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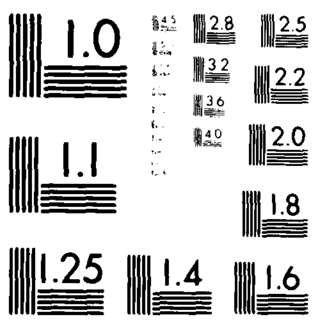

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DEVELOPMENT AND IMPLEMENTATION OF TCOR COMMO

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28 February 1980

Final Report for Period 21 February 1978—30 June 1979

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An existing tactical combat digital computer simulation model was modified and enhanced to more fully explore the role of tactical communications on the modern battlefield. Some of those modifications and enhancements included detailed representation of the communicational system and equipments in that discrete weapons effects (both conventional and nuclear) could be assessed against them. Following development of the prototype capability, four experiments with the

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20. ABSTRACT (Continued)

model were conducted to characterize the performance of communications in terms of the outcome of the battle. The first two of these cases were strictly conventional warfare while the second two cases included the employment of tactical nuclear weapons. In each pair of cases, one run maintained communications operationally perfect (impervious to weapons effects) while the other allowed for battle incurred degradation and losses. Detailed comparisons are made among the cases concluding that communication can indeed be quantified in terms of a force multiplier. Additional model refinement is shown to be necessary, especially in the area of automated command, control, and intelligence processing.

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SECTION 1
EXECUTIVE SUMMARY

1.1 DNA-TCOR OVERVIEW

The DNA-TCOR model represents an important step in meeting the needs for a mixed, conventional-nuclear, theater level, combat-arms model to examine the issues of modern conflict. The uniqueness of the interactions represented and the complexity of the conditions analyzed are a major advance in combat modeling. TCOR achieved this by discretely characterizing the battlefield and the combatants, and allowing analysis of modern ground combat maneuvers in a highly mobile war. The model features mixed event scheduling and time stepping, variable time steps, mixed Monte Carlo and expected value techniques, and automated decision making and planning at several levels of detail. The model is highly efficient; it is easy to use and modify due to the modular, top-down structured programming techniques used for code generation.

TCOR has a distinct separation of the mental and physical processes. Units which are able to issue orders to other units are called "players." Units that have a physical location are called "pseudo-players." A battalion, which commands companies, the lowest level unit in this study, is a player. Its headquarters company and each of the companies in the battalion are pseudo-players. Physical actions affect pseudo-players. The group of TCOR modules that model physical actions are called the of Combat Interaction and Communications (CIC) set. Purely mental actions are modeled by the Command, Control, and Information (C^2I) set of modules. The C^2I set processes only the players. Figure 1 depicts schematically the overall simulation concept.

In TCOR, the modules do not pass information to each other. All communications is through the Simulation Control Software (SCS). Events are scheduled to begin happening at some future point. The details of this go on a future event list (FEL) and on the discrete event list (DEL). A module called SELECT takes the event off the DEL and determines which module should be engaged to work the event.

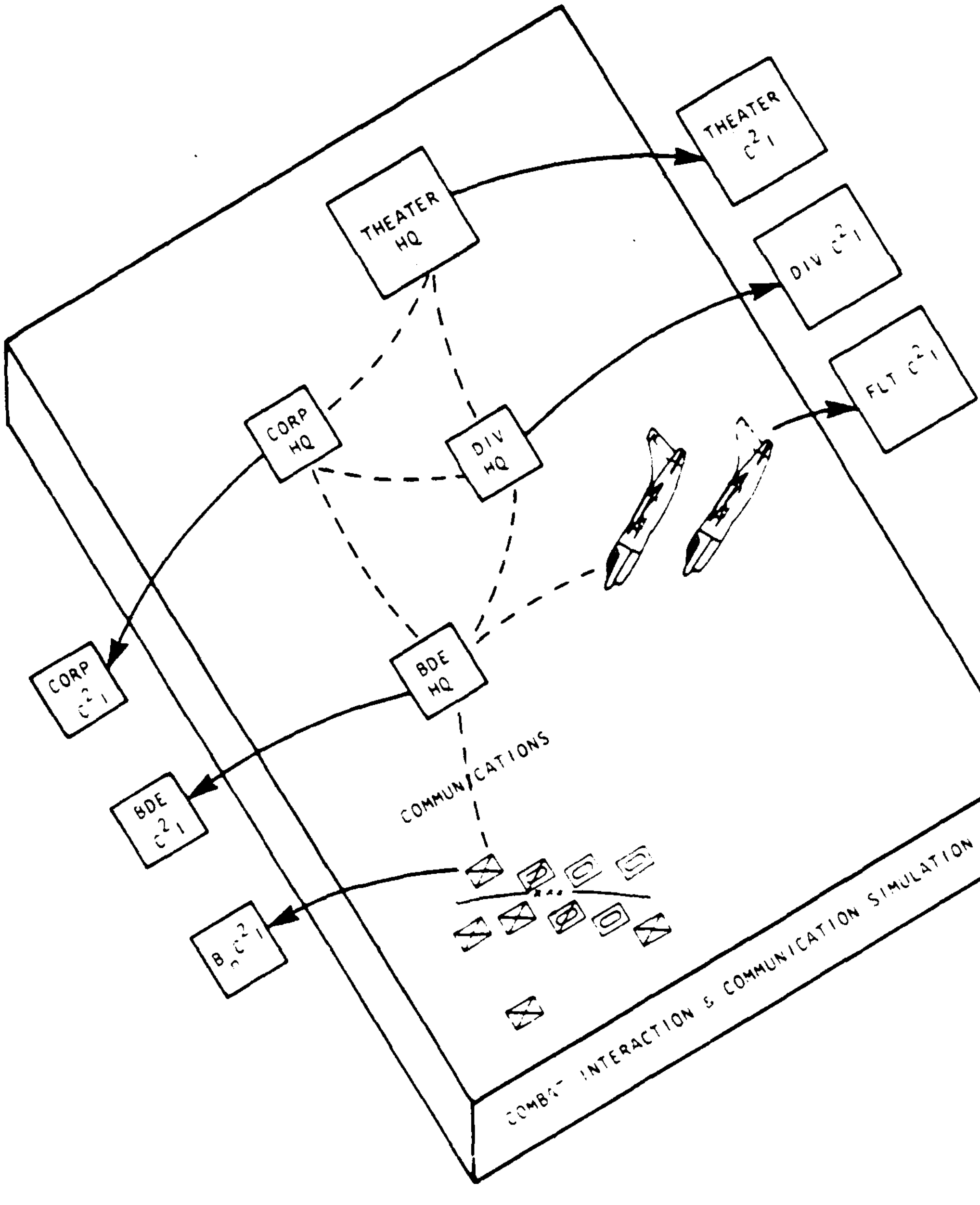


Figure 1. C^2I/CIC concept.

A key feature of the C^2I/CIC concept is the inclusion of the human player. This feature permits the Man-in-the-Loop (MITL) to enter the C^2I process and introduce new OPORDs to the units.

1.2 TRACE ENHANCEMENTS

As the acronym TRACE (TCOR Revised to Assess Communications Effectiveness) implies, the basic DNA-TCOR tactical wargam~~m~~ing model was modified, extended, and enhanced by BDM to form an analysis tool that focuses on the role of tactical communications.

BDM expanded the number of distinct types of messages and their contents was expanded. Figure 2 portrays a BDM-developed detailed message transmission processing module. An associated module permitted radios and their carriers to be attrited like any other resource in the model. (There were no replacements for any resource.) Conventional Pk's were developed and analyzed. Each weighted average Pk was converted to a Pk per unit time to be used in the model. Vehicles containing communications equipment were vulnerable to the extent of this Pk from both indirect and direct fire from the enemy. BDM created a whole new Nuclear Weapons Effects (NWE) module to handle the nuclear effects on the communications equipment. This module consisted of seven new routines that check the nuclear effects against various types of radios and their carriers and shelters.

Probably one of the most important developments was the addition of the post-processing capabilities. Prior to this time, there was little or no analyzable output from the model. Three files were created: a checkpoint file, a communications file, and a status file. The checkpoint file holds data needed to restart the simulation. The communications file holds communications for the MITL. The status file contains selected statistics.

