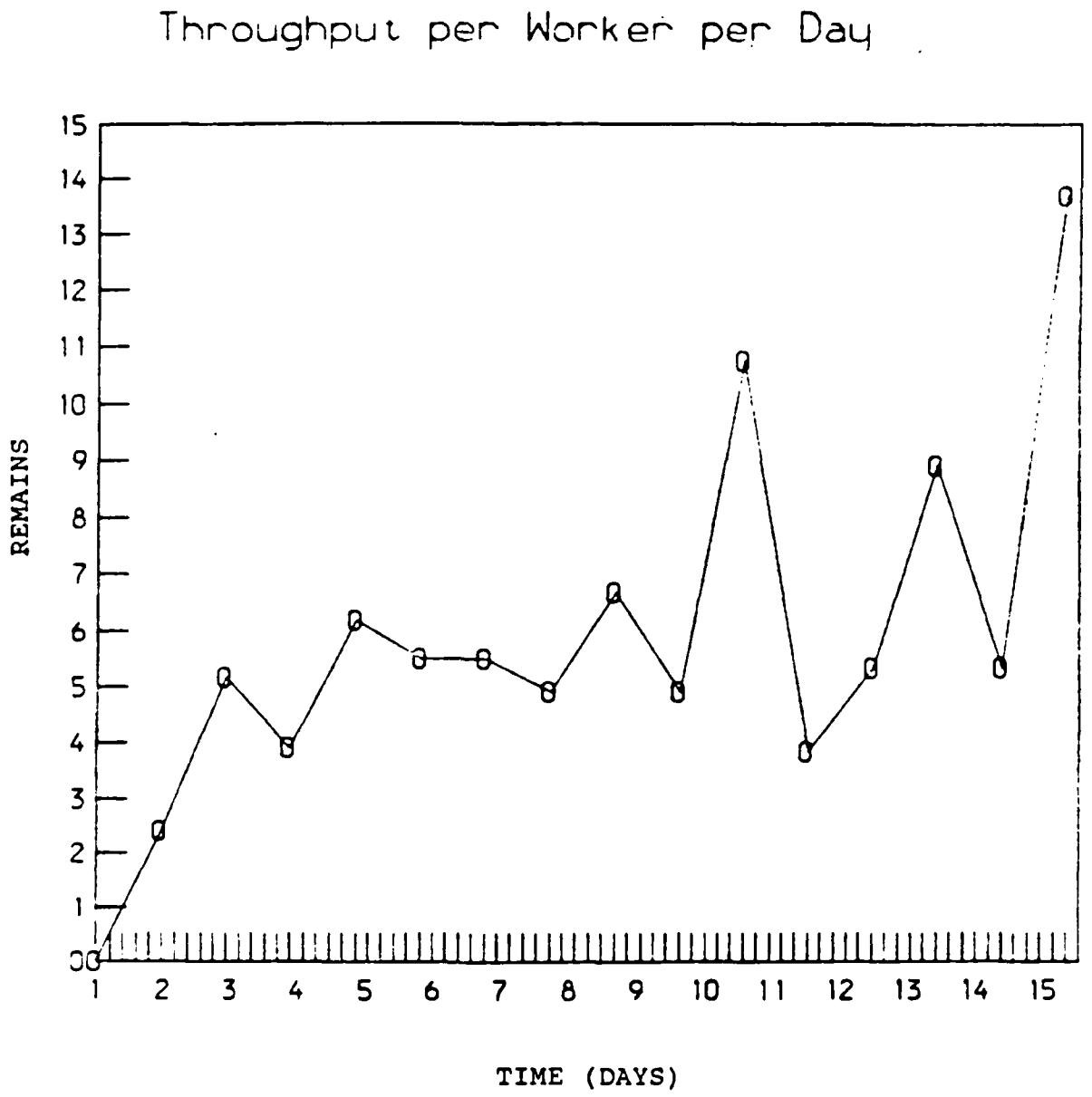


Figure 66. Division Collection Point 1, Throughput, Double Workforce

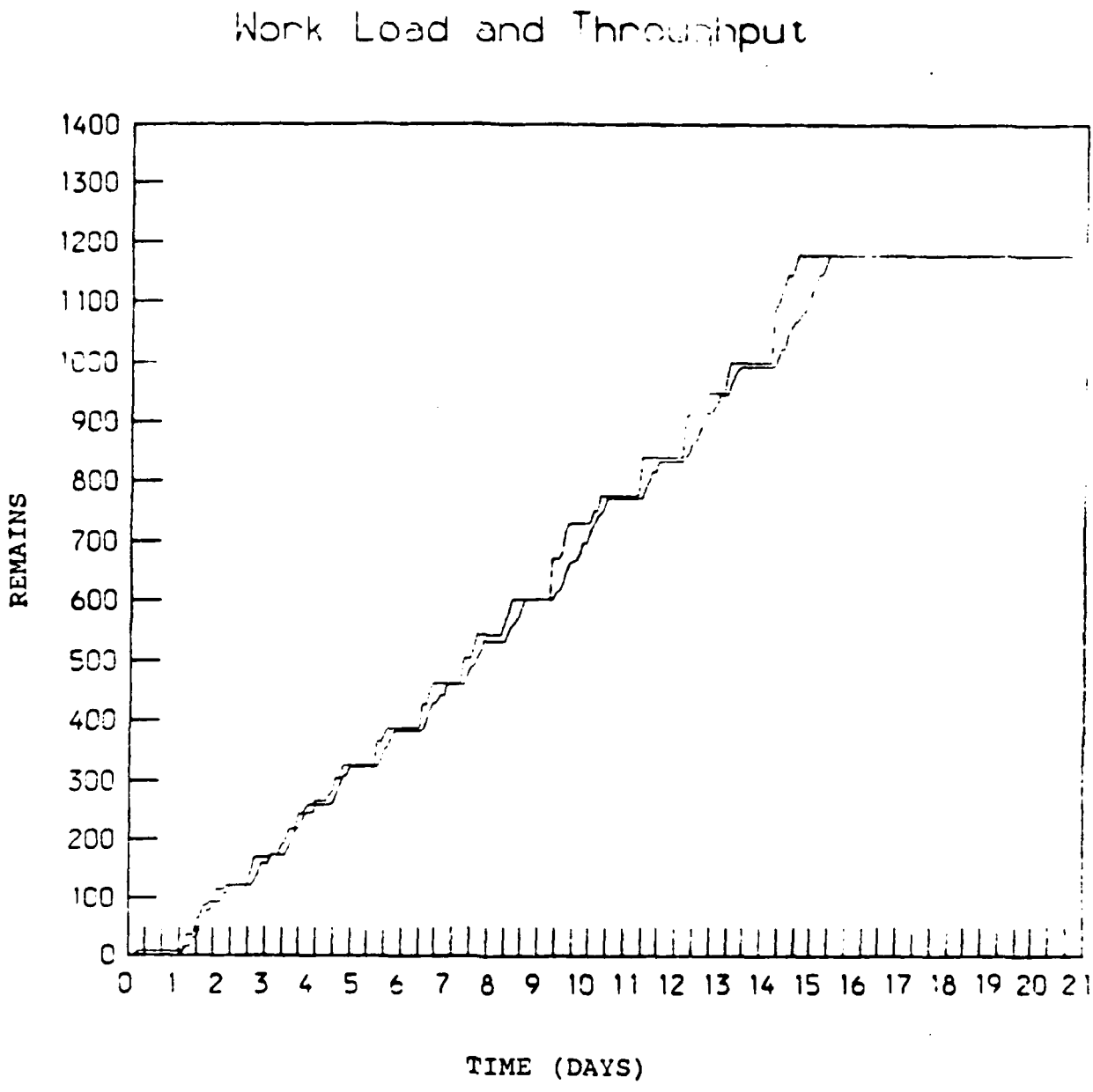


Figure 67. Corps Collection Point 1, Backlog, Double Workforce

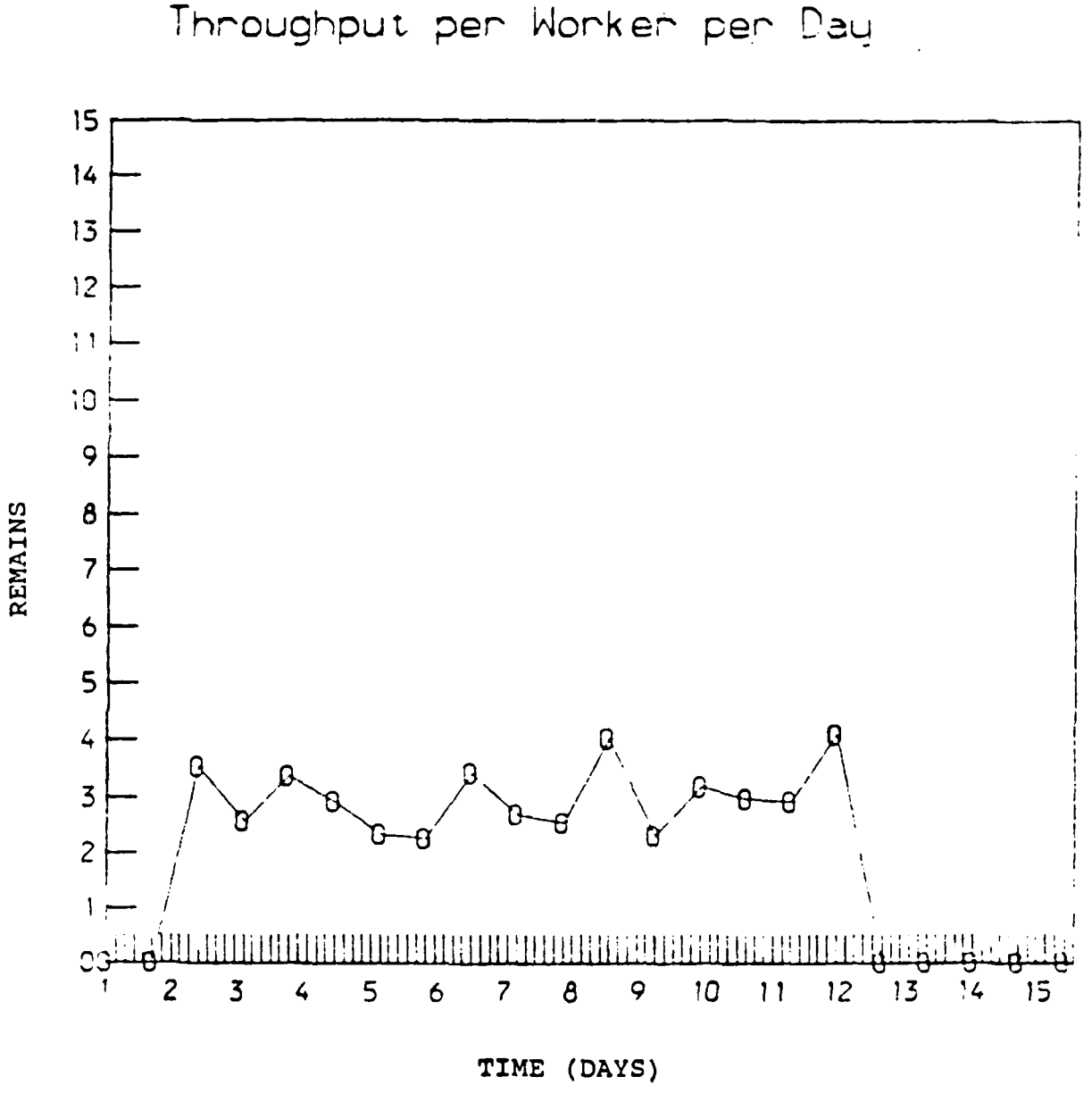


Figure 68. Corps Collection Point 1, Throughput, Double Workforce

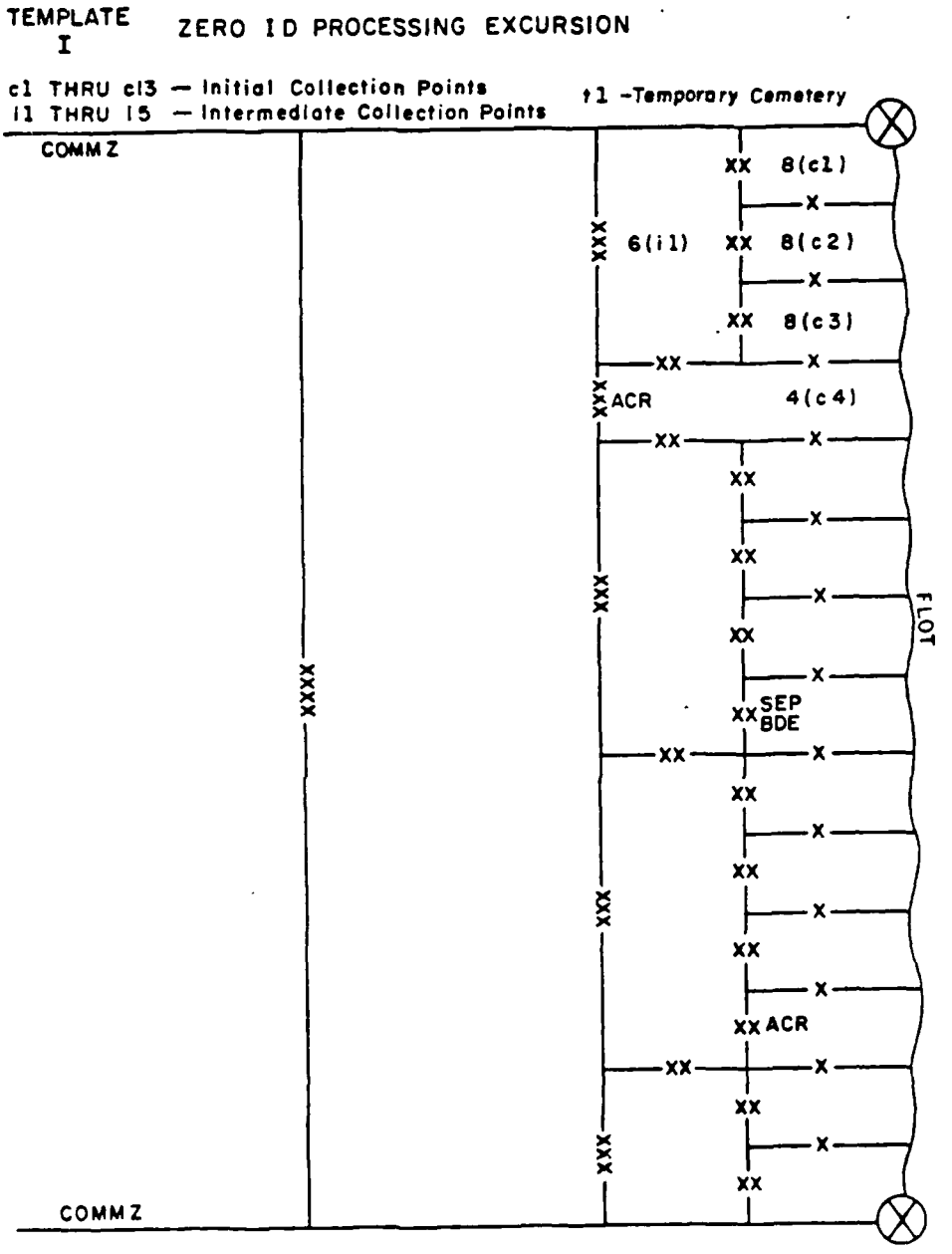


Figure 69. Zero ID Organization

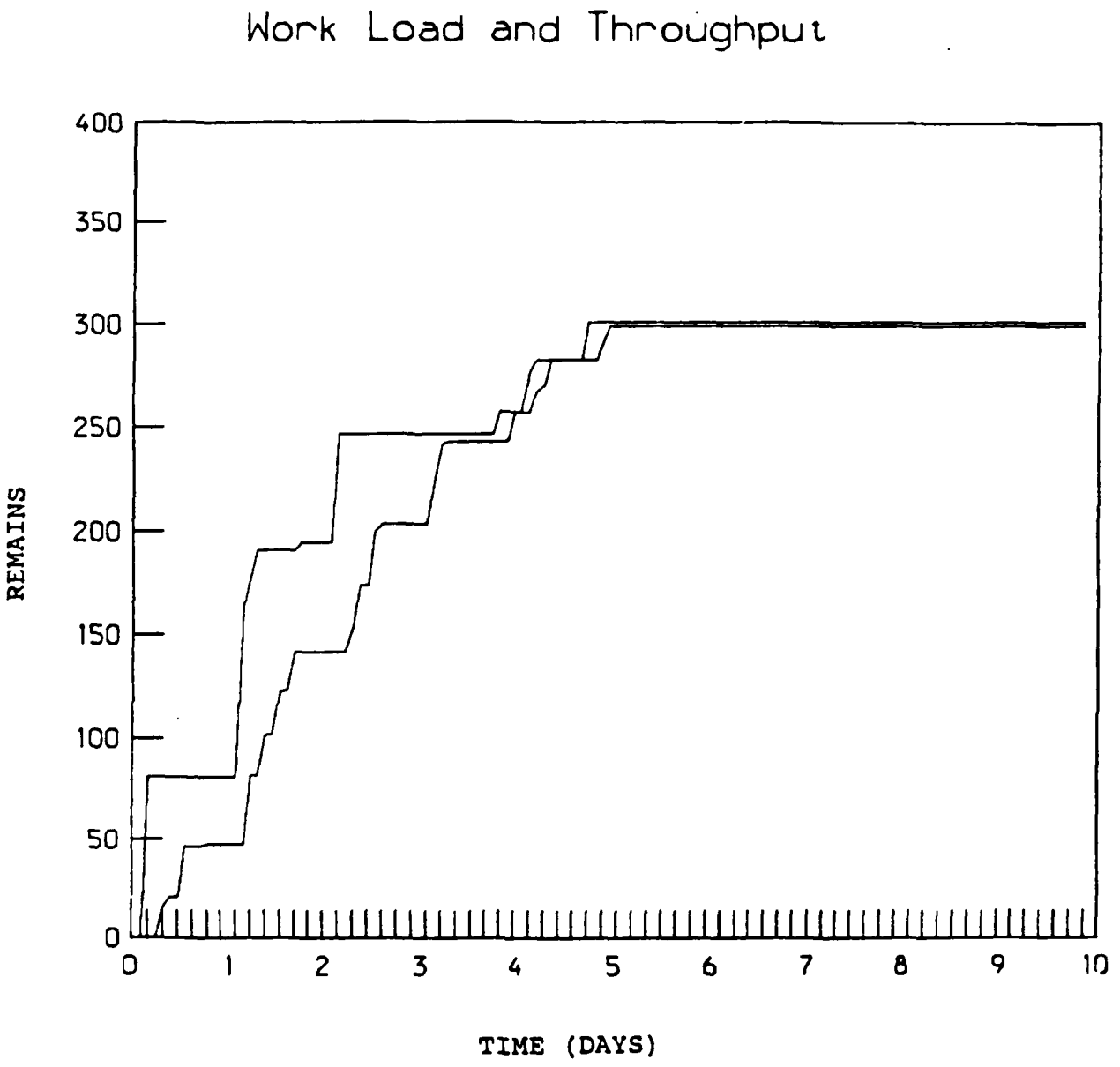
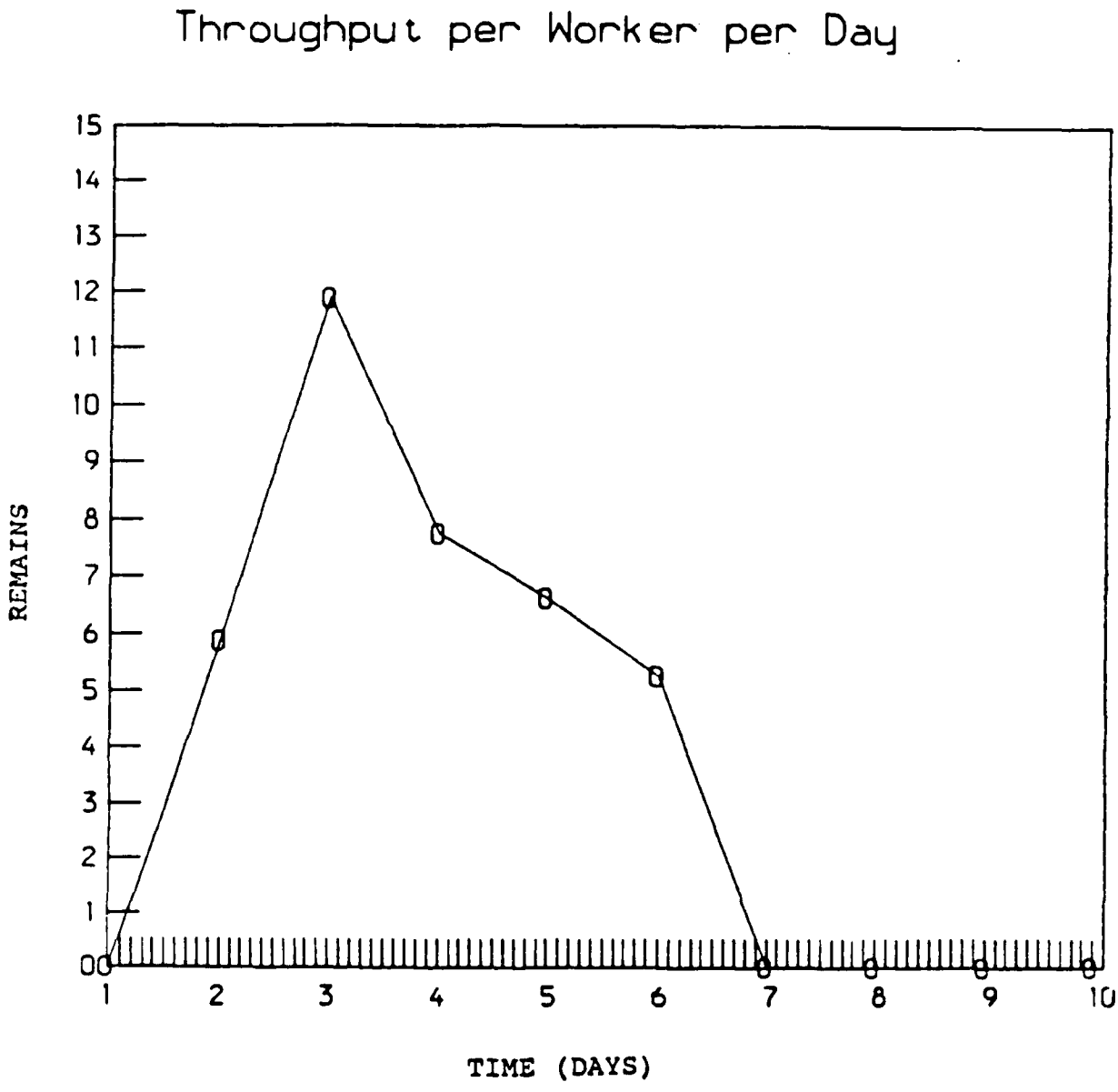