Responses to many stimulae were added to the C^3 functions of the model. Prior to TRACE improvement, model sensitivity to the battlefield environment was very small and primitive.

1.3 CASES EXAMINED

BDM conducted four experiments using the prototype TRACE model; specifically, these cases explored the progress of friendly forces, with

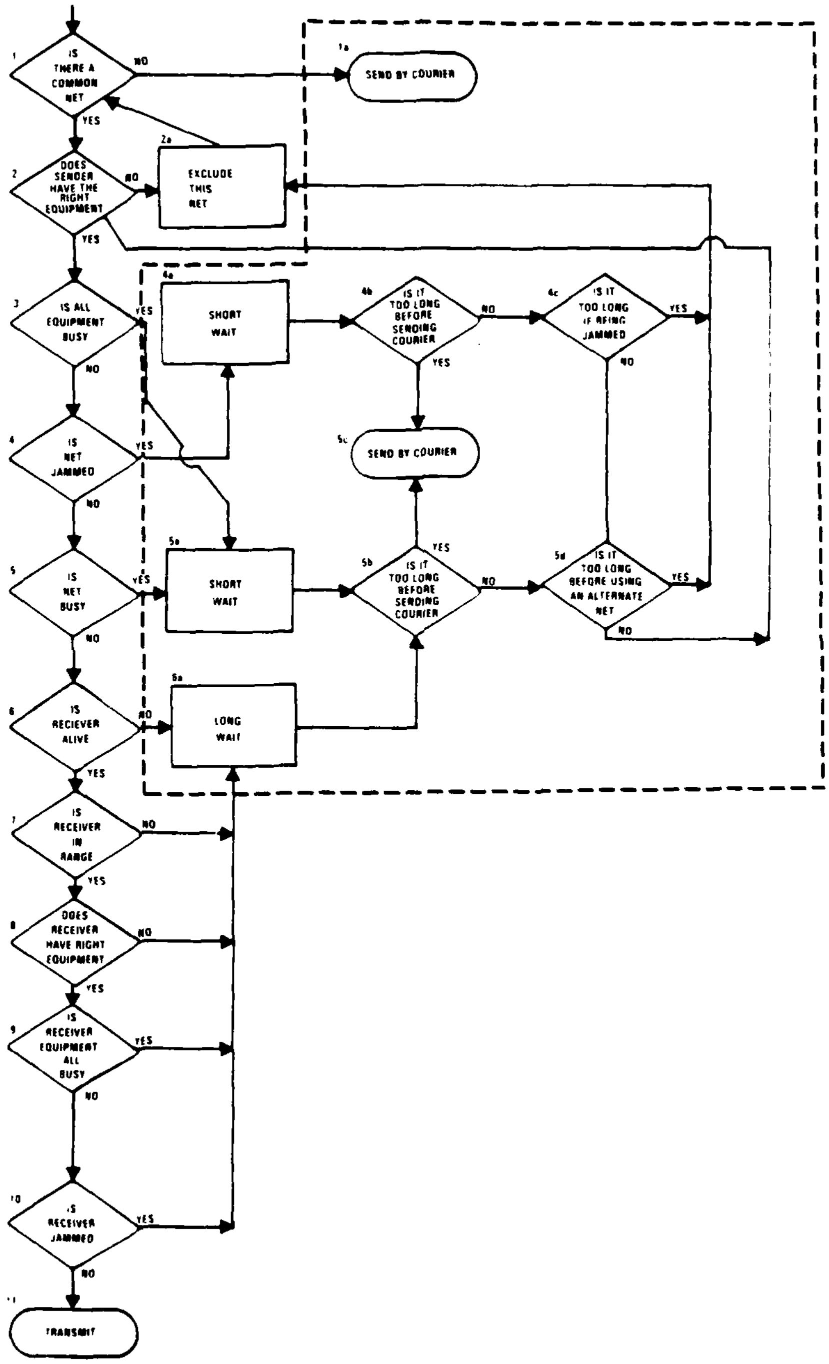


Figure 2. Communications logic flow diagram.

nondegradable and with degradable communications, in a conventional and mixed conventional and nuclear environment. The scenario used in the four experiments represented a Red tank division breaking through a defensive line held by one of the two forward brigades of a Blue armored division. Figure 3 depicts the Red a two echelon attack: a tank and a mechanized regiment followed by two tank regiments. During the conflict a BDM staff member acted as the MITL. He had previous field command experience and was otherwise not associated with the project. Every two hours (by the simulation clock) the TRACE project staff briefed the MITL on the progress of the battle. This briefing was based solely on the communications received at the MITL's headquarters. It was presented in the form of a map overlay showing unit locations. All orders given by the MITL were then injected into the model and another two hours were simulated. During the nuclear cases the MITL had direct control of all friendly nuclear releases.

1.4 RESULTS AND ANALYSIS

The four experiments were numbered in order of production and will be referenced by their number.

Case I	Conventional War - No communications degradation
Case II	Conventional War - Communications degradable
Case III	Nuclear War - No communications degradation
Case IV	Nuclear War - Communications degradable

There were also two experiments called Case III-FP and Case IV-FP. The FP stands for "free play." In these cases, there was no MITL nor any human intervention. At first these cases were intended as a checkout of the model. However, the results were sufficiently interesting to include for comparison with the cases involving the MITL. The drawdown of combat resources was analyzed extensively. The expenditure of ammunition by supporting forces were linked directly to communications performance. Loss exchange ratios were developed for all six cases in the form of Red unit loss per Blue unit loss. Cases I and II, III and IV, and III-FP and IV-FP were then compared against each other and the results normalized. Figures 4 and 5 show the results graphically at the 5½ and 8½ hour point in

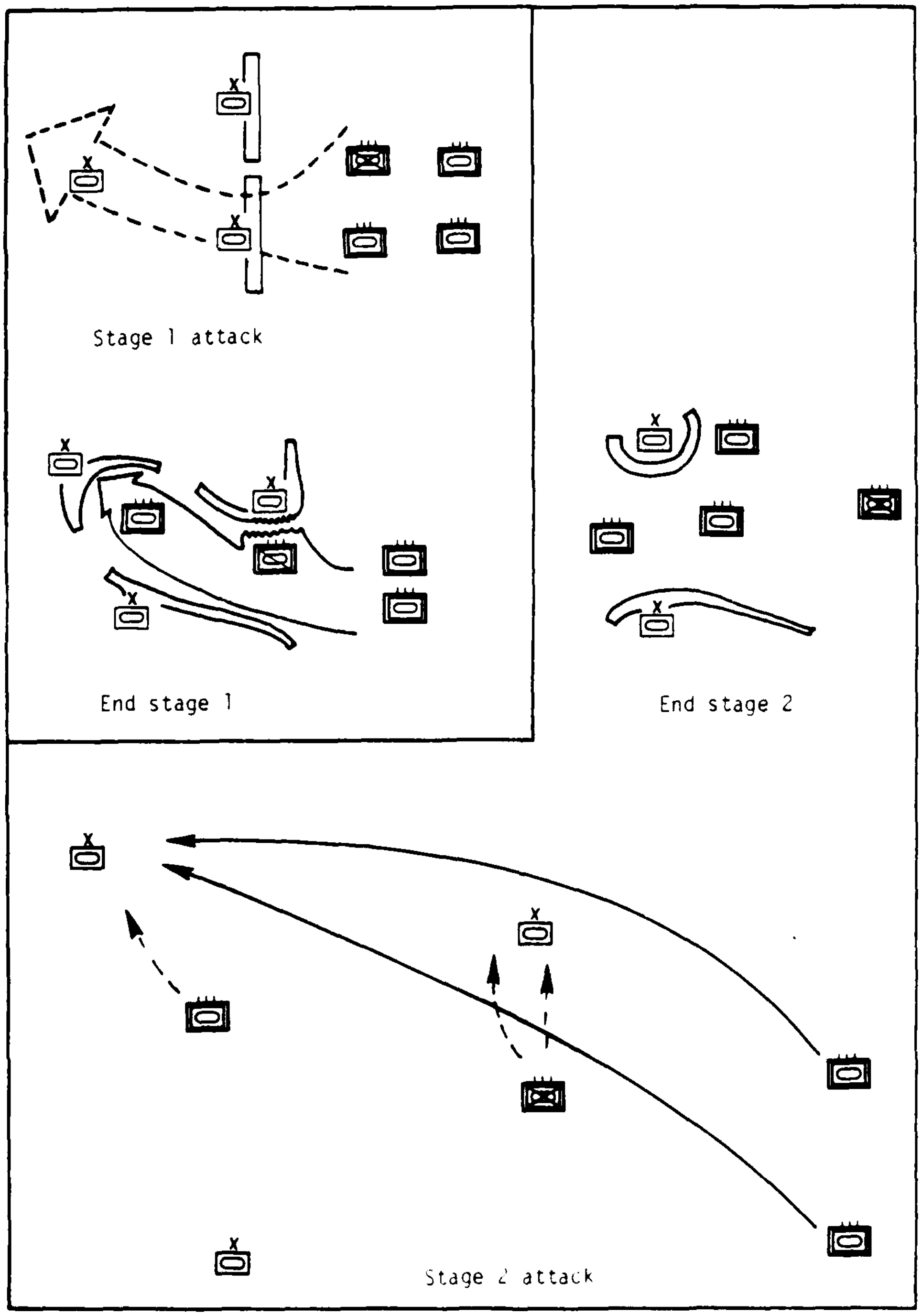


Figure 3. Red two echelon attack.

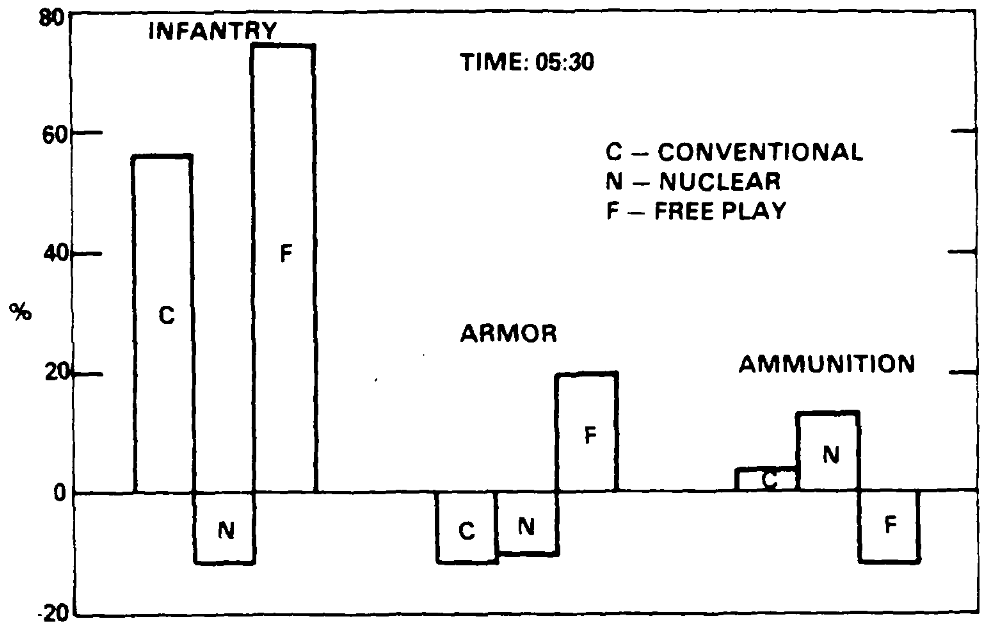


Figure 4. Degraded and non-degraded communications loss exchange ratio comparisons at 0530.

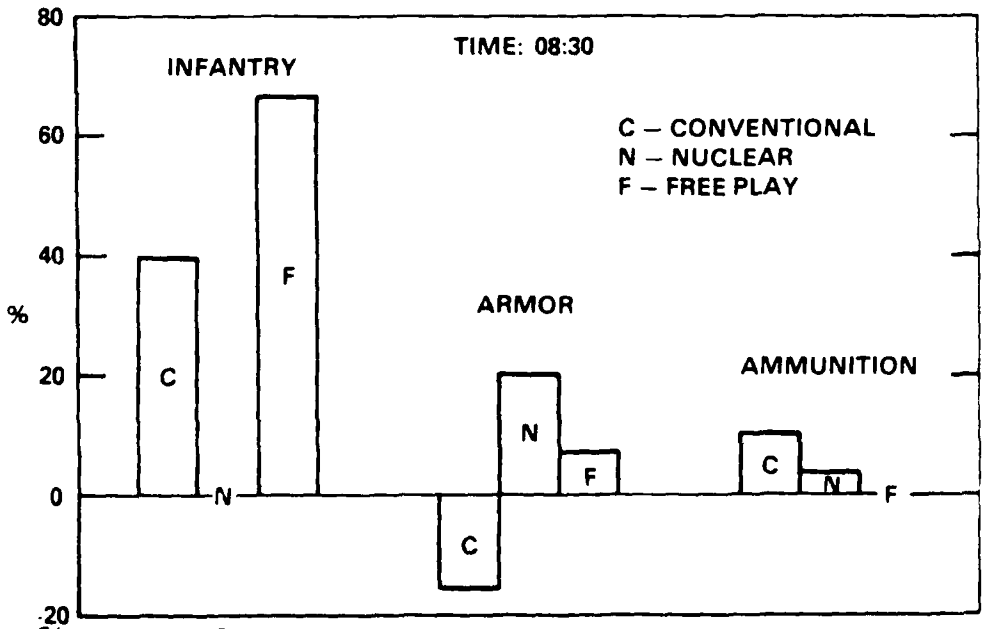


Figure 5. Degraded and non-degraded communications loss exchange ratio comparisons at 0830.

the conflict. A consistent technique for measuring ground loss was developed and applied against the maps generated by the TRACE post-processor. Combining this ground lost with the combat resources lost by both sides, a payoff parameter (P) was developed for Blue.

$$P = \frac{(\text{Red resources lost})}{(\text{Blue resources lost})\ (\text{Blue ground lost})}$$

Comparing the cases in the same fashion as before, P (nondegradable communications) is shown in Table 1.

Table 1. Case payoff parameters and comparisons

CASE	PAYOFF	RATIO
I	.0152	1.103
II	.0138	
III	.0165	.732
IV	.0225	
III-FP	.0160	1.341
IV-FP	.0120	

1.5 CONCLUSIONS AND RECOMMENDATIONS

This study began with the hypothesis that communications aids performance on the battlefield. The results did not prove this in a statistically significant manner. In a subjective sense, it could be seen that the communications did aid the MITL in conducting the battle. The main difficulty in proving the initial hypothesis was the lack of statistical confidence in the results generated by the set of cases run. This study has shown that improved communications has a measurable effect on the progress of the battle and the C^2 capabilities of the commanders. The study gave evidence that good communications acts as a force multiplier but was not able to measure this multiplier. It did point out the interfering conditions and the path to parameterizing most of them. Hence, this type of analysis shows promise for isolating and measuring the force multiplier. Further study may now follow two different directions. Although seemingly in the opposite directions, they are not mutually exclusive and should be considered together.

The first direction is a proper simulation study totally excluding human induced variance. This requires that the C^3I functions be automated totally. It also requires acceptance of the belief that artifical intelligence (AI) can reasonably reproduce the C^2 thought processes. Once a suitable C^2 AI system is placed into a model like TRACE, autoregressive analysis can be used over a number of sets at similiar cases where each set has a number of runs in it sufficient for statistically sound results. Degradation of communications could then be quantified and tests made to determine the distribution of the communications force multiplier.

The second direction is the gaming approach. This approach does not require belief in the ability of AI techniques. A group of MITLs is assembled and trained. Each MITL participates in about 30 cases -- sufficient number to make small samples techniques applicable. Mean results can be determined across a MITL's group of cases. By an extention of the Central Limit Therom, it is known that these means are normally distributed. This facilitates meaningful statistical analysis of the crosscorrelations of the degradation parametric variations in a commander's ability to perform his function. In this way, the force multipliers can be indirectly measured.