Figure 70. Collection Point 1, BDE, Backlog, Zero ID



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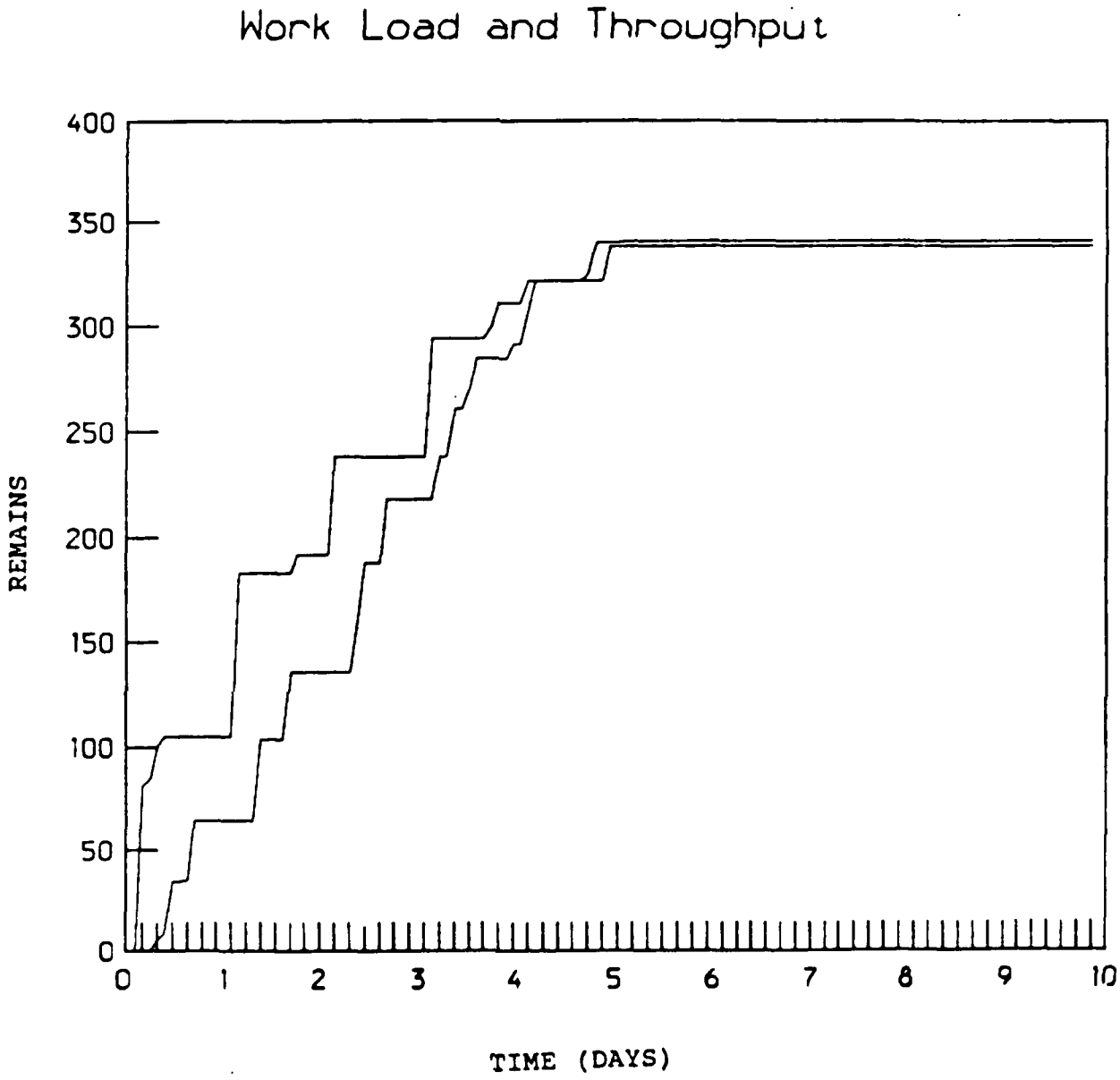

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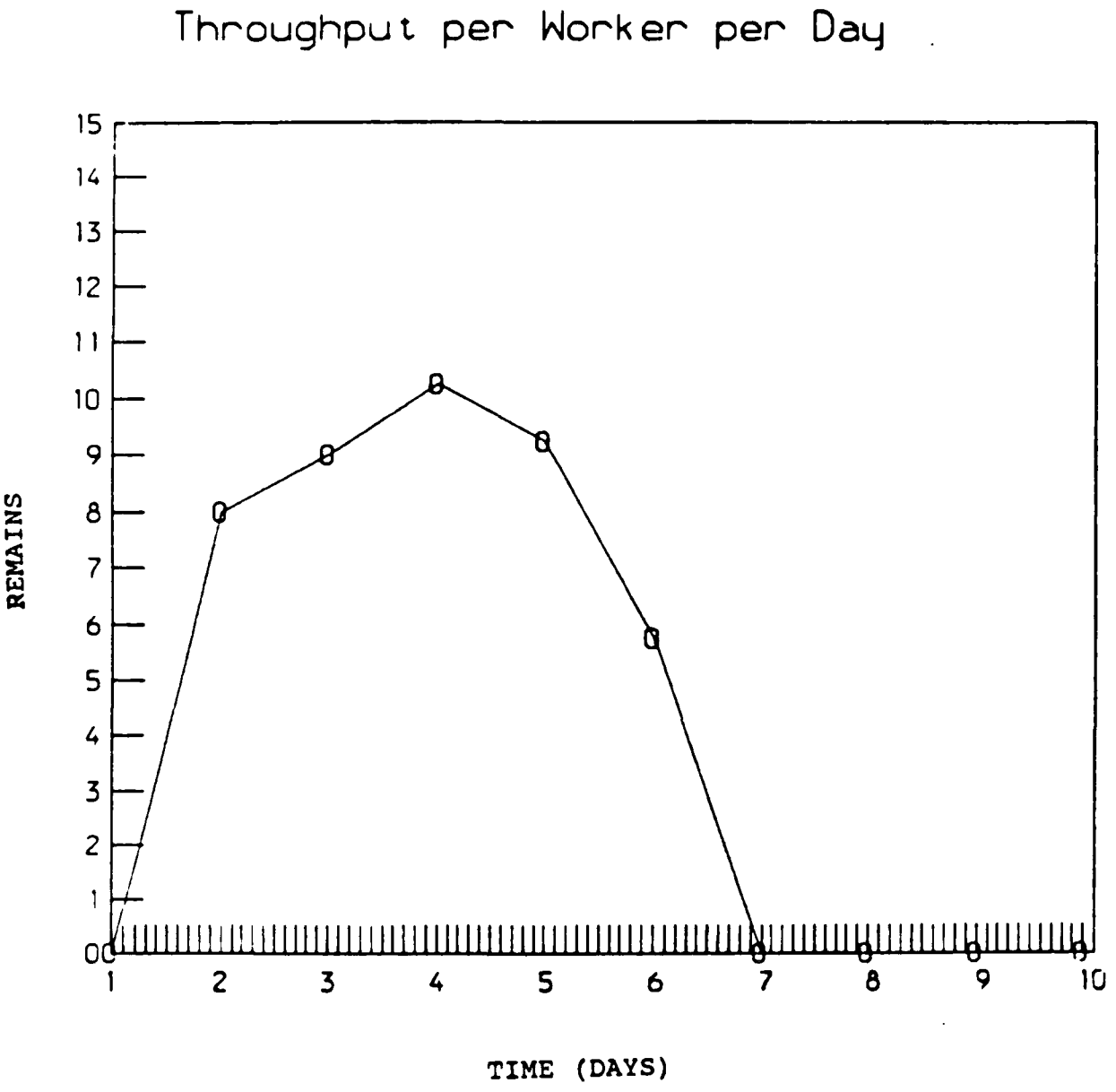