SECTION 2
DNA-TCOR OVERVIEW

2.1 INTRODUCTION

The DNA-TCOR model represents an important step toward meeting the need for a mixed, conventional-nuclear theater level combat-arms model to examine the issues of modern conflict. The uniqueness of the interactions that had to be represented and the complexity of conditions to be analyzed required a major advance in combat modeling. TCOR achieves that goal by characterizing the battlefield and the combatants discretely, allowing analysis of modern ground combat manuevers and the use of air power in a highly mobile war. The model features mixed event and time stepping, variable time steps, mixed Monte Carlo/expected value techniques, automated decision making and planning at several levels of detail, and a modular, top-down structured approach to computer code generation. The integration of these techniques has resulted in a model which is efficient, transparent, virtually self-documenting and easy to use and modify.

2.1.1 Concept for Separating Mental and Physical Processes

The actions of all modeled units, including the command elements, are processed by two different sets of modules depending on the nature of the actions. If the unit actions are physical, such as moving, acquiring targets, or firing, they are modeled within the Combat Interaction and Communication (CIC) set. Any action that is purely mental and occurs within the unit or command element is processed by models within the Command, Control, Information (C^2I) set. Together, these two sets are referred to as the C^2I/CIC concept.

Since all of the command elements and the communications networks physically exist on the tactical battlefield, they are represented in the combat interaction simulation as shown in Figure 6. All units with command level responsibilities are considered to be "players." Within the corps area, the battalions are the lowest level players, having command of the companies. The brigade, division and corps are also treated as players. The lowest level units are "pseudo-players." In this representation, the

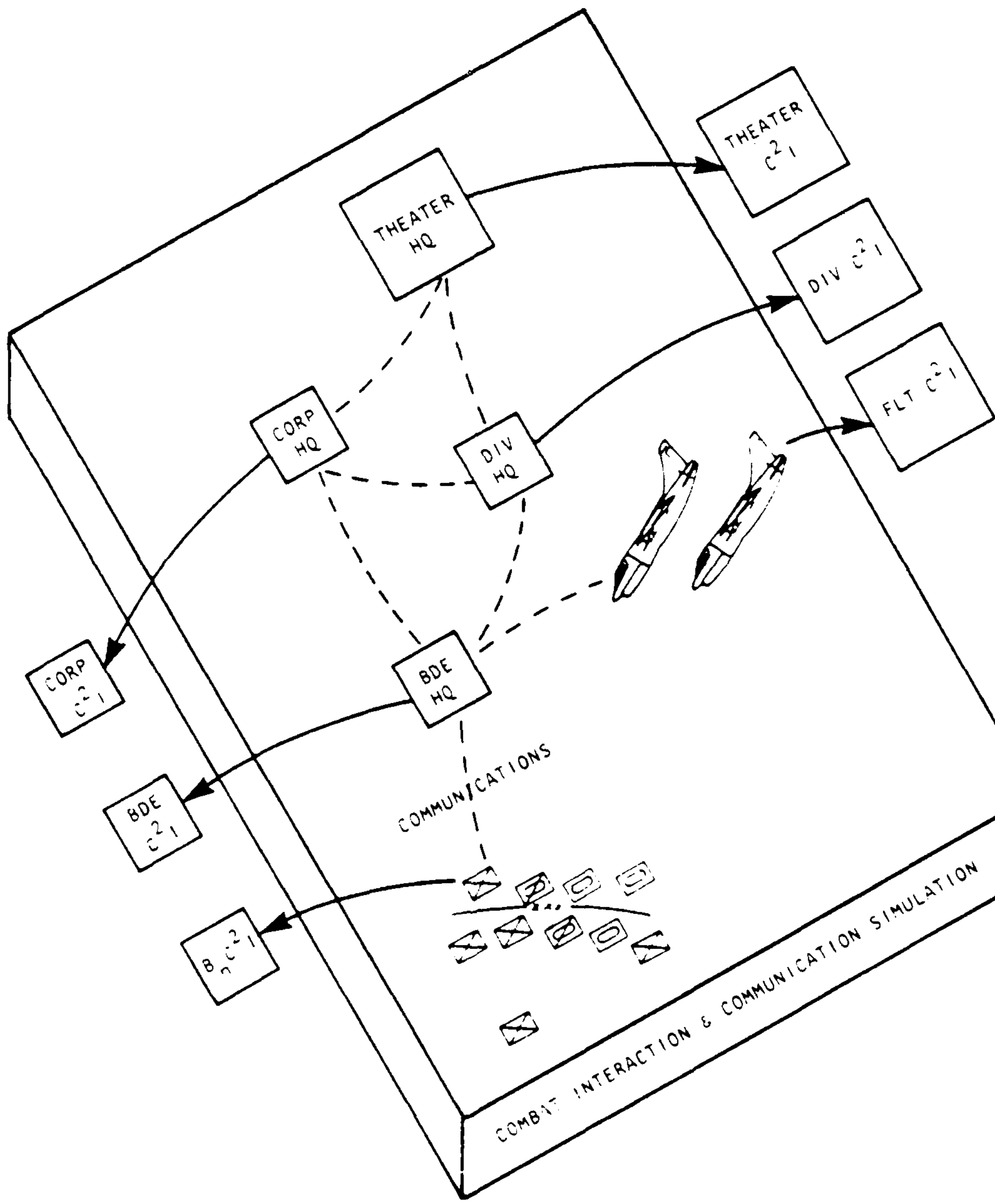


Figure 6. C^2I/CIC concept.

CIC simulation treats all command units in the same manner as the maneuver and artillery elements are treated. The combat interaction model treats each of the physical actions taken against the pseudo-players. The headquarters units of the players are themselves pseudo-players. In such a configuration, the CIC simulation calculates damage done to the headquarters and the movement of the headquarters when these actions are appropriate. In addition, the CIC simulation models the physical communications network when it is under attack.

When a message reaches a player via an appropriate communications network, the modeling of the mental processes is done in decisionmaking C^2I modules. The command element's physical activities take place within the CIC simulation, but all modeling of decisionmaking is done in the C^2I simulation. After a decision is made, the resultant order message is returned to the "physical" commander within the CIC simulation for transmission to other players via the appropriate communications network within the CIC simulation. Basically "players" are C^2I entites and "pseudo-players" are CIC entities.

The C^2I processor in TCOR consists of a system of individual models which process the decisionmaking actions of the various players. These modules do not communicate or interface directly with one another but only with the Simulation Control Software (SCS). The CIC is similarly composed of a system of modules, each processing different actions of the various pseudo-players. As in the case of the C^2I modules, these are written so that they do not communicate with each other but only with SCS.

2.1.2 TCOR Structure

The major functional areas of TCOR are:

(1) Automated Data Base,
(2) C^2I/CIC Process Modules,
(3) SCS,
(4) Simulation Data Structure, and
(5) Man-in-the-Loop (MITL) capability.

The general structure of TCOR, as shown in Figure 7, is described in this section. Each component is described in detail in subsequent sections.