Figure 73. Collection Point 2, BDE, Throughput, Zero ID

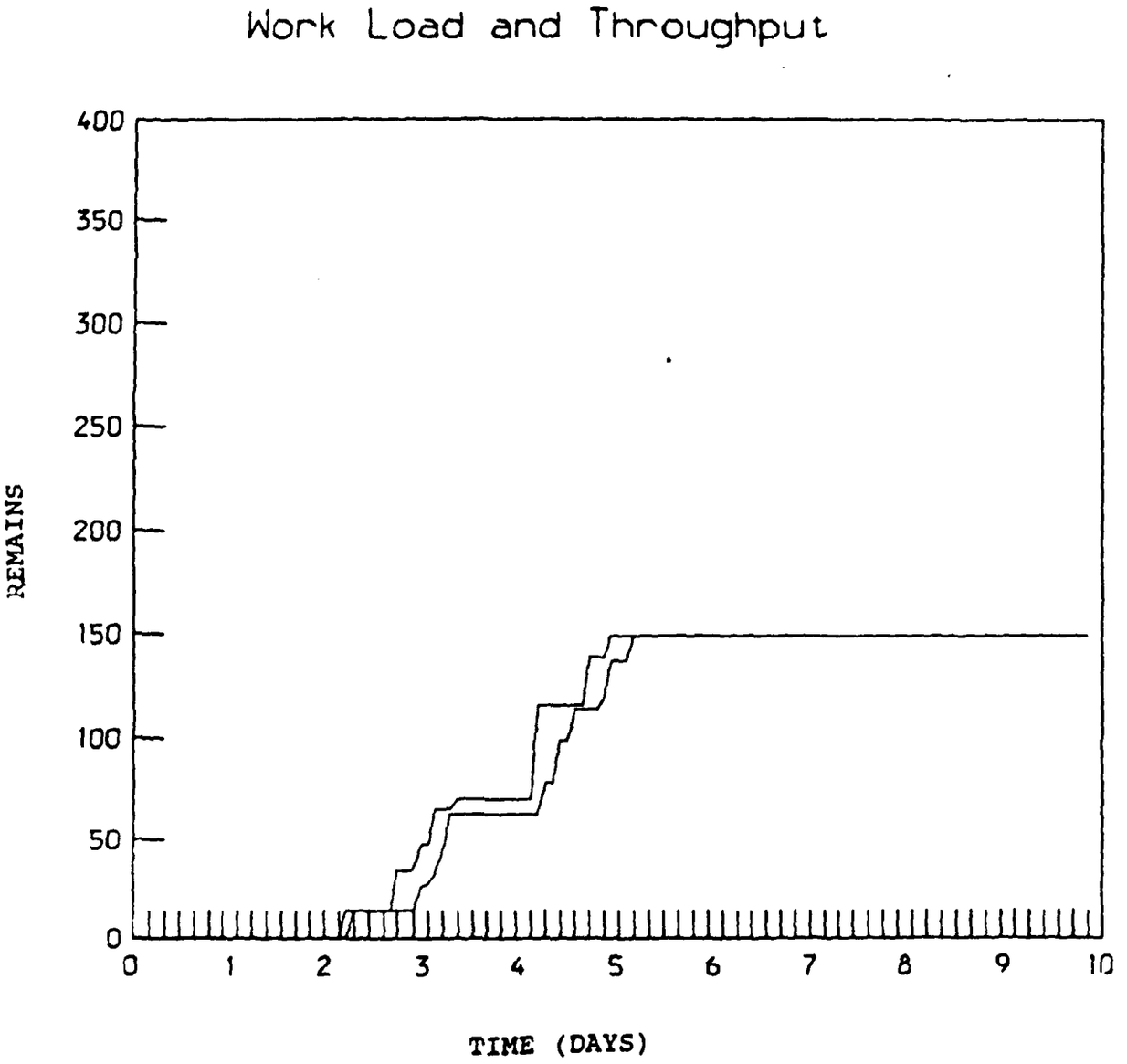


Figure 74. Collection Point 3, BDE, Backlog, Zero ID

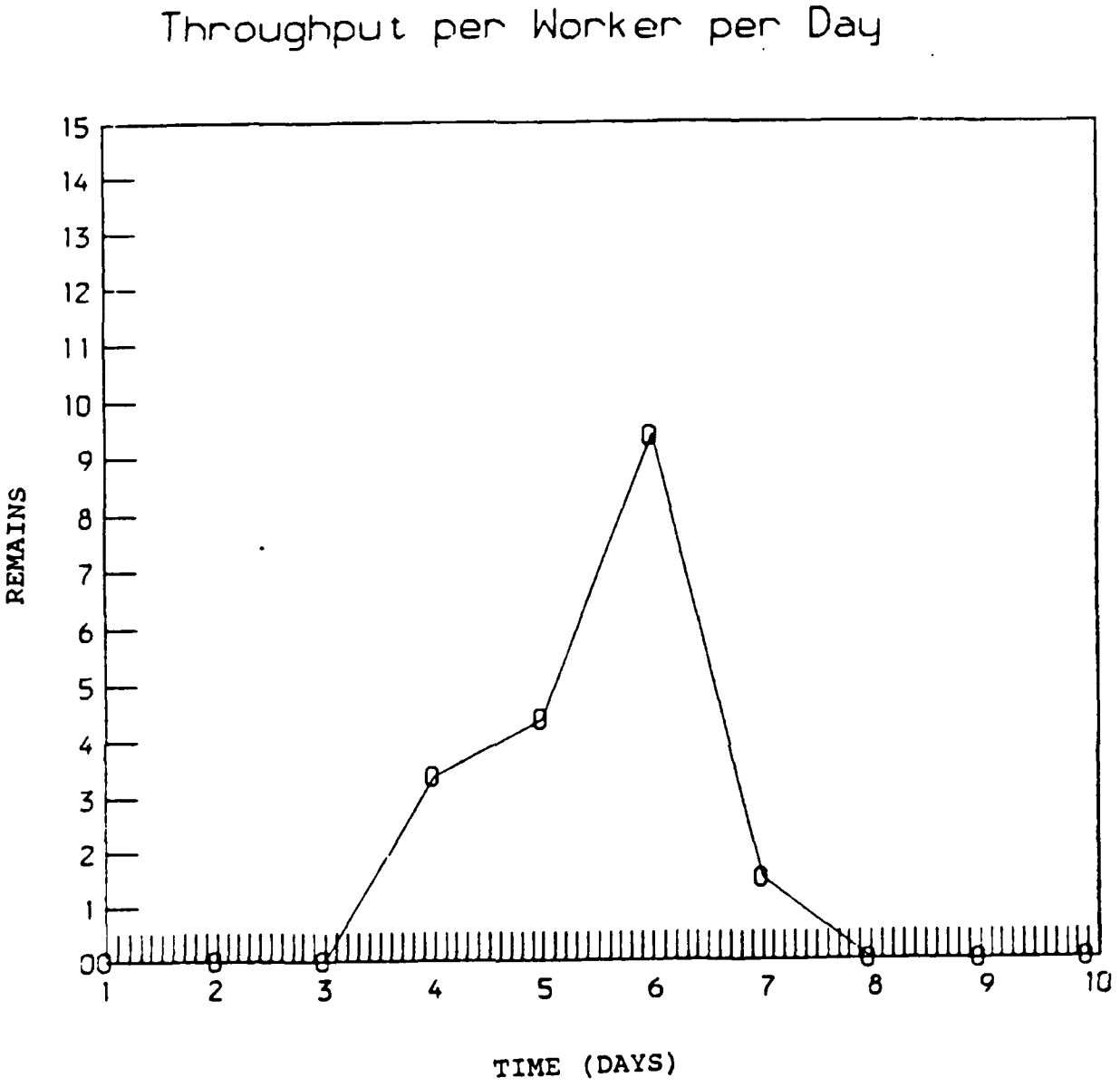


Figure 75. Collection Point 3, BDE, Throughput, Zero ID

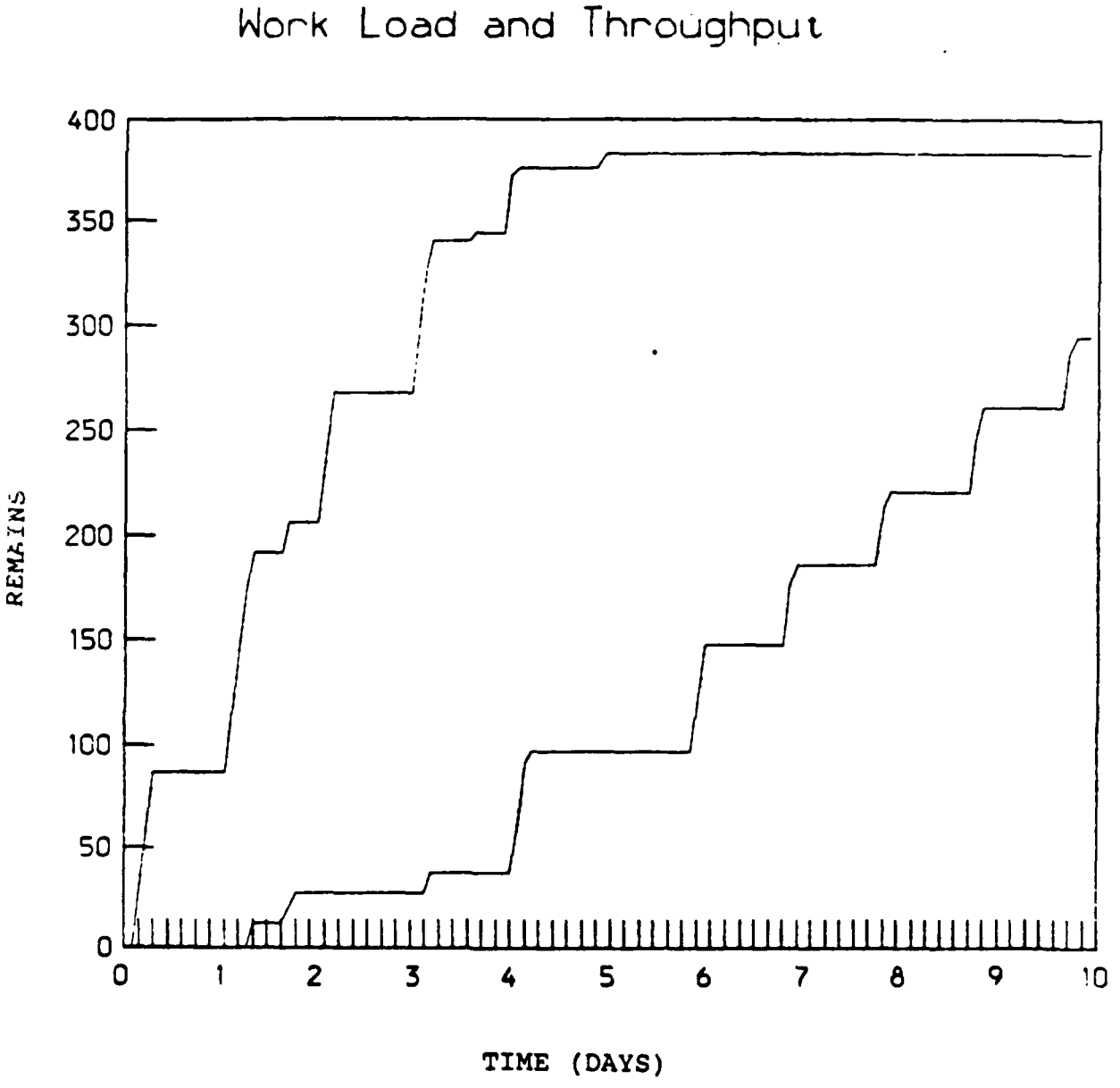


Figure 76. Collection Point 4, ACR, Backlog, Zero ID

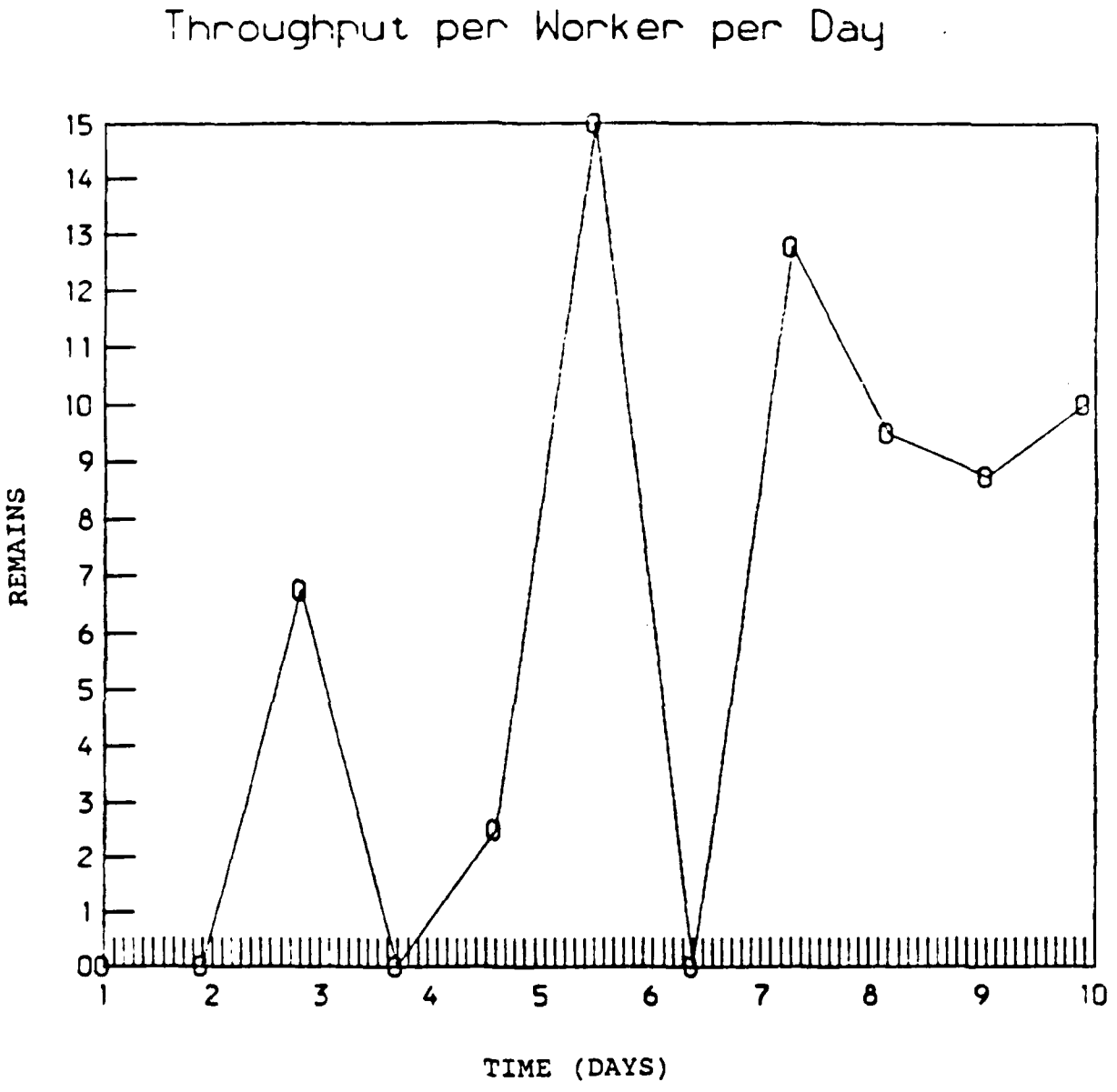


Figure 77. Collection Point 4, ACR, Throughput, Zero ID

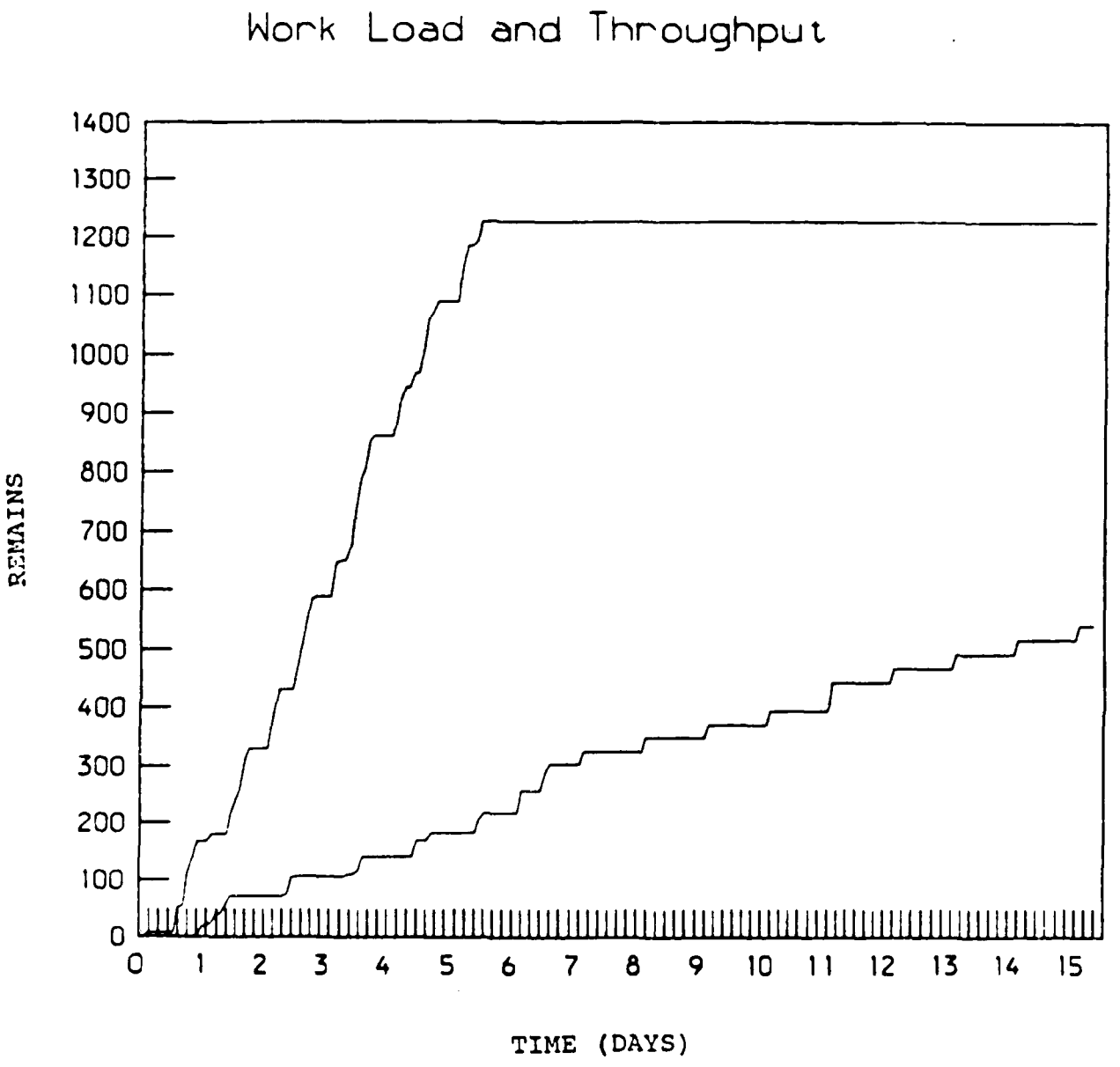
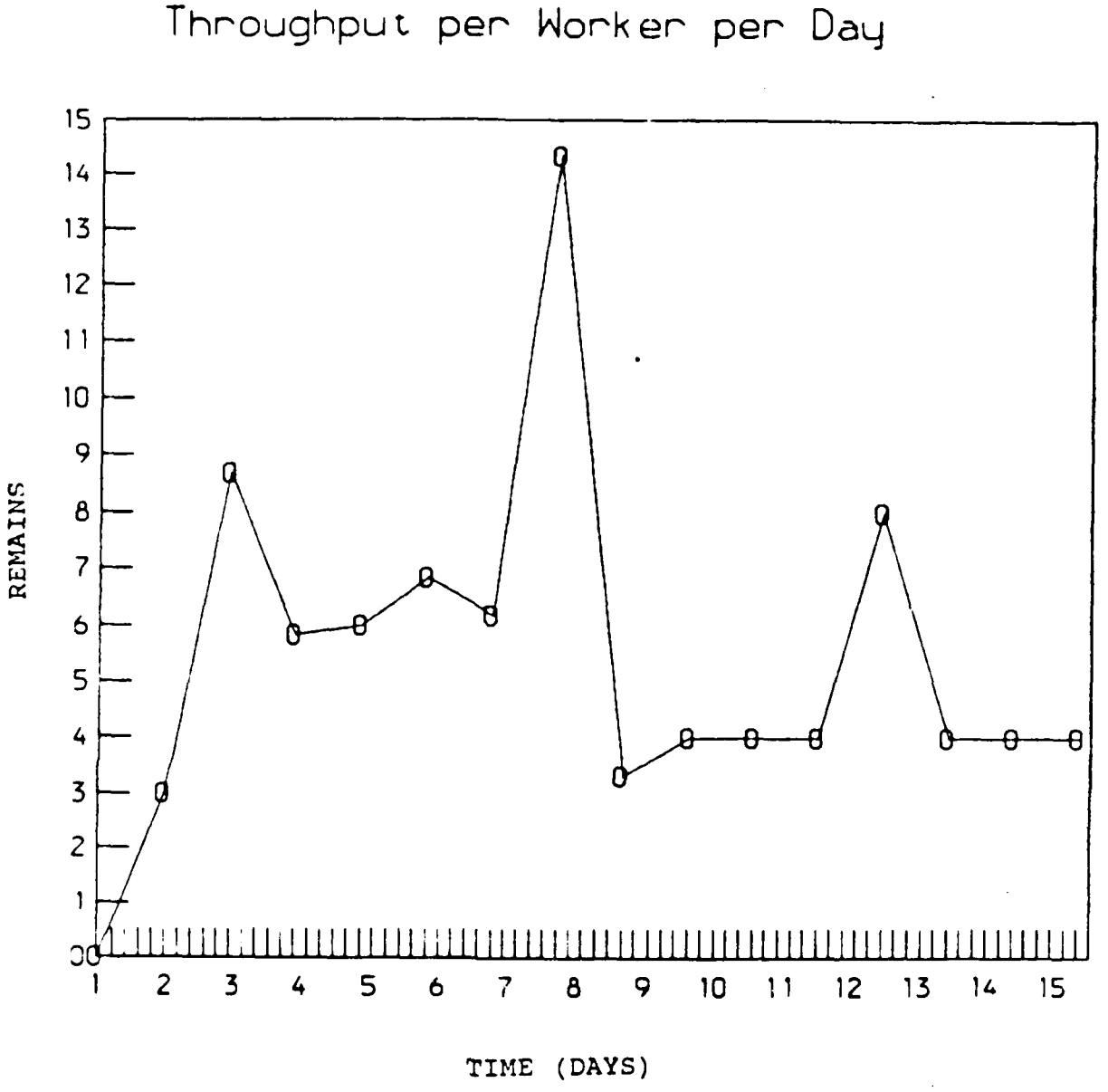


Figure 78. Division Collection Point 1, Backlog, Zero ID



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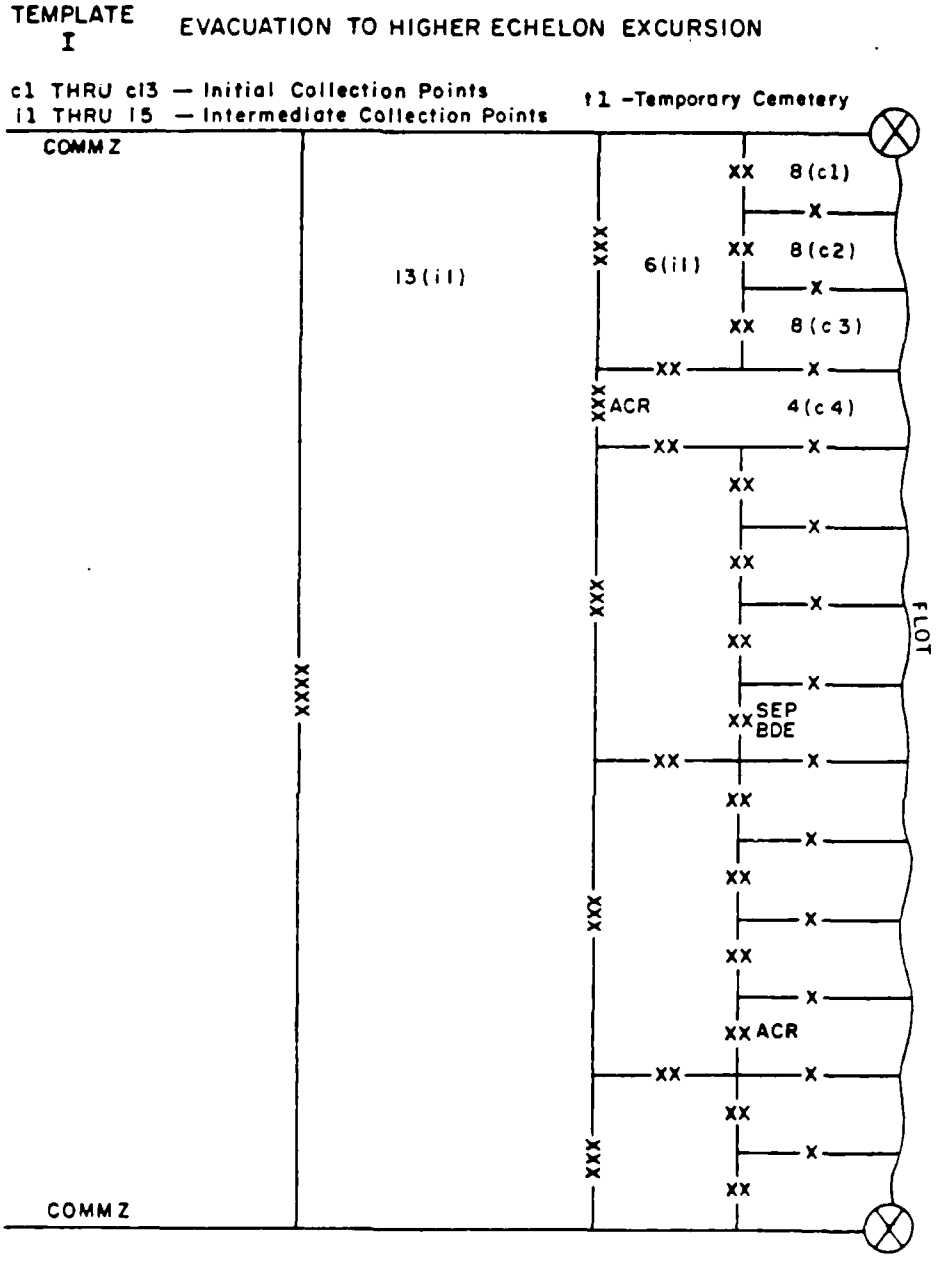


Figure 80. Evacuation to Higher Echelon Organization

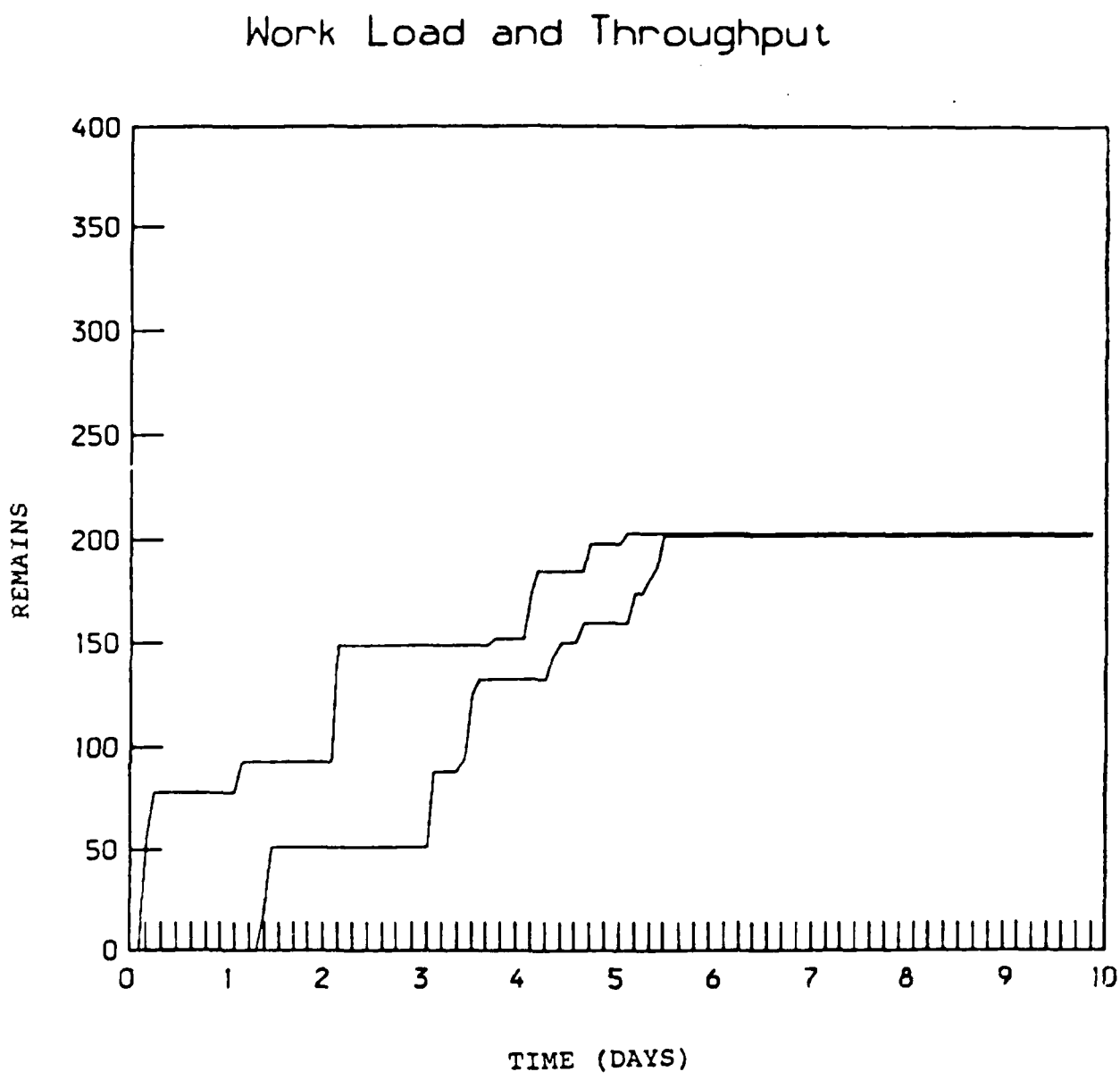
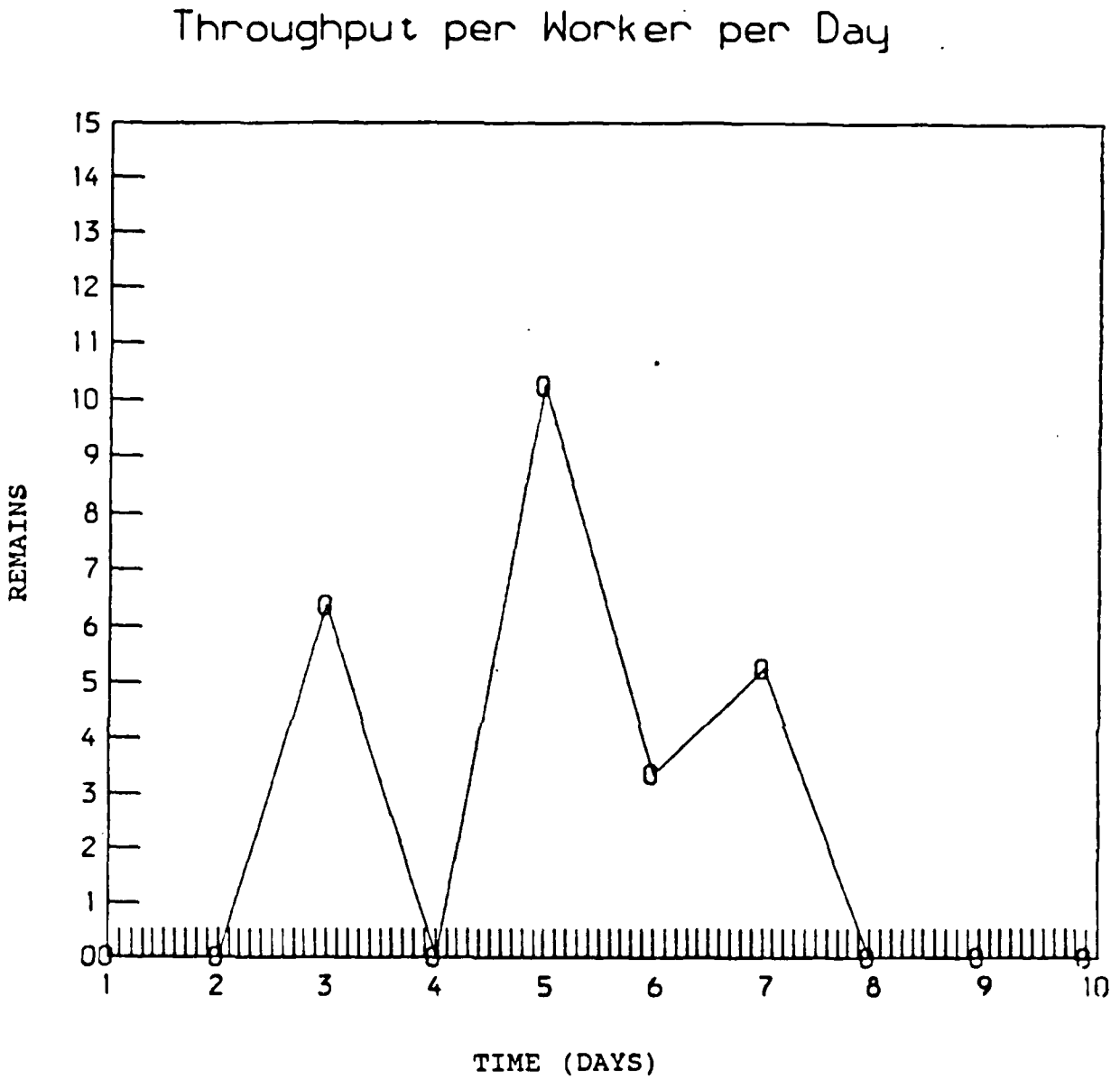


Figure 81. Collection Point 1, BDE, Backlog, Evac



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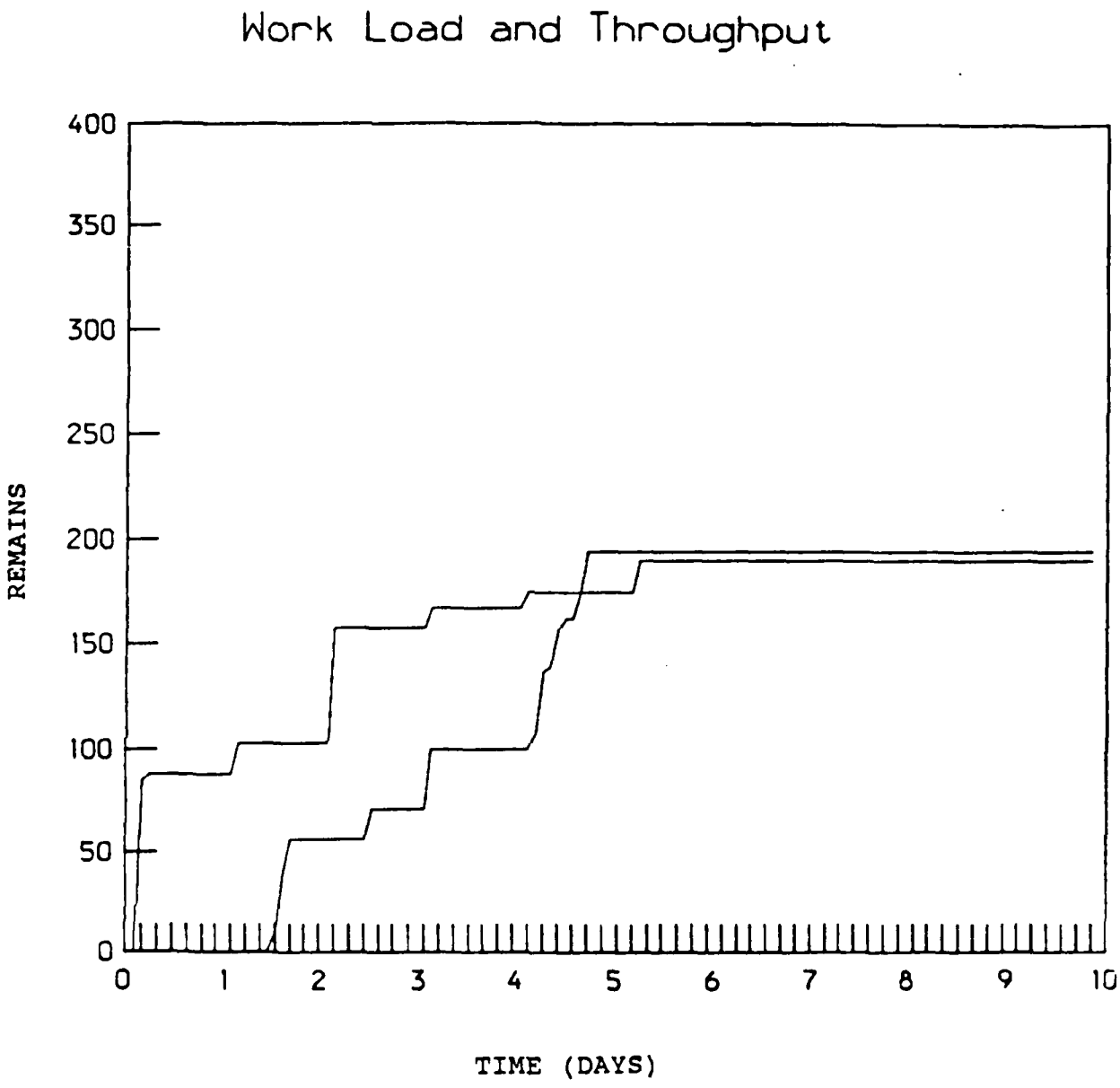