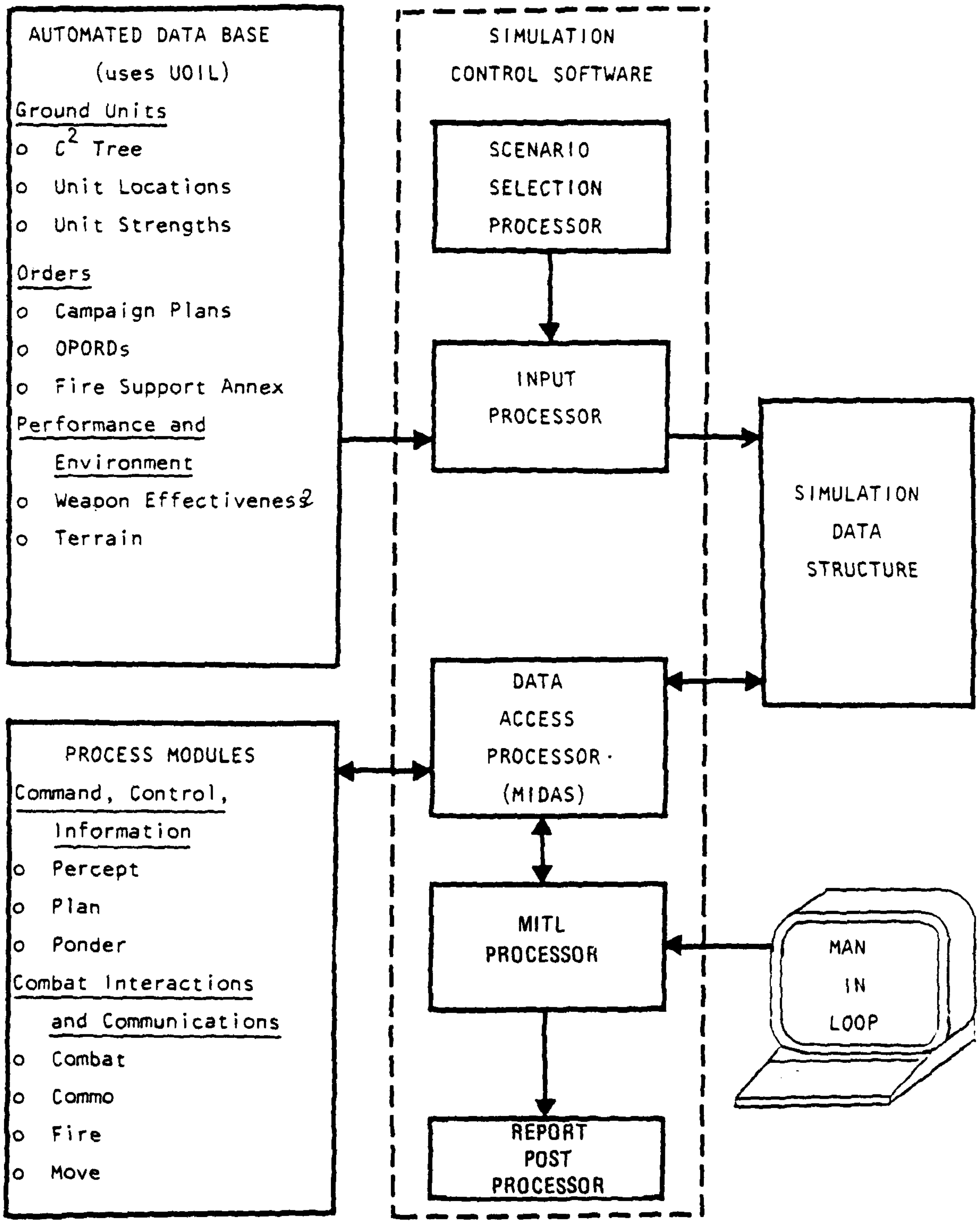


Figure 7. General DNA-TCOR structure.

Input to the TCOR model is achieved by means of a User Oriented Input Language (UOIL) employing subject, verb and object phrases. An example of UOIL appears in Appendix C of this report.

In the UOIL Red and Blue sides are identified by an introduction line followed by the unit identification, unit location and command structure. Other input data, such as terrain and communication network descriptions, are described in a similar form.

The Scenario Selection Processor (SSP) is the interface for the user to initialize the execution of TCOR. The user identifies the data in the Automated Data Base (ADB) that is to be used and specifies any additions or modifications required for the specific scenario. The Input Processor (IP) locates the appropriate data, merges the SSP and ADB information and creates the initial Simulation Data Structure (SDS).

The input data is stored in a dynamically-allocated data space that expands, contracts, and is reused depending on the actual requirements for space during input or execution. This is accomplished by use of list processing techniques and eliminates the requirement to edit and change C^2I and CIC modules when additional data structures are required. The major data elements are shown in Figure 8.

The scoreboard contains all of the real attributes of each unit in the simulation. The perceptions list contains the unit's understanding of its battle environment. The communications network is characterized by nodes and links. The Discrete Event List (DEL) contains all of the currently scheduled events that are to occur at a future instant in time. This list is sorted by a highly-efficient leftist tree algorithm. The Continuous Event List (CEL) contains all of the currently scheduled events that are to occur during a period of time. The effects of the events on the CEL are calculated for various time intervals. The difference in time intervals and step sizes that are used simultaneously for different events is a power of two greater than the smallest step size allowed in the simulation. The sequencing of the step sizes is accomplished by a highly-efficient binary hierarchical control algorithm. The sequencing of events on the CEL with events on the DEL is accomplished by the CONTROL function in the Module Control Processor (MCP).

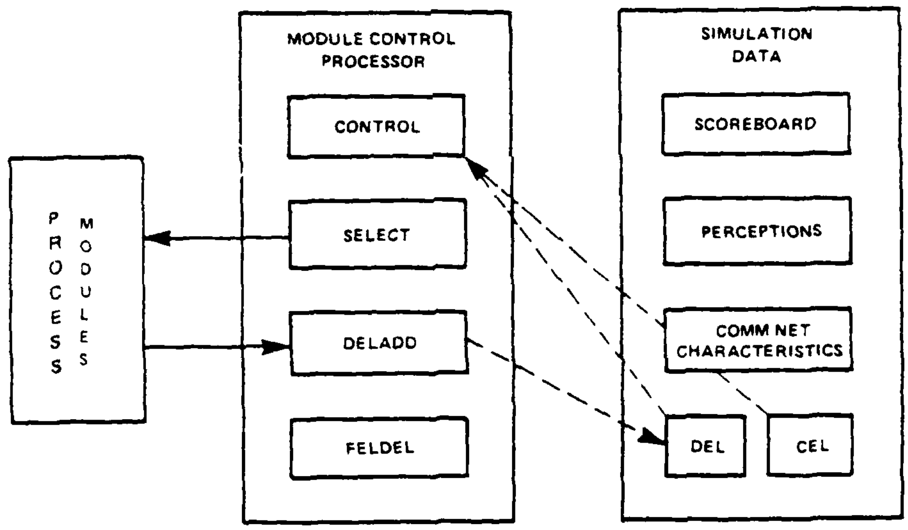


Figure 8. Interactions among major elements of the C^2I/CIC concept.

SELECT determines which module should process the current event. After the module calculates the effect of the event on the simulation, it may add an event to the DEL via DELADD or delete events from the DEL or CEL using the future event list delete function (FELDEL). All events on the CEL are initialized by an event on the DEL but once an event is on the CEL its time step may be increased or decreased directly.

The simulation is initiated by input of an event or events on the DEL. The event is removed from the DEL by CONTROL and transferred to SELECT to call the appropriate CIC or C^2I module. The number and complexity of the modules vary widely depending on the degree of detail required and the scope of the simulation. There are sets of modules that differ by combat unit size and functions as depicted in Figure 9. In addition, there are alternative modules that provide for decisions by employing man-in-the-loop techniques. Modules can be mixed as desired in any one simulation. The time at which each event occurs may be stored for post simulation query by a routine named CACHE. This query is done using a post processor and provides the capability to trace the impact of each event on unit status to its source. In addition, combat reports are produced by the Report Processor.

A key feature of the C^2I/CIC concept using the TCOR structure and software is the capability of introducing a human player into the decision-making processes. This is called the Man-in-the-Loop (MITL). In such a situation, the human would play the role of any or all of the commanders being simulated and "make" the decisions for the model. Whenever human interaction is required the main simulation is halted, the MITL processor is run and human generated orders are entered into the model. The main simulation is then restarted.