Figure 83. Collection Point 2, BDE, Backlog, Evac

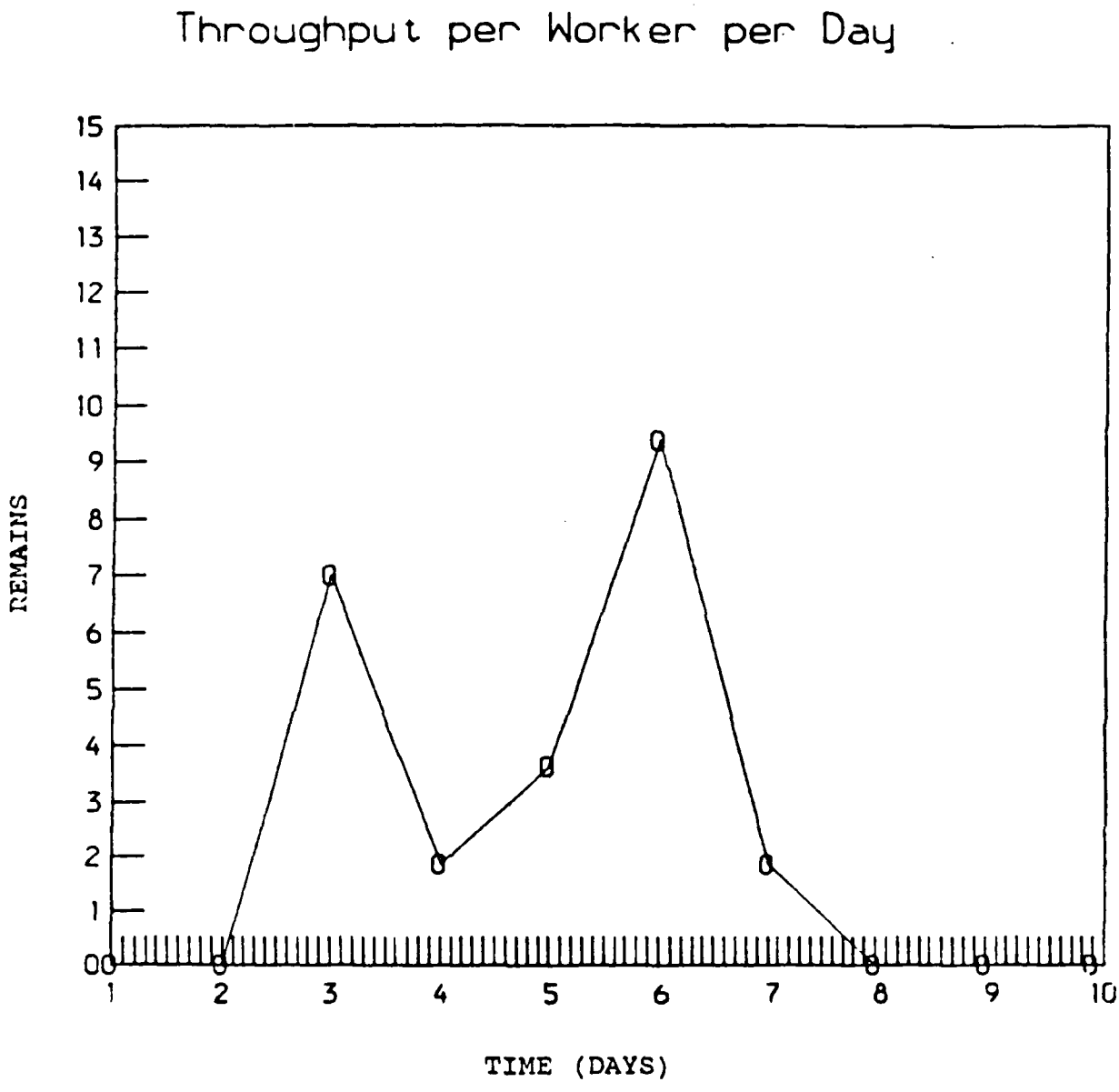


Figure 84. Collection Point 2, BDE, Throughput, Evac

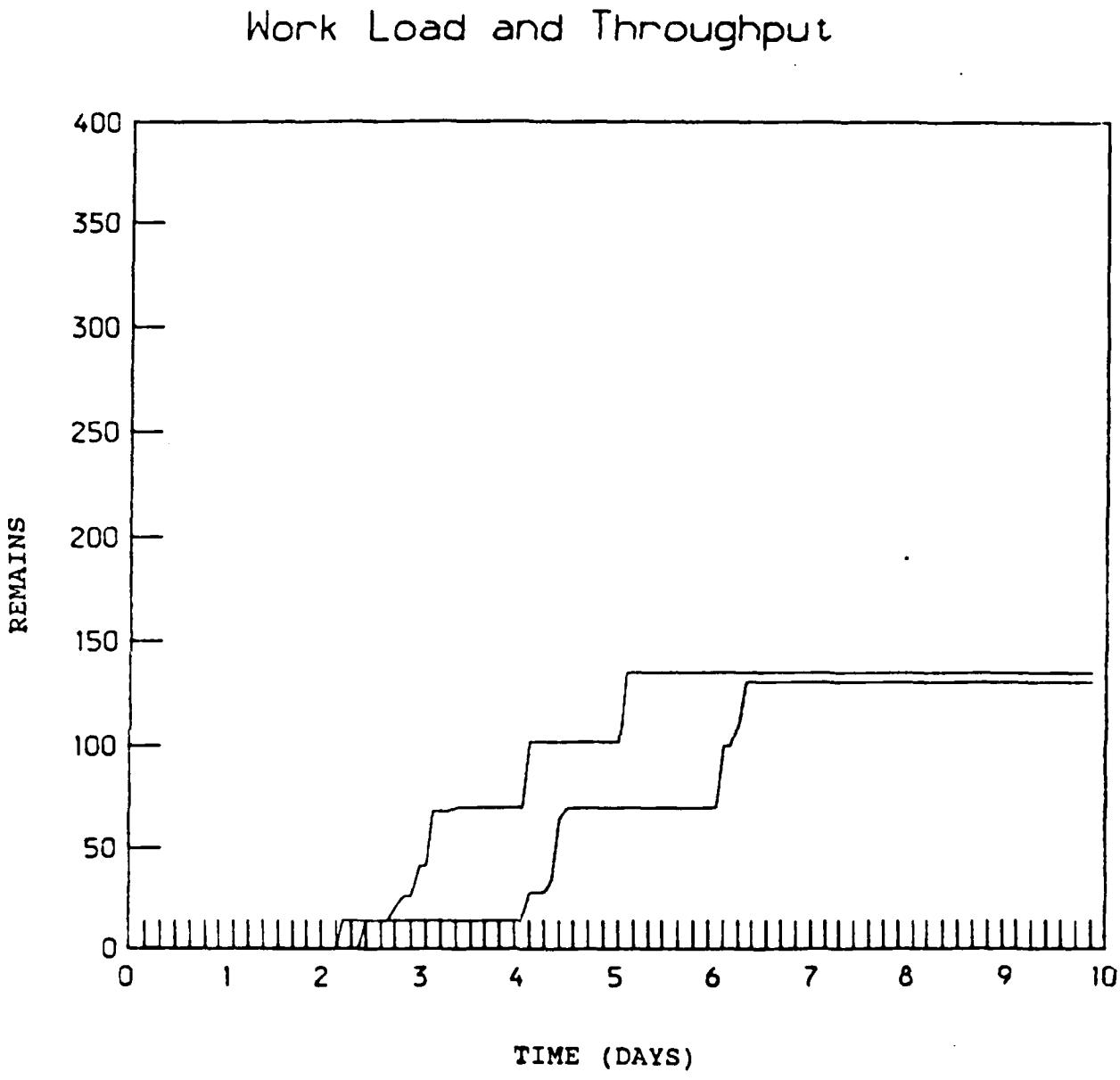


Figure 85. Collection Point 3, BDE, Backlog, Evac

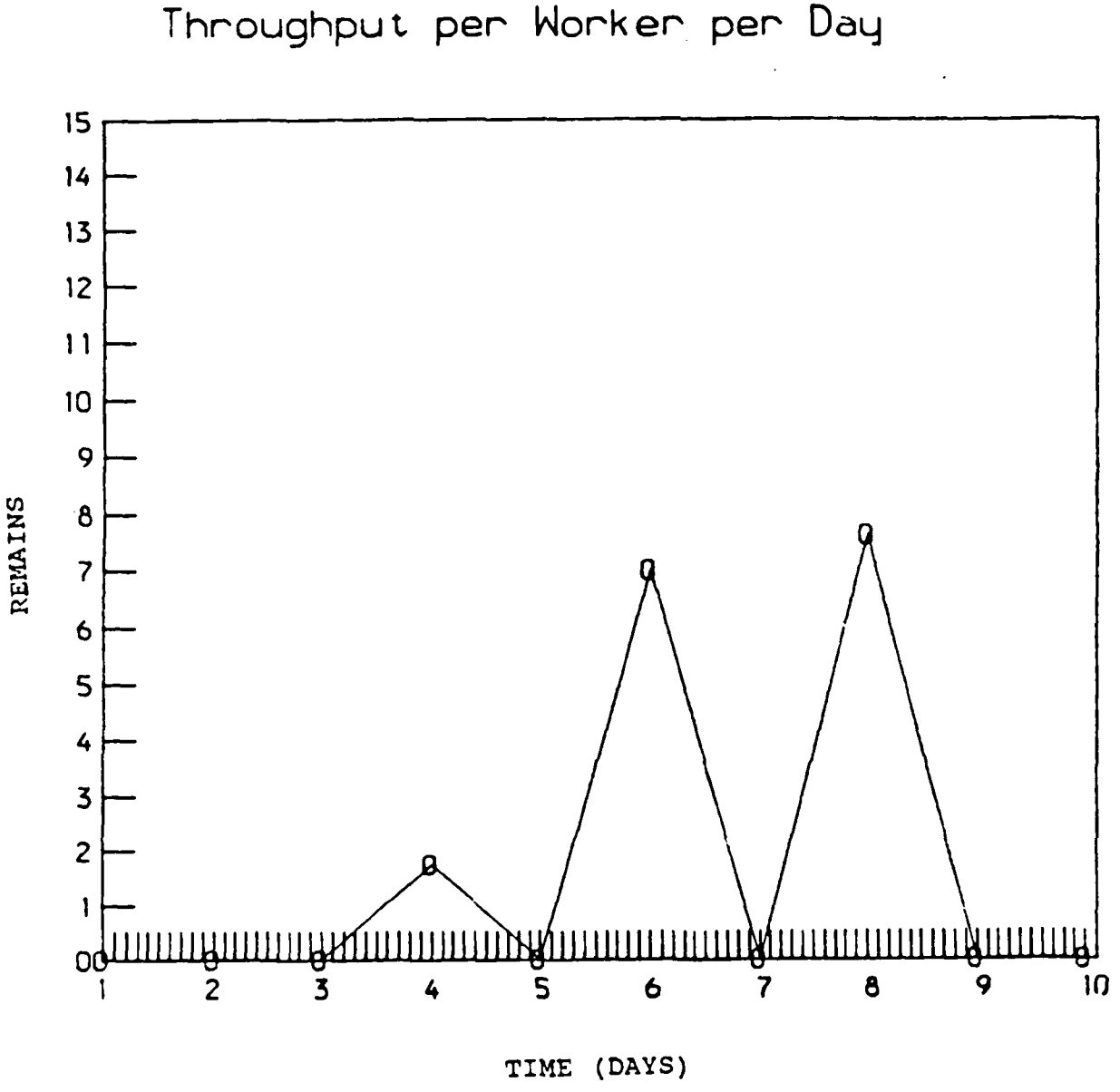


Figure 86. Collection Point 3, BDE, Throughput, Evac

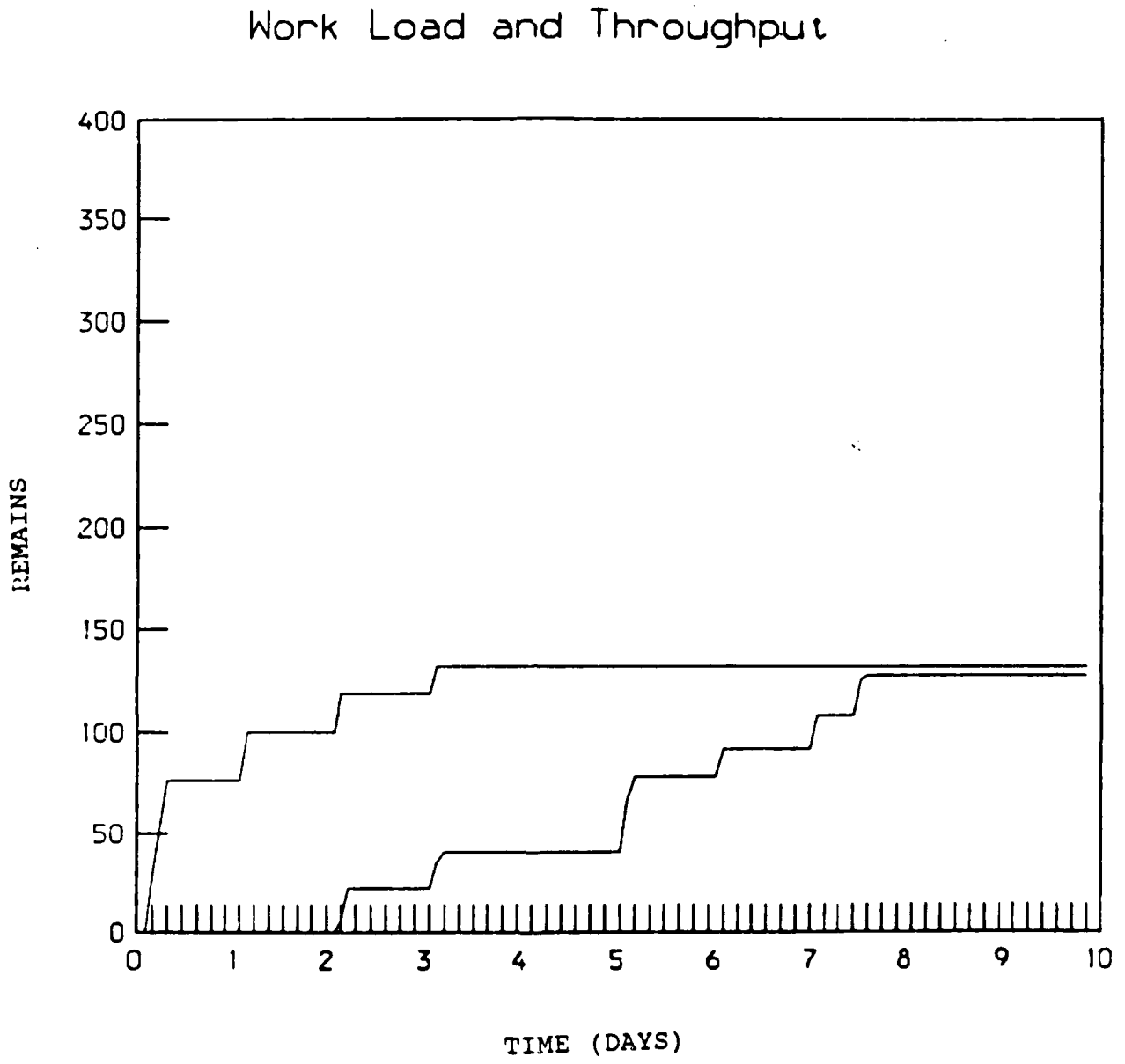


Figure 87. Collection Point 4, ACR, Backlog, Evac

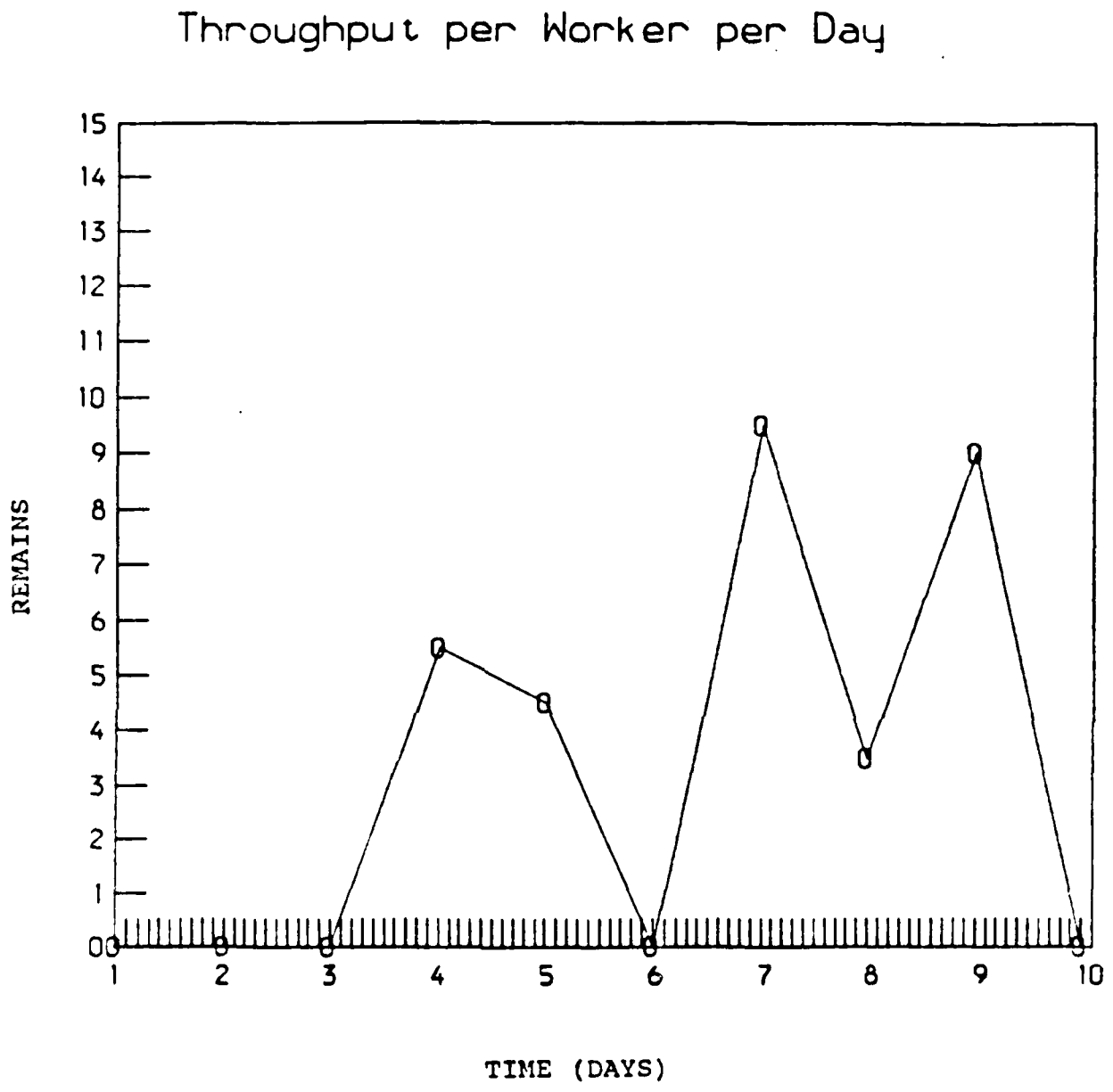


Figure 88. Collection Point 4, ACR, Throughput, Evac

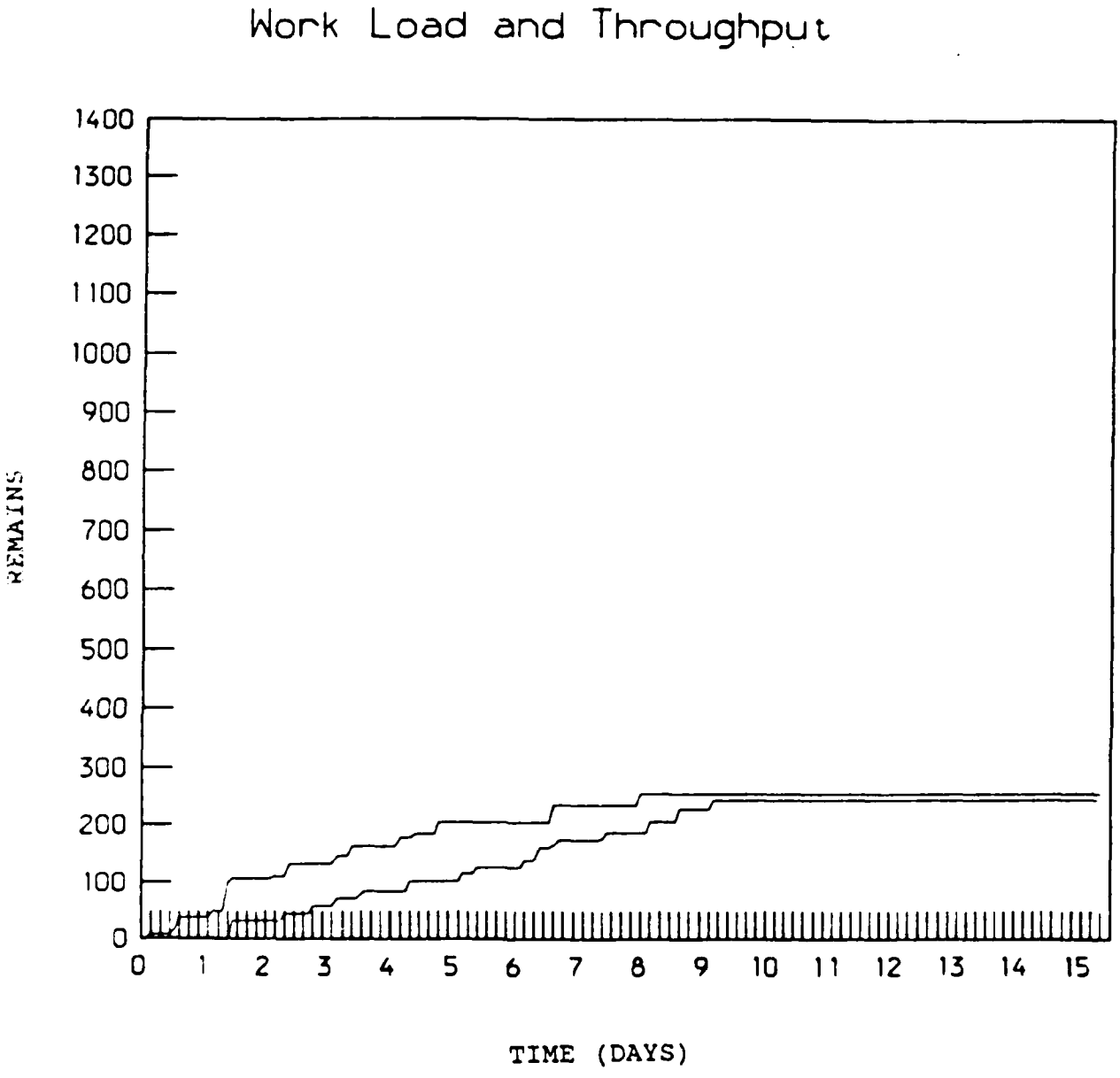
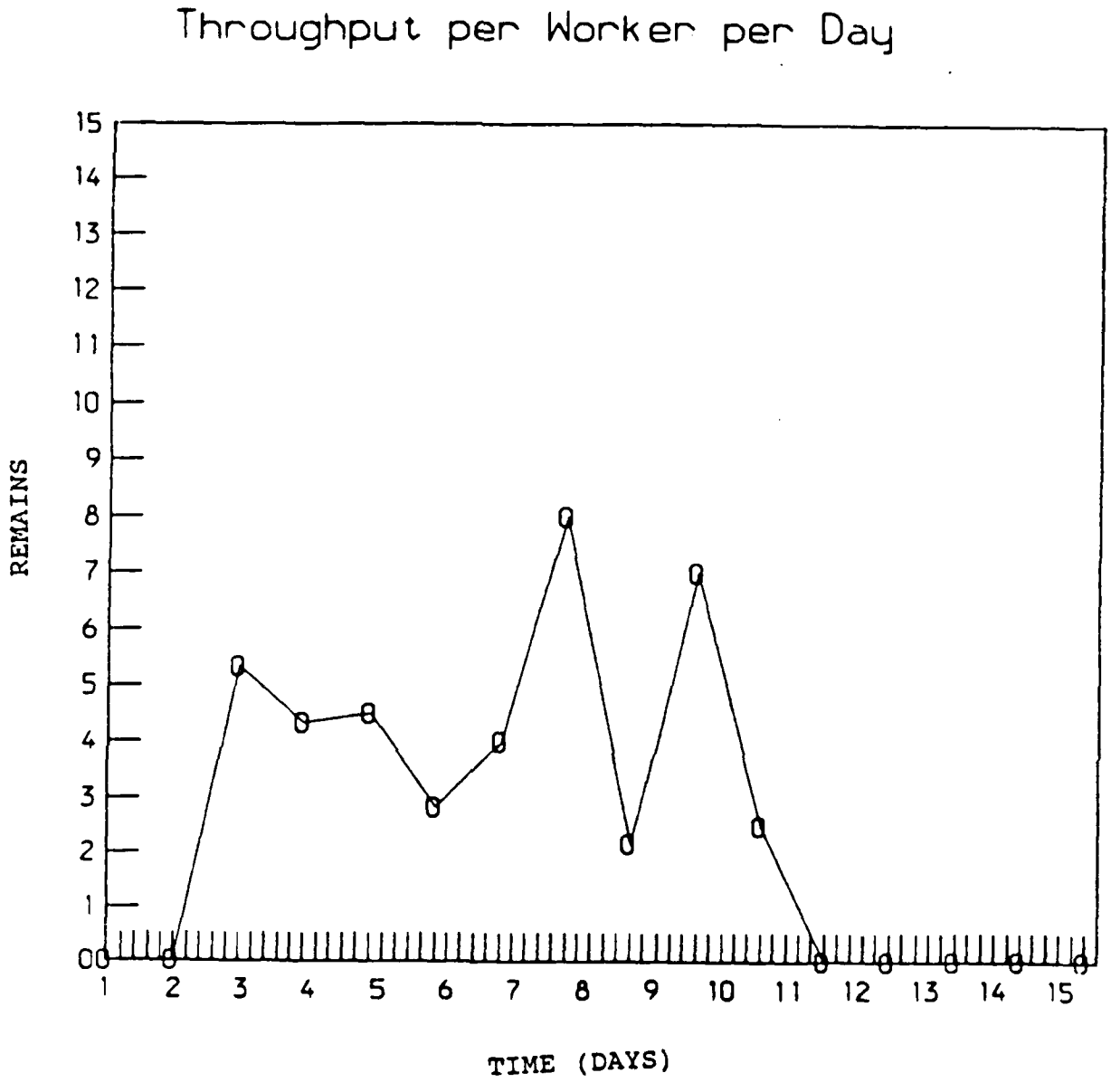


Figure 89. Division Collection Point 1, Backlog, Evac



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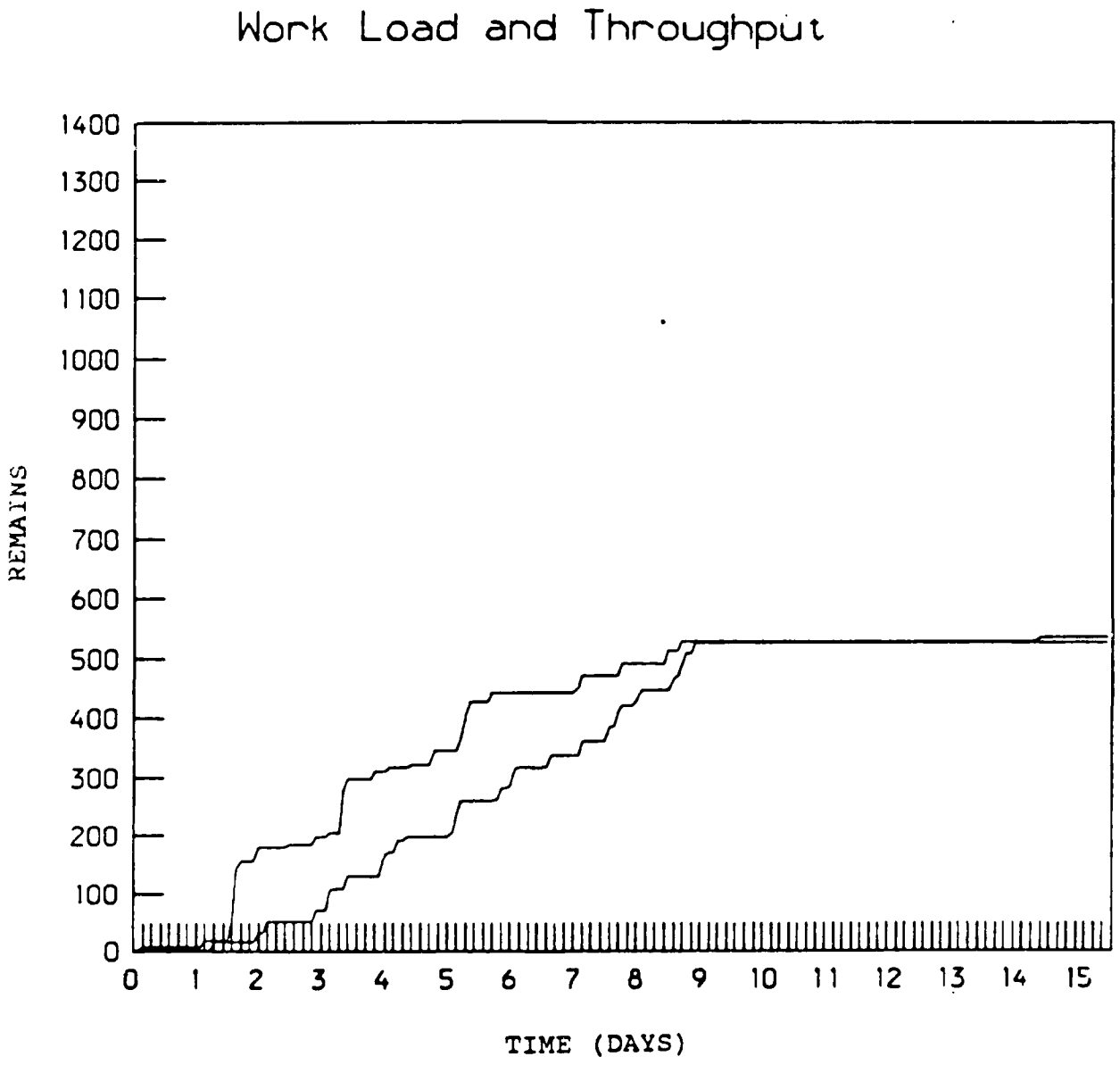