In calling a human decision maker, the C^2I logic would display to the decision maker only that data that exists in the computerized commander's status display board, i.e., his perceptions. This data could be different than the "real" situation, such as being inaccurate, incomplete, distorted, or out of date. It would, however, be the data that the simulation had calculated as available to the human commander and would be the

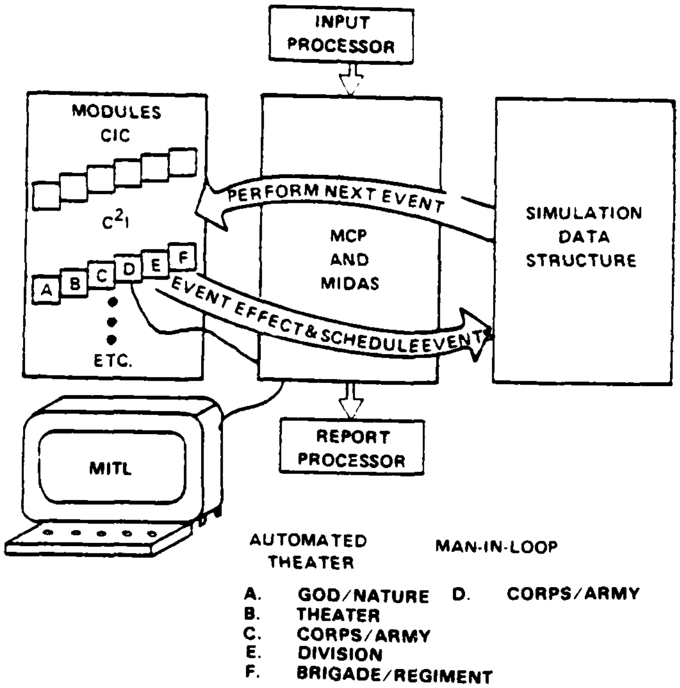


Figure 9. TCOR Modularity

same data available to an automated module. In TCOR II-A, however, perceptions are the same as the "real" situation at the time at which the are perceived. Since the current version of TRACE is derived from the II-A version of TCOR, this is also true for the TRACE model.

2.2 SCOPE

TCOR is a symmetric two-sided theater level model, containing two primary levels of detail. One Corps/Army area contains detailed modeling to the battalion level (with company centers), and the other Corps/Army areas are modeled as corps (with division centers). The scope of the automated C^2 in the TCOR II-A version is sufficient to control the interactions involved in force buildup, road march, and the initial phases of meeting engagements and breakthroughts. Opportunistic combat reaction, decision, and movement are accomplished by man-in-the-loop operation.

The basic element in TCOR II-A is a maneuver unit. Input parameters require some level of aggregation of the capabilities of the weapon systems that maneuver units possess. This aggregation process is a function of the assumptions derived from specific combat scenarios.

2.3 PROCESS MODULES

The Command, Control, Information (C^2I) process modules are PERCEPT, PONDER, and PLAN. The combat Interaction and Communication (CIC) process modules are COMMO, MOVE, COMBAT, and FIRE.

2.3.1 Command, Control, Information (C^2I).

2.3.1.1 General. Command and control processes represented in all corps areas include plan formulation and selection, resource allocation, targeting, and issuance of directives and orders. TCOR models the command hierarchy and several types of command structures. All commanders at the various echelons are provided with information (via PERCEPT) appropriate for the C^2 processes modeled. Decision making for the theater commanders and the detailed Corps/Army commanders is performed through the man-in-the-loop capability. (Man-in-the-loop capability also provides a research tool for gaining a better understanding of these more complicated decision processes and for developing decision making algorithms for use in later phases of the TCOR development.) C^2 processes below theater (aggregated areas) and Corps/Army (detailed area) are treated by automated means subject to override via man-in-the-loop capability of the theater and detailed corps commanders. Nuclear release procedures may be directed or automated according to the realease permissions in the orders issued by the MITL.

Target acquisition processes are modeled notionally (in PERCEPT) in the aggregated area. In the detailed area, rudimentary representations of sensors are modeled to perceive company/battery centers with no further target discrimination. Target perceptions are treated by rudimentary fusion processes to provide targeting information.

2.3.1.2 Modules. The PERCEPT module encompases all processes related to incoming stimuli or information. The PERCEPT module also assimilates new information into the unit's existing perceptions. All types of acquisition devices such as radars, sensors, visuals, etc., are under the purview of PERCEPT. PERCEPT is event-stepped. In TCOR II-A, units have only one "acquisition device" with one range associated.

The PLAN module contains logic to develop rudimentary OPORDS for subordinates. The OPORDs prescribe objectives, sectors of operation, type of operation, weighting factors for movement choices, thresholds for casualty totals, casualty rates and movement rates. Allocation of resources occur under the PLAN module in a very simple routine which considers enemy threat, resources available, and type of operation being carried out (such as attack or defend). The PLAN module interfaces with man-in-the-loop and user input. For example, changes to OPORDs will be through the PLAN module.

The PONDER module is a low level decision making module and chooses a general response to an input stimulus. For example, if an enemy shoots at a unit, the potential victim will decide in PONDER if he wants to shoot back, move, ask for help, or any combination of these. In military terms, the PONDER module acts as the adjutant or S-1; it distributes incoming correspondence to the proper action staff section. This section (for example, operations, intelligence, or supply) will then decide what specifically should be done. The PONDER module uses delay times to account for loading of the system, "thinking and reacting" time, and is event-stepped.

Movement and location of forces is in accordance with the multi-level hexagonal coordinate system developed in TCOR I. Company centers in the detailed corps area are associated with hexagons of 1.35 km diameter (center-to-center). Divisions, in the aggregated corps areas, are located in hexagons of 25 km diameter. Terrain information is treated in terms of trafficability and cover and concealment indices which are stored at the highest level hexagon consistent with terrain variability.

2.3.2 Combat Interaction and Communications

2.3.2.1 General. The CIC processes modeled included ground movement, direct fire, indirect fire, tactical air support, and communications. Ground combat is modeled simultaneously at two levels of detail. Within the aggregate Corps/Army areas, the model represents combat between corps and army division centers using notional weapon systems (armor, infantry and artillery) capable of both conventional and nuclear fires. Within the detailed Corps/Army areas, the model represents the operations of maneuver battalions (consisting of company centers) possessing armor and infantry weapon systems and the ability to move and enter combat with opposing forces. In addition, it represents the operations of artillery battalions (consisting of battery centers) equipped with tube artillery of rockets and capable of moving and firing at enemy maneuver, artillery and C^2I units. Artillery batteries within the battalion are capable of supporting more than one maneuver battalion at a time in accordance with instructions from a fire direction center. The combat effectiveness of a unit is influenced by the effective range and firing rate of its weapon systems and the vulnerability of the enemy weapon systems being fired upon. Weapon systems are described by parameters related to their mobility, reliability, and lethality. The actual employment of weapons systems in an orchestrated combat action is influenced by physical limitations, the plans and order developed or used in the model, and the perceptions of enemy forces present in the area. Attrition is influenced by the cover and concealment index of the target location. Ground mobility is constrained by OPORD input, trafficability, and casualty levels in both area types.

2.3.2.2 Modules. COMMO simulates a generalized communications network linking all units in the chain of command. Specific communications hardware systems are not portrayed. Network performance is represented by a message delay time but point-to-point communication never breaks down completely. The message delay time is random from a Poisson distribution. COMMO is event-stepped.

MOVE provides for non-combatant movement towards an objective that has been directed by an OPORD. The effective movement rate is a function of the trafficability index associated with the unit's location. The choice of direction is a function of the provisions of the OPORD, such as speed range, cover and concealment, massing, and threat constraints. MOVE is event-stepped.

COMBAT calculates the movement of units in combat and the effect of their fire on opposing forces as a function of weapons allocation cover and concealment, force element kill rate (infantry, armor, artillery, CAS), and target composition. COMBAT is time-stepped.

The FIRE module is concerned with indirect fire from artillery battery centers against enemy targets. These can be either maneuver companies, artillery batteries, or command units. Both nuclear and conventional fire may be represented in this module. Firing missions are ordered by the artillery battalion (fire direction center) in response to fire support requests from maneuver units. The duration of a fire mission is calculated using the battery's firing rate. This value is added to the scheduled start time to determine the end of the fire mission. When the end of the firing mission is calcualted and event is scheduled to post the attrition results. The FIRE module is event-stepped.

2.4 DATA INPUT REQUIREMENTS

Three classes of data are needed to use the TCOR model:

(1) ground unit descriptions,

(2) initial OPORDS for the top level ground units in the scenario to be represented, and

(3) environment and performance parameter values.

All classes of data are normally input by means of the UOIL and thus can readily be varied when desired. The input medium is normally punched cards with a separate card for each item of data that is entered. (Input via CRT is also possible.) Each class of data is discussed in detail below. Examples of UOIL inputs for the pilot runs are exhibited in Appendix C. A rigorous treatment of all data inputs and simulation outputs is available in Reference 2. A higher level synopsis of those inputs is provided in the remainder of this section of facilitate the reader's understanding of the model and its capabilities.

2.4.1 Ground Unit Descriptions

Each ground force unit to be represented in the simulation is defined by three items of information:

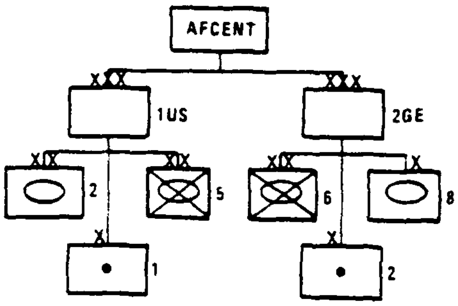
(1) position in the command structure,

(2) initial location, and

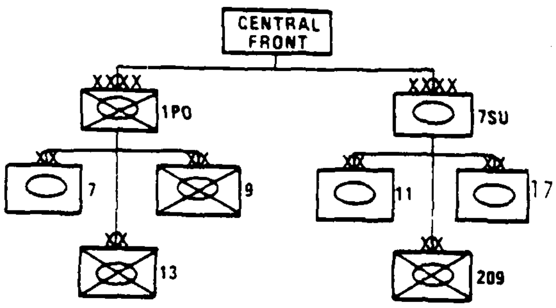
(3) initial force strength.

Command structure is defined in terms of "the chain of command" starting at Corps (Blue) or Army (Red) headquarters for each side of the conflict scenario to be simulated. In the detailed area only a company or battery level unit can have a physical location and be attacked. Thus, headquarters for higher echelon units are represented as Headquarters Headquarters Company or Battery (HHC or HHB). In the aggregated areas, only divisions or independent brigades/regiments can have a physical location. Higher headquarters are represented as "divisions" in the aggregated areas. The number of units immediately subordinate to a given command echelon can be considered to be unlimited for any scenario that can be forseen at present. Figure10 illustrates how a command structure for a hypothetical theater would be represented in UOIL. Although this example treats only the aggregated areas, data for the detailed area is in similar form.

The initial locations of each of the units to be represented can be input by hex number, or latitude-longitude coordinates. This is done by means of a separate card which contains the unit number followed by the statement "is at xxxxxxxx (coordinates)." For the example in Figure 5, a



BLUE DEFINITIONS
CORPSHQ - CORPS HEADQUARTERS
ARMDIV - ARMORED DIVISION
MECHDIV - MECHANIZED INFANTRY DIVISION
ARTYGRP - ARTILLERY GROUP
ARMBDE - ARMORED BRIGADE



RED DEFINITIONS
TKDIV - TANK DIVISION
MRDIV - MECHANIZED RIFLE DIVISION
TKAHQ - TANK ARMY HEADQUARTERS
CAAHQ - COMBINED ARMS ARMY HEADQUARTERS

NOTE: PREFIX AG INDICATES UNIT IS IN AGGREGATED AREA IN THE MODEL.

COIL INPUT CARDS

BLUE.	(1)
US.(UNITED STATES)	(2)
1 AGCORPS COMMANDS 1 AGCORPSHQ.	(3)
1 AGCORPS COMMANDS 5 AGARMDIV.	(4)
1 AGCORPS COMMANDS 2 AGMECHDIV.	(5)
1 AGCORPS COMMANDS 1 AGCORPSARTYGRP.	(6)
GE.(GERMANY)	(7)
2 AGCORPS COMMANDS 2 AGCORPSHQ.	(8)
2 AGCORPS COMMANDS 6 AGMECHDIV.	(9)
2 AGCORPS COMMANDS 8 AGARMBDE.	(10)
2 AGCORPS COMMANDS 2 AGCORPSARTYGRP.	(11)
RED.	(12)
PO. (POLAND)	(13)
1 AGCAA COMMANDS 1 AGCAAHQ.	(14)
1 AGCAA COMMANDS 7 AGTKDIV.	(15)
1 AGCAA COMMANDS 9 AGMRDIV.	(16)
1 AGCAA COMMANDS 13 AGMRDIV.	(17)
SU. (SOVIET UNION)	(18)
7 AGTKA COMMANDS 7 AGTKAHQ.	(19)
7 AGTKA COMMANDS 11 AGTKDIV.	(20)
7 AGTKA COMMANDS 17AGTKDIV.	(21)
7 AGTKA COMMANDS 209 AGMRDIV.	(22)

Figure 10. Hypothetical command structure.

companion location card would be prepared for each command structure card except numbers 1, 2, 7, 12, 13, and 18.

The TCOR Model represents the strengths of ground force units in terms of the numbers of four generic types of weapon systems. They may have armor (main battle tanks), infantry units and anti-tank units (light tanks, anti-tank guns and anti-tank guided weapons), artillery tubes, (guns, howitzers, and multiple rocket launchers), and rockets (guided surface-to-surface missiles such as Lance and Scud) assigned to Corps/ Armies. Theater-level missiles such as Pershing and Scaleboard are not explicitly included). Note that infantry units and antitank units are treated the same. Thus, they will be referred to by either or both names.

The effectiveness of the generic types of weapon systems is expressed in terms of kill rates against each of four types of targets. These kill rates are input by means of two 4x4 matrices of shooters and targets--one for each side. Development of these parameter values is discussed in later paragraphs. For now it is sufficient to understand that there is provision for only one value to assess the capability of Blue (Red) tanks to inflict attrition on Red (Blue) tanks in both the detailed and aggregated areas. To account for variation in the effectiveness of different Blue (Red) weapon systems, a standard US and USSR weapon system of each generic type has been selected and the number of other weapon system types that a unit possesses is increased or decreased in proportion to the Effectiveness Ratio (ER) of the specific system to the standard. For example, the standard Blue tank is the US M60A1. a British tank squadron possessing 18 CHIEFTAIN tanks (ER=1.1) would be considered to have 20 M60A1 equivalents (18x1.1 = 19.8). The numbers of other types of weapons are adjusted similarly. The M113-TOW is the standard anti-tank weapon. For the Red side, the T-62 and Sagger ATGM correspond. Capabilities of artillry tubes are based on a weighted average of the US M109/M110 for Blue and the Soviet 122-MM and 152-MM howitzers for Red. Rockets are based on Lance and Scud, respectively.

In addition to specifying the adjusted number of tanks, ATU, tubes, and rockets that a unit has, it is necessary to specify the number of rounds of conventional and nuclear munitions. Generally, Blue units are assumed to have their basic loads and Red units their standard unit of fire. For example, a Blue armor company has 62 rounds for each tank and a Red tank company has 40 rounds for each tank.

Unit strengths are input by cards using the following format--(unit designation) has (xxx) TANKS, (xxx) ATU, (xxx) TUBES, (xxx) ROCKETS, (xxx) ROUNDS, (xxx) GROUNDNUKES. The values attributed to HHC, HHB and AGDIVHQ are a nominal ATU/Tank capability and a nominal amount of ammunition.

2.4.2 Initial Operations Orders

Two sets of OPORDs must be prepared: one each for the detailed Blue corps and Red army commanders. These are quite similar in format and are discussed from the detailed Blue corps standpoint. OPORDs are input to the MITL processor for inclusion in the data base. Part IV, Appendix C shows a complete set of orders, first for Red (2 divisions) then for (Blue). The Blue units are given their movement and loss constraints, told whether or not nuclear fires are permitted and then given their boundaries. After the boundaries come the mission statement (types and time) and the phaselines. Complete details on this are found in reference 2.

2.4.3 Environmental and Performance Parameter Values

Terrain is the only type of environmental data used in TCOR II-A. (Weather and other environmental factors are planned to be added to future versions of TCOR.) Terrain effects are manifested in the model in two ways:

(1) As trafficability constraints on movement, and

(2) As cover and concealment constraints on attrition.

These two effects are expressed as indices associated with a particular hex, usually at the 9.45 km hex level. These indices are used in the MOVE and COMBAT modules, respectively, to modify the rate and direction of movement and unit attrition. (No detailed terrain was used in the TRACE study.)

2.4.4 Weapon Effectiveness

Weapon system performance is expressed in terms of kill rates as described above and illustrated in Figurell. The corresponding Red matrix is of similar form.