Figure 91. Corps Collection Point 1, Backlog, Evac

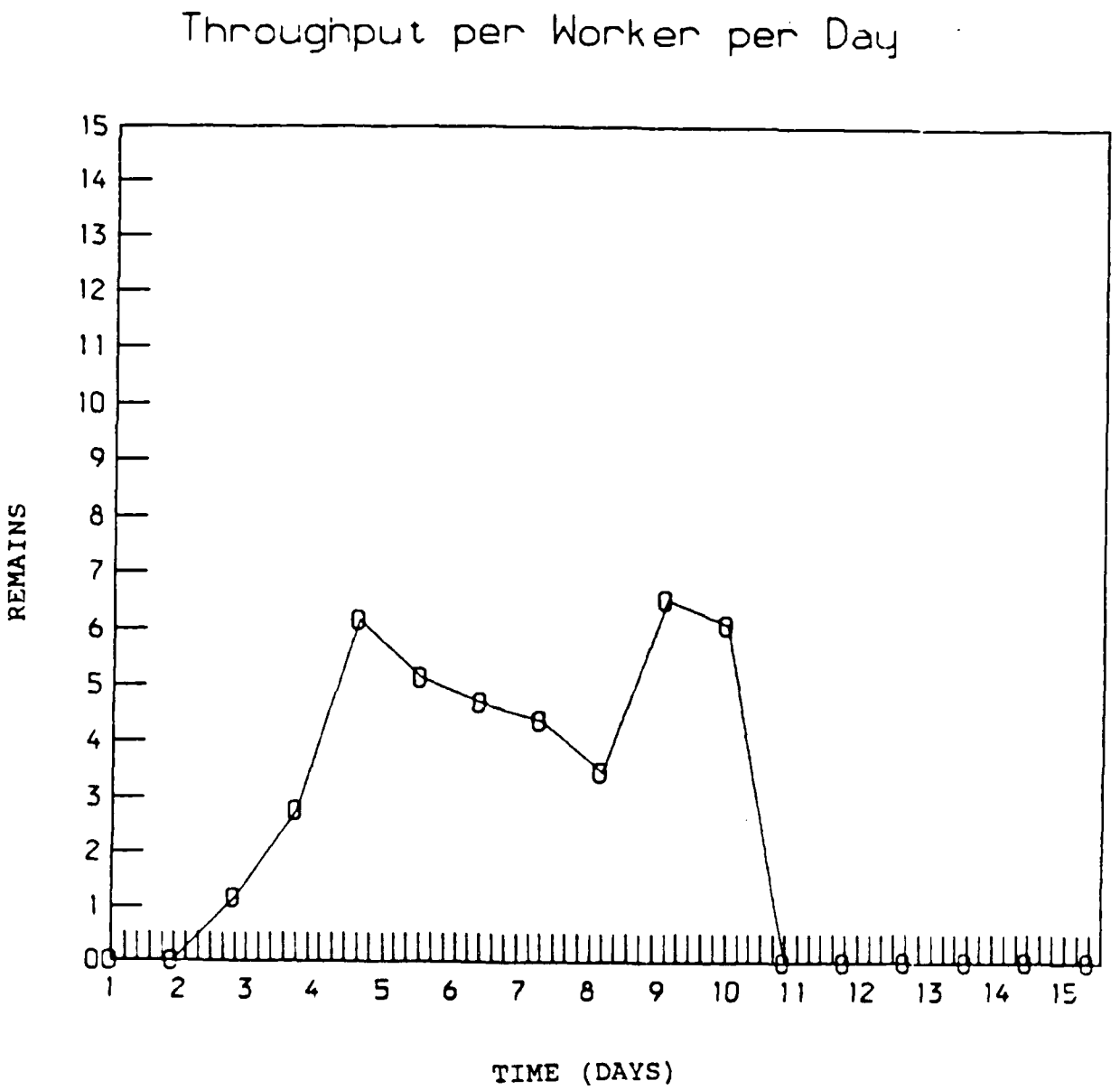


Figure 92. Corps Collection Point 1, Throughput, Evac

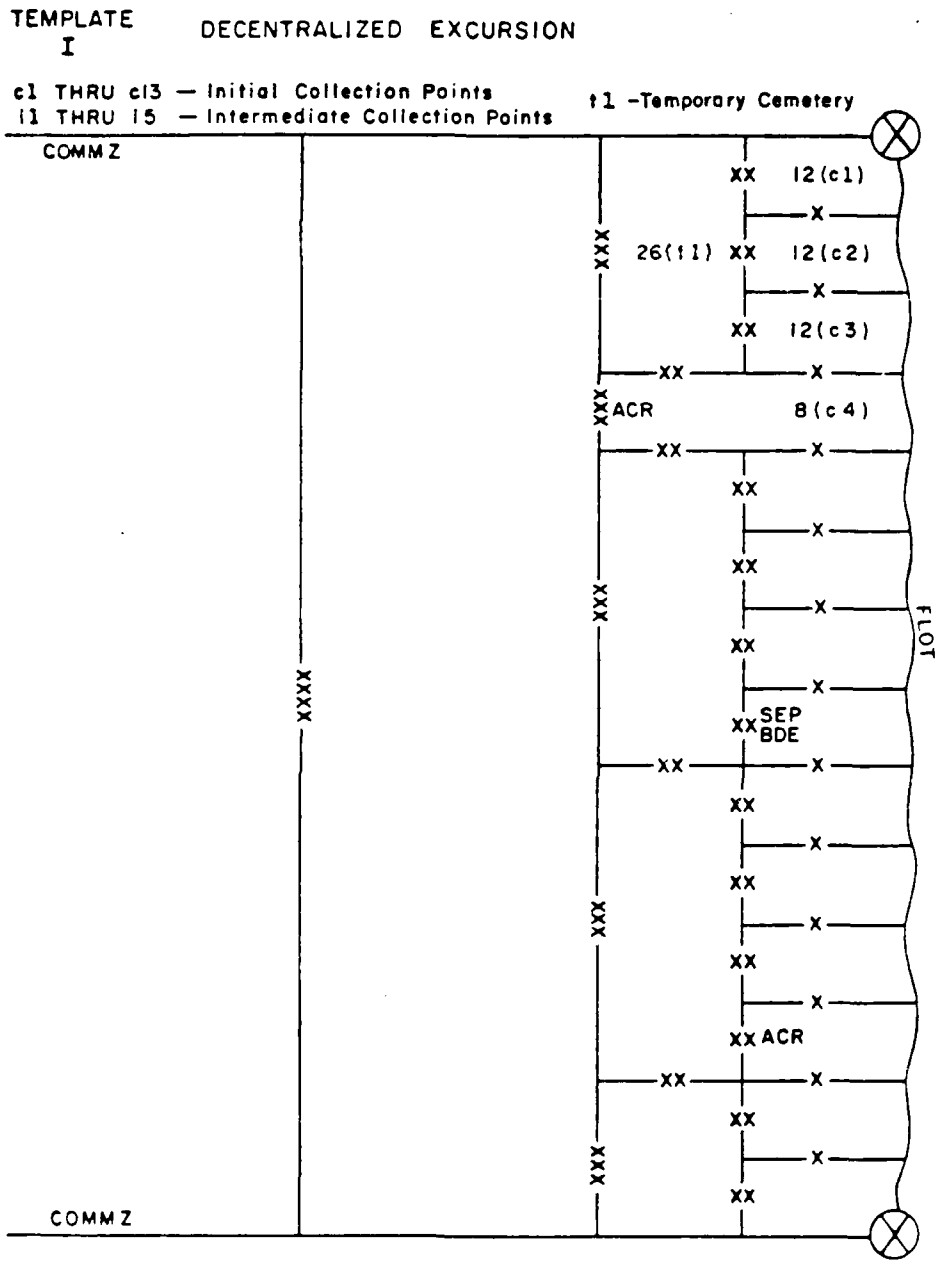


Figure 93. Decentralized Organization

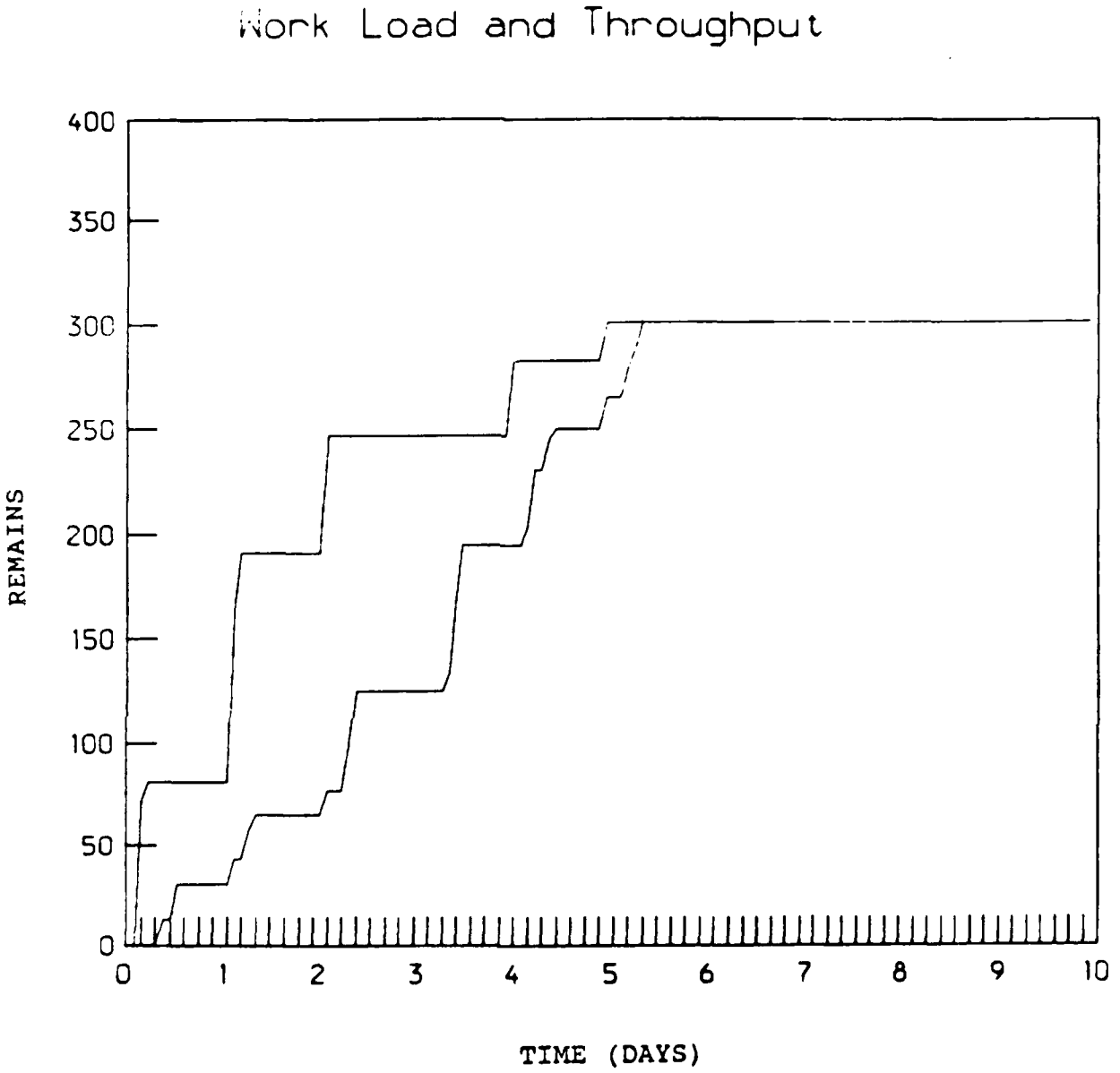


Figure 94. Collection Point 1, BDE, Backlog, Decentral

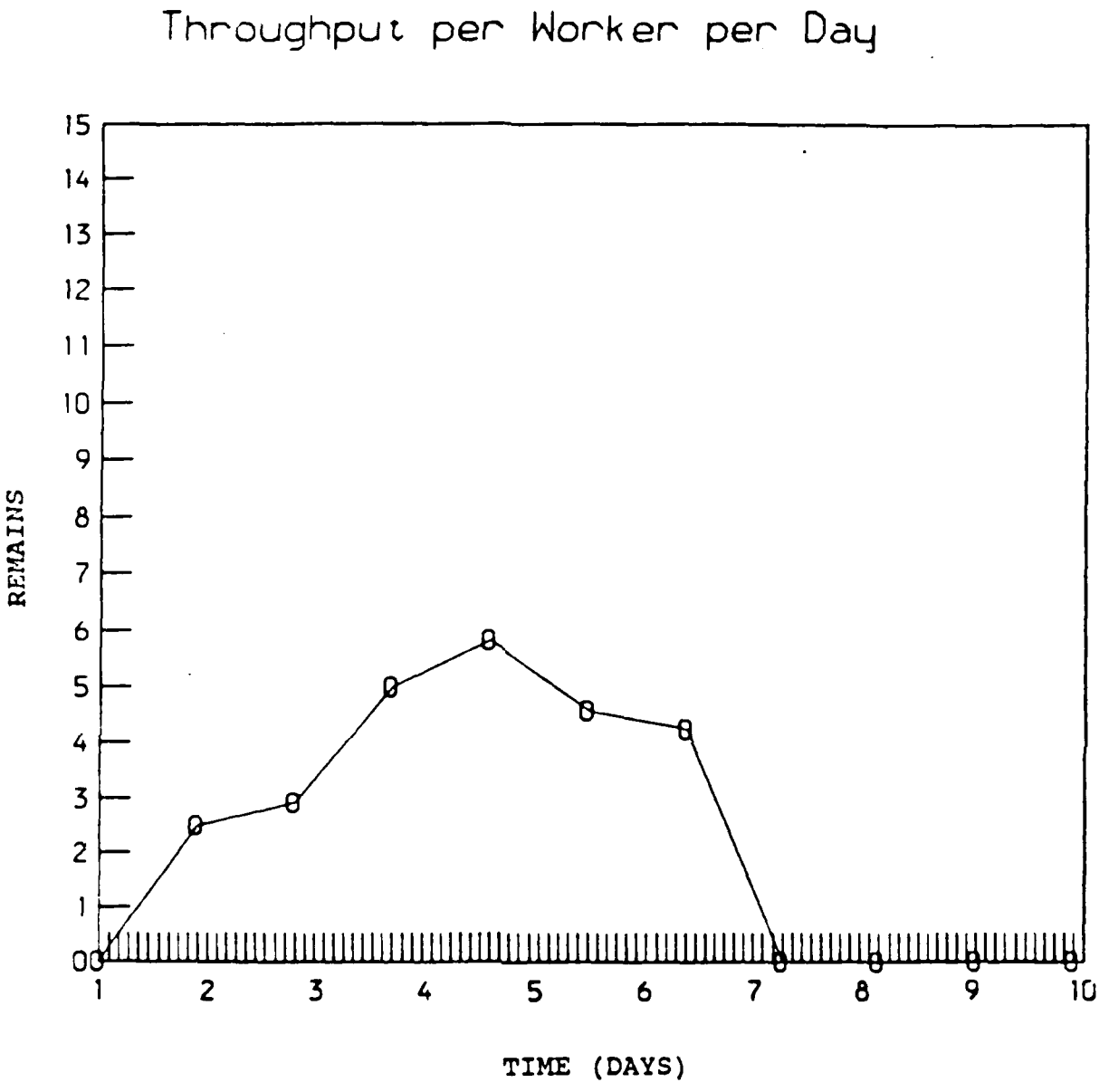


Figure 95. Collection Point 1, BDE, Throughput, Decentral

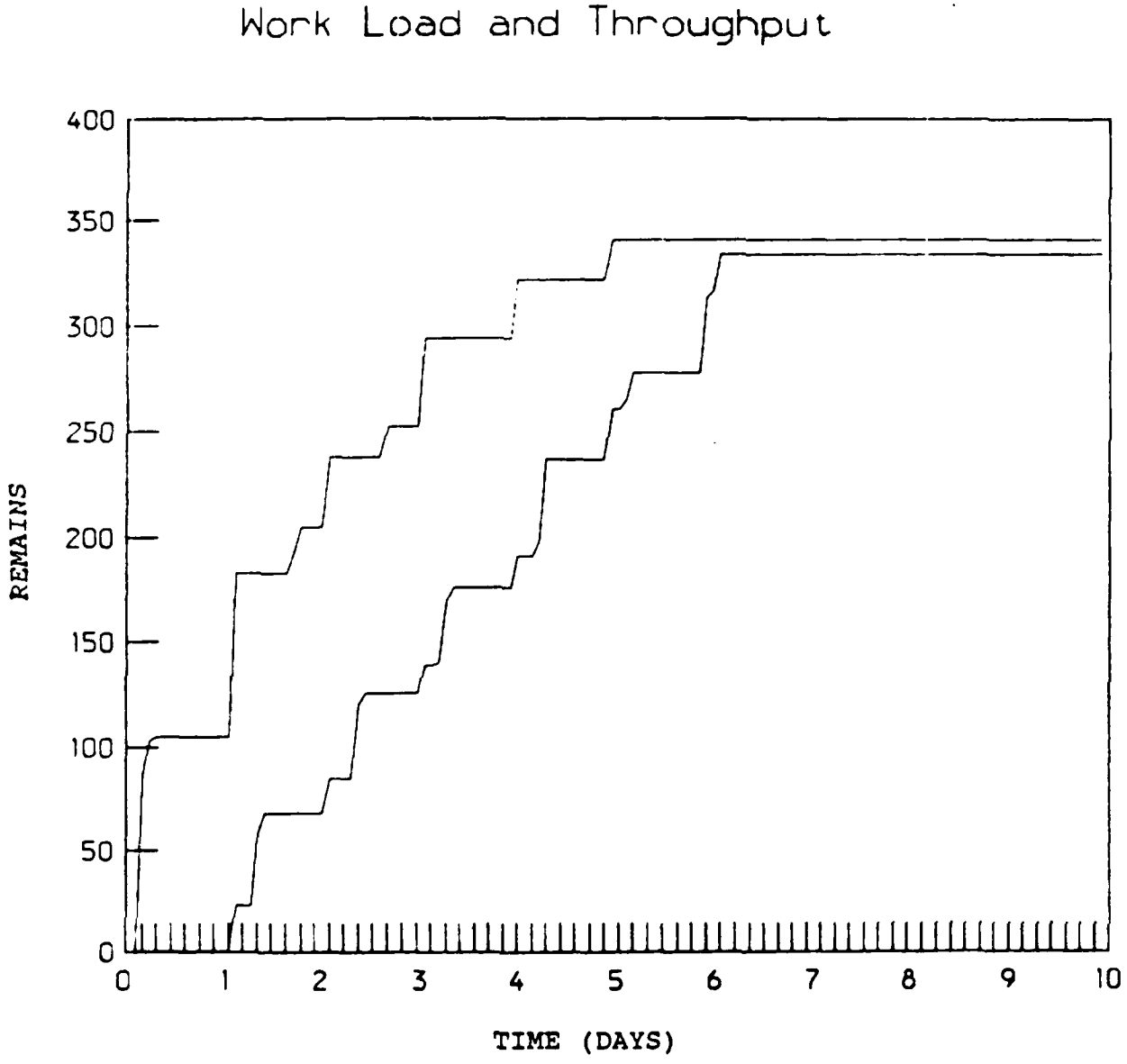


Figure 96. Collection Point 2, BDE, Backlog, Decentral

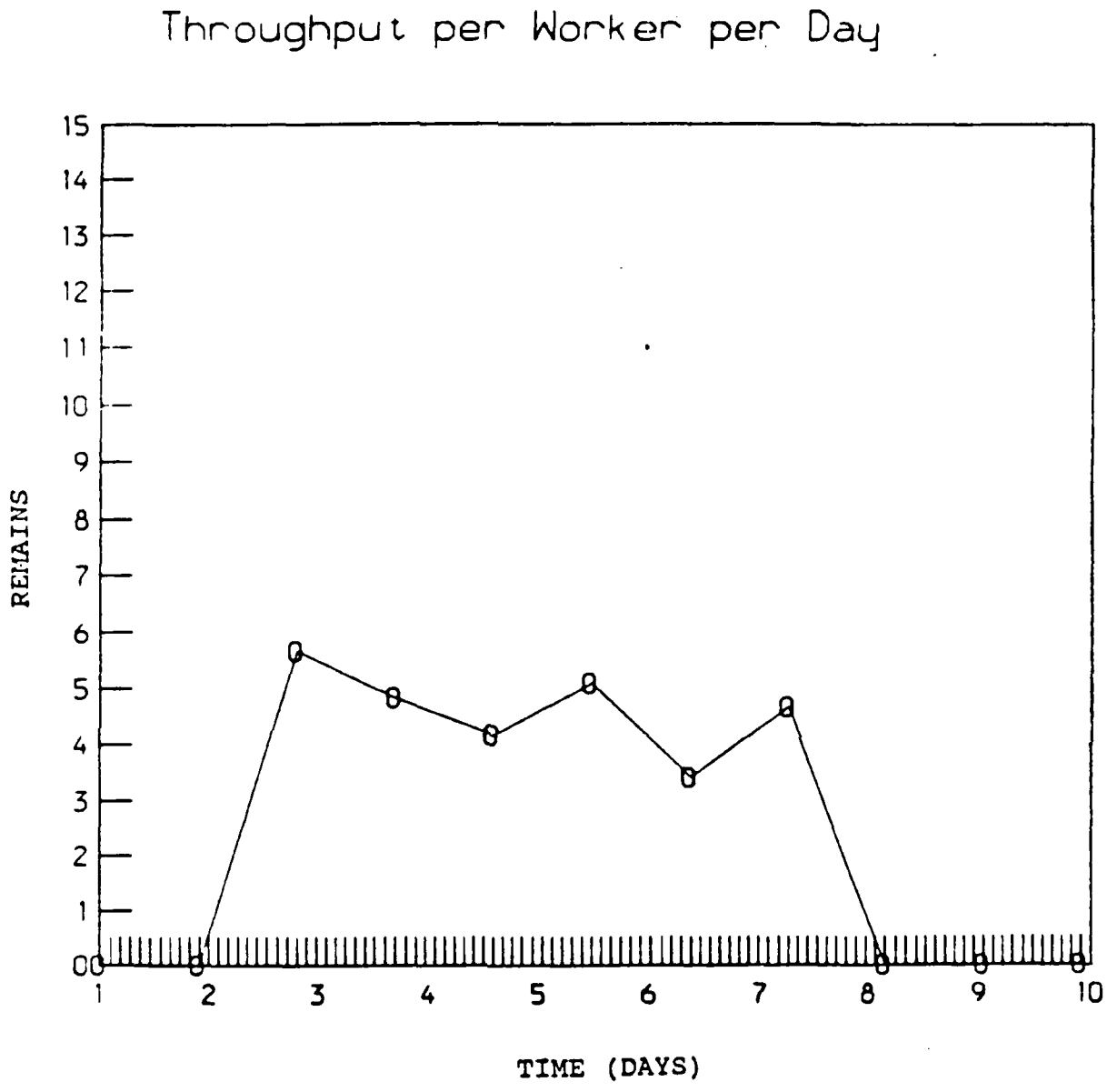


Figure 97. Collection Point 2, BDE, Throughput, Decentral

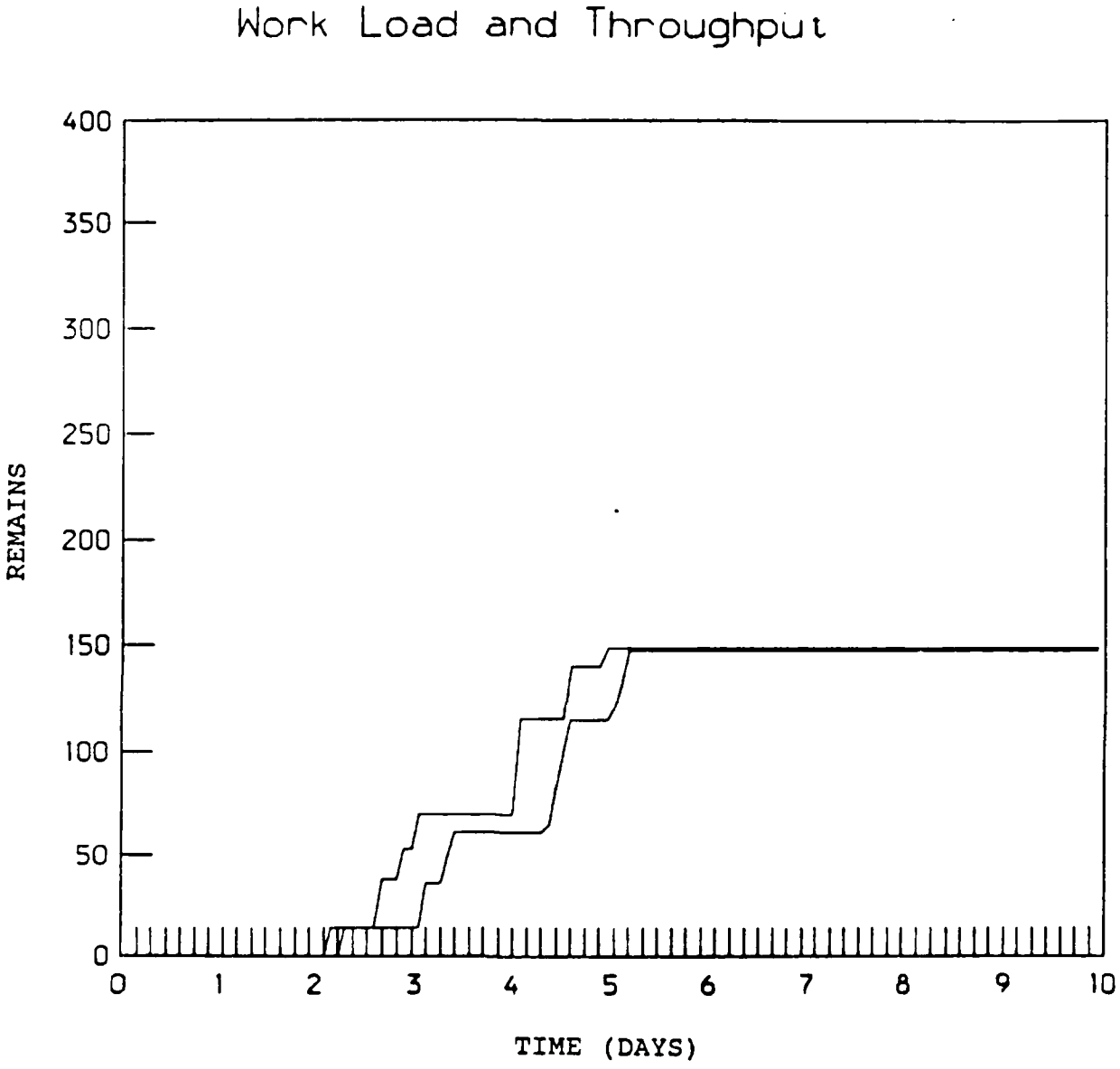
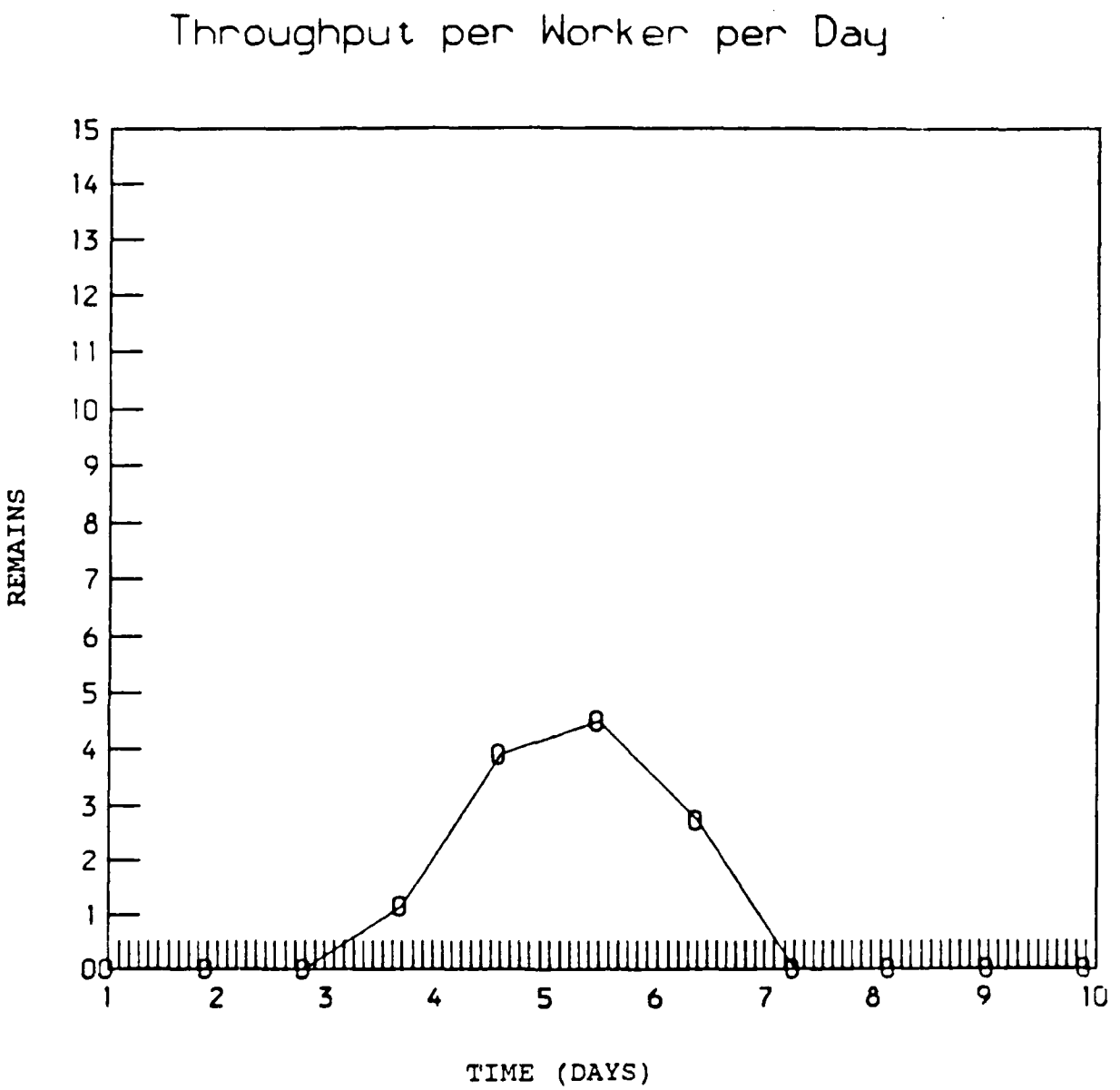


Figure 98. Collection Point 3, BDE, Backlog, Decentral



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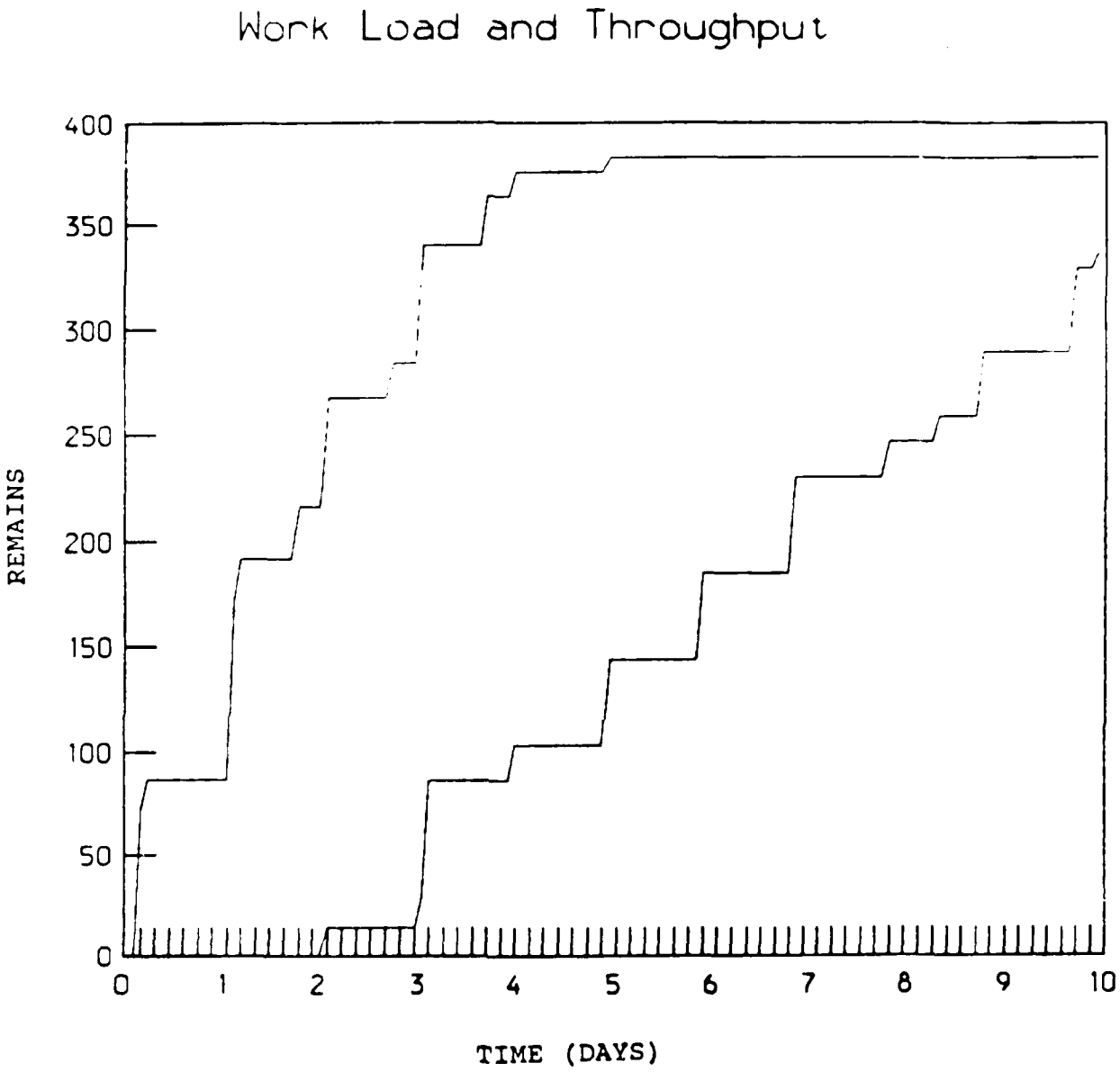
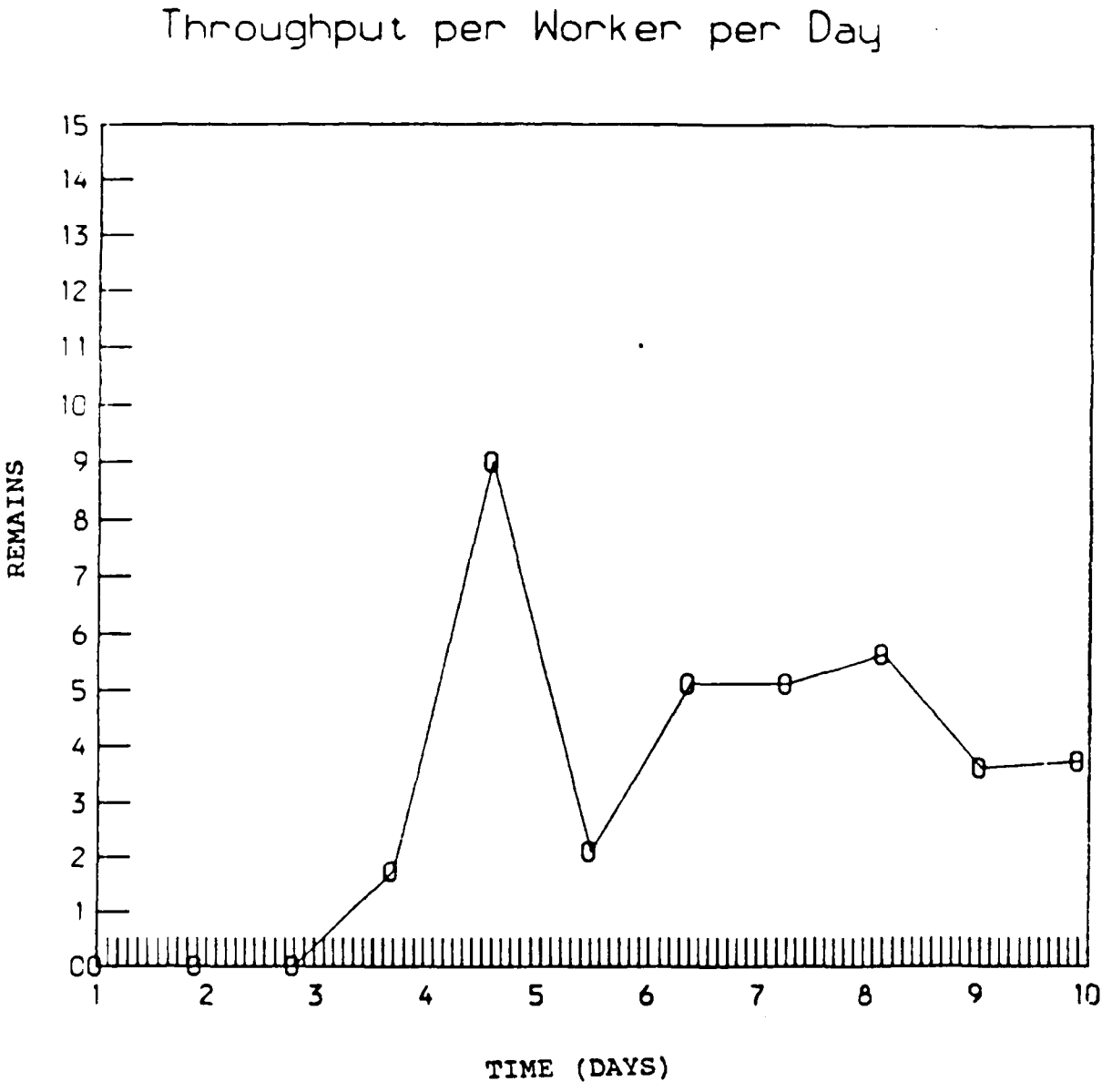


Figure 100. Collection Point 4, ACR, Backlog, Decentral



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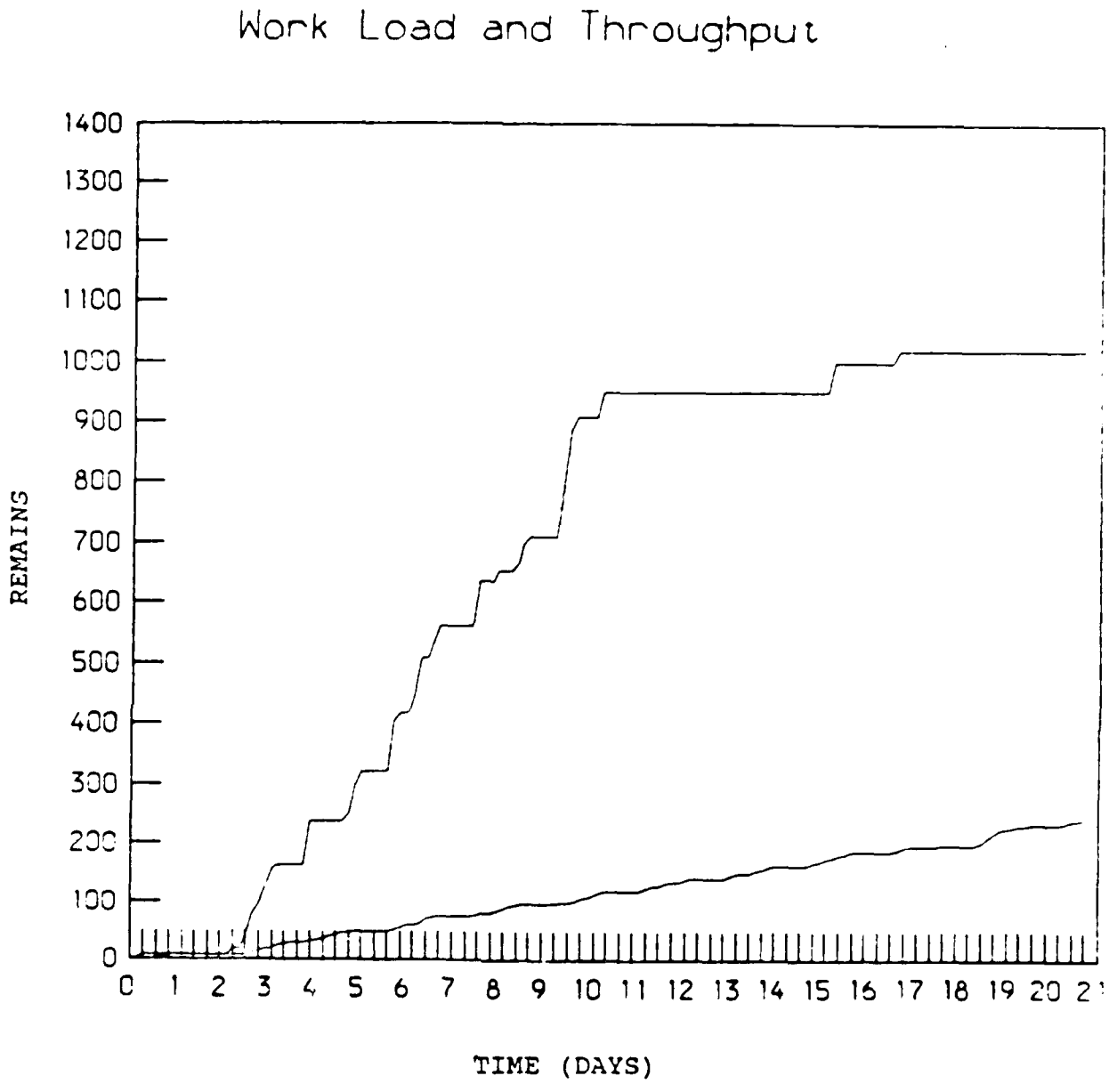

Figure 102. Division Cemetery, Backlog, Decentral

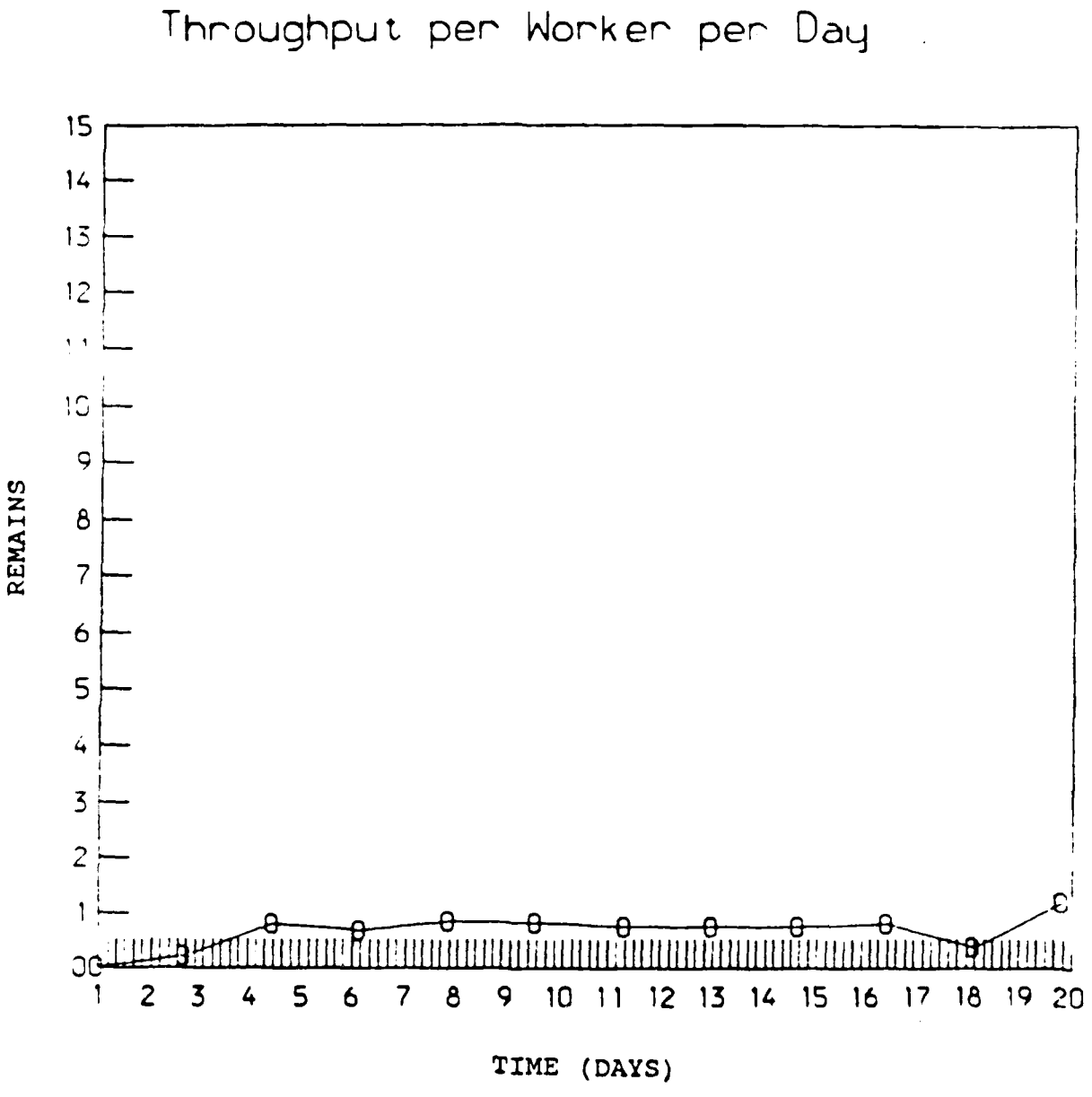

Figure 103. Division Cemetery, Throughput, Decentral

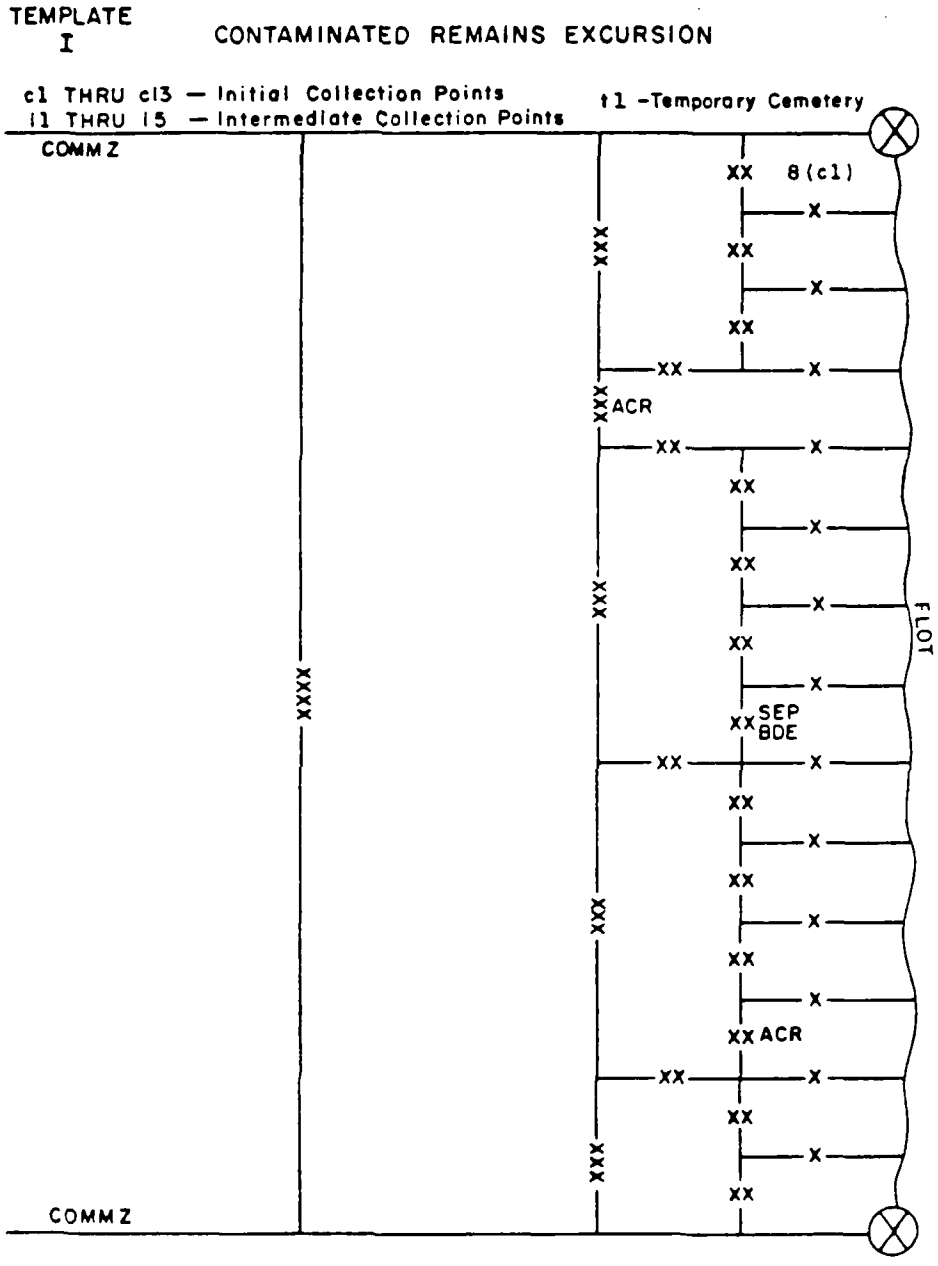

Figure 104. Contaminated Remains Organization

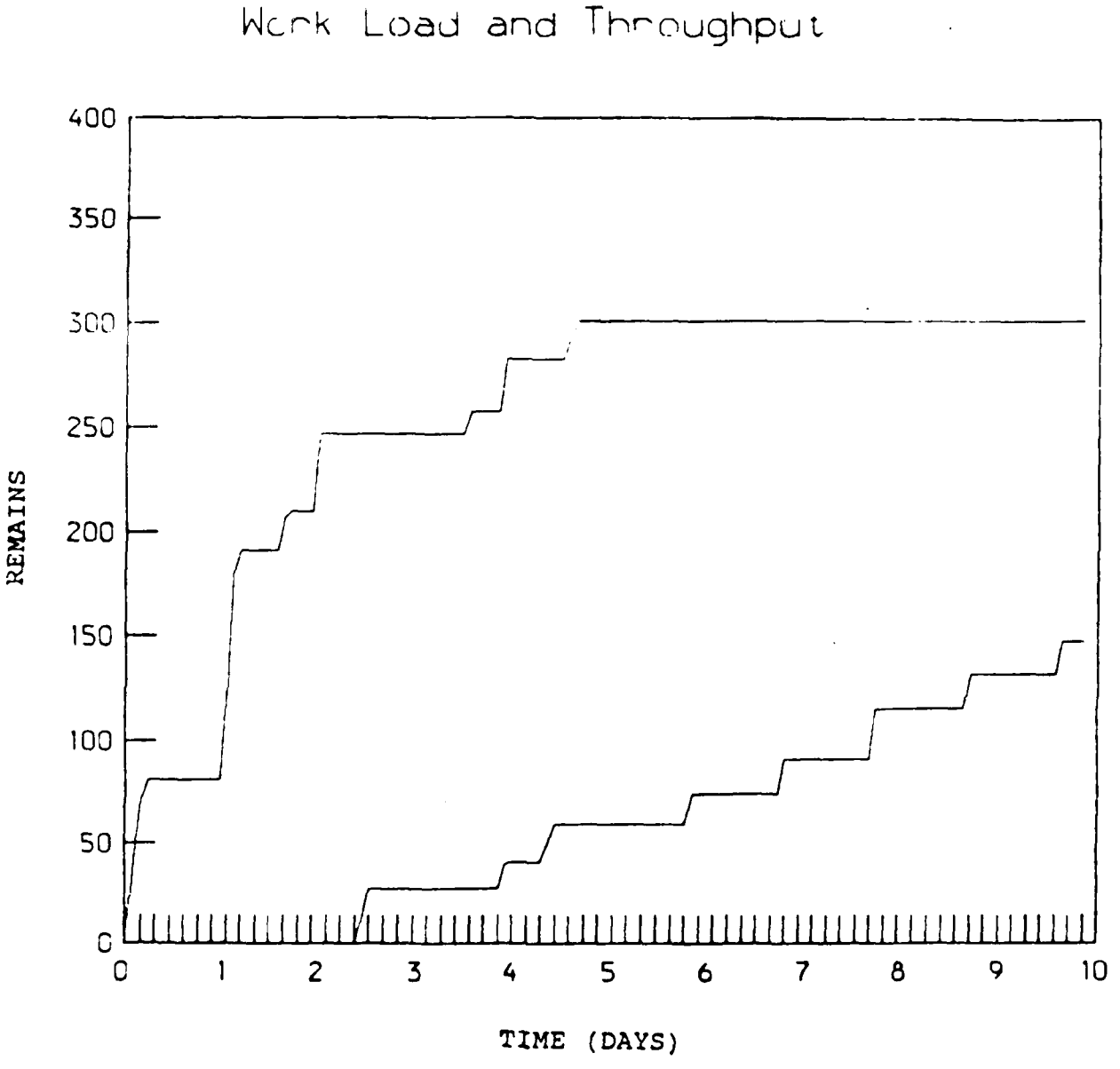

Figure 105. Collection Point 1, BDE, Backlog, Contaminated Remains

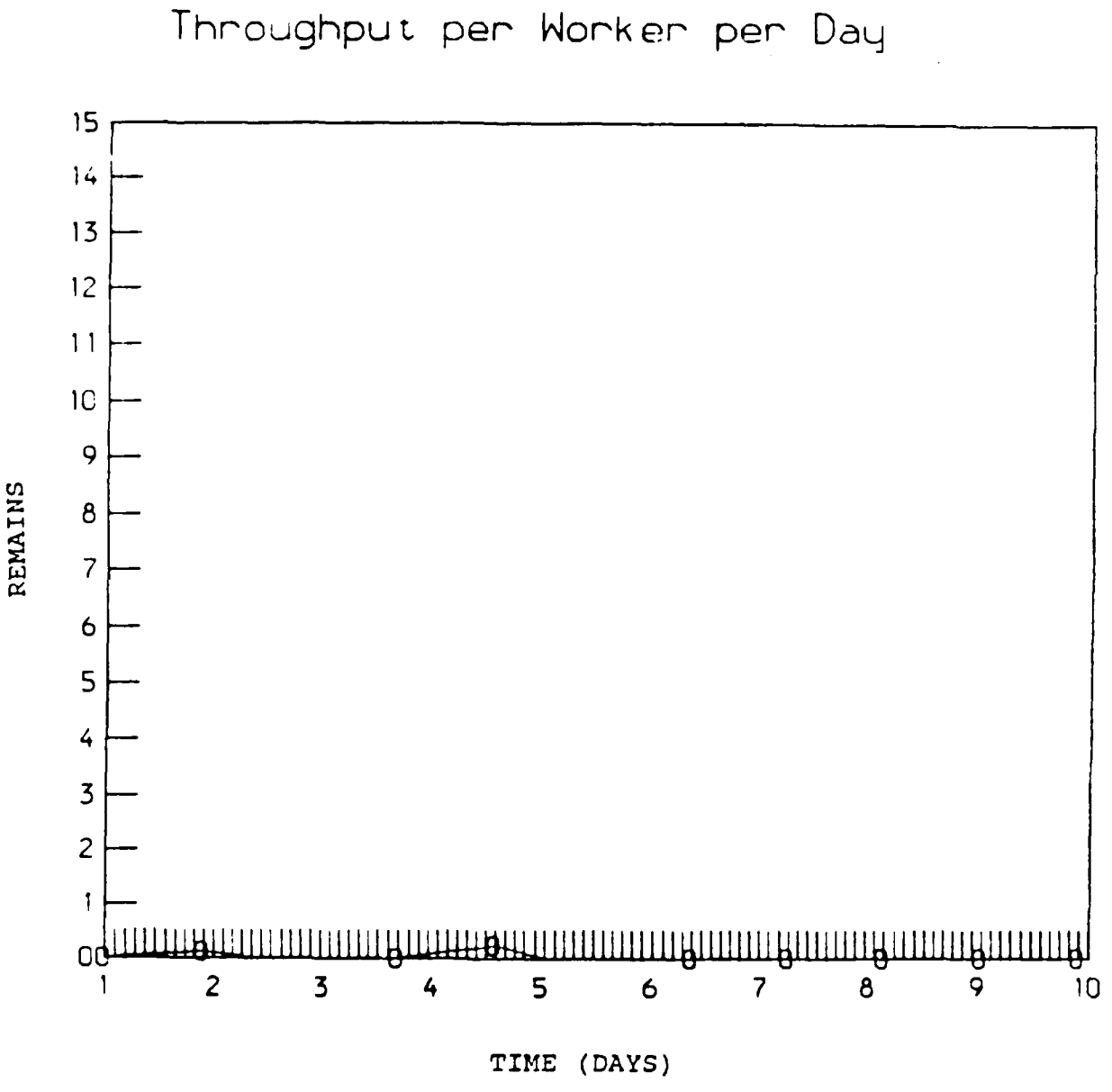

Figure 106. Collection Point 1, BDE, Throughput, Contaminated Remains

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