	TANKS	ATU	TUBES	ROCKETS
TANKS	.0165	.0097	.0001	.0001
ATU	.0026	.0030	.0001	.0001
TUBES	.009	.009	.002	.0001
ROCKETS	.35	.44	.9	.49

Figure 11. Standard Blue Weapon System Kills of Standard Red Weapon Systems in 64 Sec.

The kill rates in Figure 6 are derived using the relationship:

Kill rate = P_{KIS} X FR X TR

Where P_{KIS} = single-shot probability of kill given a shot.

FR = Firing rate or expected number of rounds expended in one time period (64 seconds) against a particular type of target (allocated).

TF = Tactical factor to account for the shooter being suppressed by enemy artillery, and shooting at dead targets.

Although a single value of kill rate is used for both the detailed and aggregated areas this potential disparity is minimized by the specific combat attrition equations used for the aggregated areas. This is done by reducing the number of shooters to represent the condition where all unit weapons are not in range of all targets during a given time period.

2.4.5 Air Operations

The TCOR II-A Model represents air operations in a highly aggregated fashion. There is no detailed modeling of bases or flights. It's purpose is more to add a communications load and to provide some front line interdiction at the nuisance level. There are no inputs associated with the air operations.

SECTION 3
TRACE ENHANCEMENTS

3.1 INTRODUCTION

As the acronym TRACE indicates, (TCOR Revised to Assess Communications Effectiveness), the basic DNA-TCOR tactical wargaming model has been appropriately modified, extended, and enhanced resulting in a analysis tool that focuses on the role of tactical communications.

3.2 COMMUNICATIONS

3.2.1 Messages

There are five types of messages represented in the TRACE model. They are:

(1) combat orders (OPORDS),
(2) status reports (SITREPS),
(3) artillery fire requests,
(4) close air support requests, and
(5) intelligence reports of observed enemy units.

Only player units send and receive messages. Players may send and receive messages on behalf of a pseudoplayer, as discussed in the next paragraph.

3.2.2 Message Simulation

There are a number and variety of stimuli that can generate messages in the five message type categories.

3.2.2.1 Orders. When a Man-In-The-Loop (MITL) enters orders for a unit, if it has any player subordinates, it generated an orders message for each one of the player subordinates. Each of these in turn will send an orders message to it's player subordinates and so on until all players under the one receiving MITL orders have received an orders message.

3.2.2.2 Status Reports. There are three subtypes of status reports. The first is the "reached objective". This is sent by every pseudo-player, through its commanding player, to the next higher level. It is sent when ever a pseudoplayer has reached its current objective. The second type is the "killed in action". This type is sent whenever a unit notices a neighboring unit being destroyed. A neighboring unit is one in the same or adjacent, level 3 hex. The last type is the "general" status report. This message is sent, with a probability, every time a move event is executed. Certain combat events will also, on a probability, cause one to be sent.

3.2.2.3 Request for Artillery Fire. Artillery fire may be requested at a particular unit/hex whenever a moving enemy unit is identified, an enemy unit using direct fire is identified, an enemy transmitting unit is detected, or an enemy unit is in direct fire range of a friencly unit in combat. Each of these cases has a probability of request associated with it. In the last case only, the single most threatening enemy unit of those within range of each pseudo player will have fire requested against it. For RED only, they may make two requests in this last case due to the policies of greater employment of artillery.

3.2.2.4 Request for Close Air Support. Blue units in combat, in addition to requesting artillery against the most threatening enemy unit, may, with a lower probability, also request a CAS attack against the same unit. (This represents the assumption that Blue will have local air superiority.)

3.2.2.5 Intelligence Reports. These reports are sent on a probabilistic basis whenever an enemy unit is identified while moving or in direct fire combat.

3.2.3 Message Processing

When a unit decides to sent a message it schedules the first message transmission attempt to happen at zero or more minutes later. This time represents the message preparation time. When the scheduled time comes up the player sending the message attempts to transmit the message. It is at this point that TRACE becomes vastly different, communications-wise, from all other members of the METRIC family of models.

3.2.3.1 Establishment of Communications. The sender must first establish communications with the receiver. Figure 12 illustrates the steps taken to accomplish this or to determine that it can't be accomplished. The numbers in parentheses in the text below reference points on the flow chart.

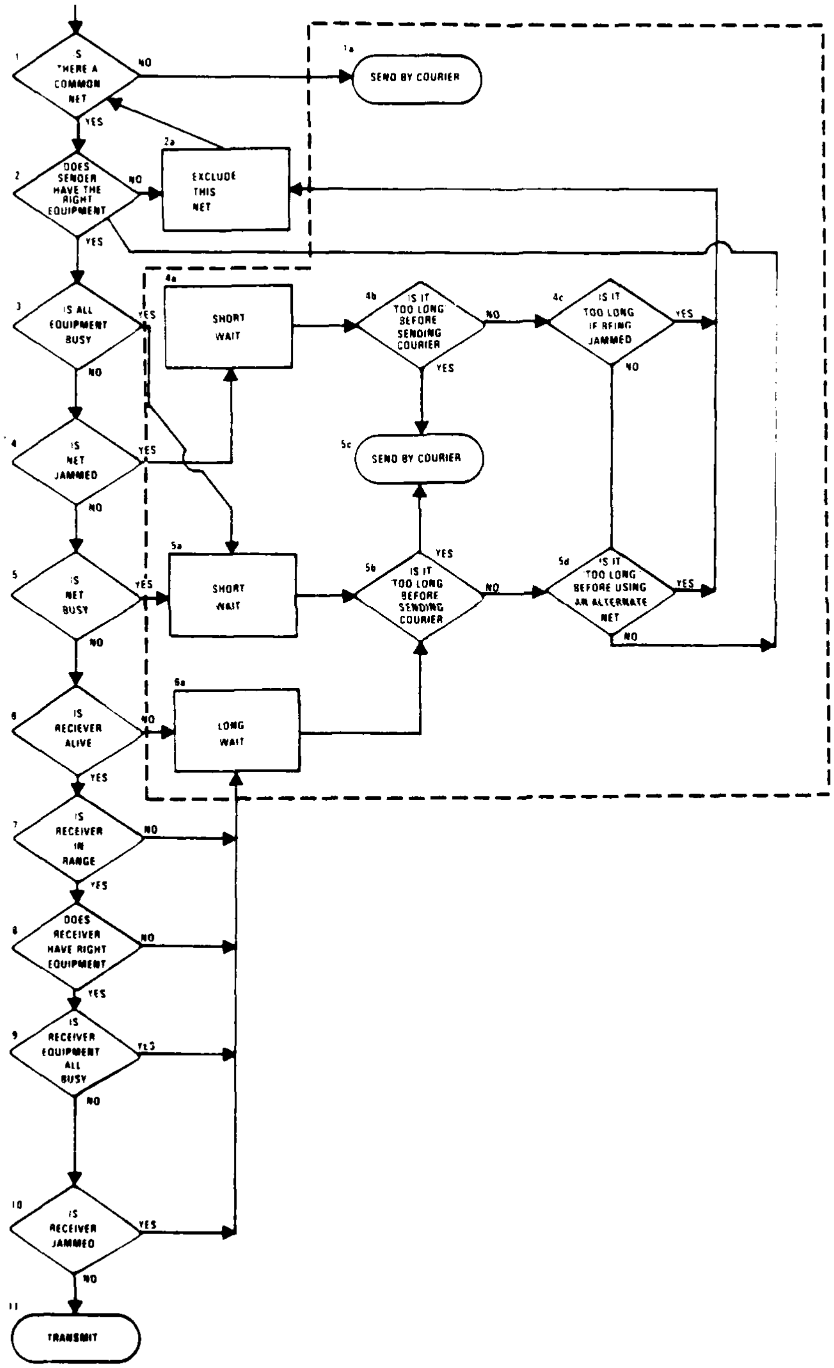


Figure 12. Communications logic flow diagram.

The sender checks (1) to see if the receiver is on any net that the sender is authorized to transmit over. The first net he checks for is the one appropriate to the message type. If there is none the sender must courier (1a) the message. If the sender does have a net, he determines (2) whether he has any equipment that covers the frequency of the net. If not (2a) another net must be chosen.

Given a net and the proper equipment, the equipment is checked (3) to see if it is all in use at this time. When all equipment is busy a short time delay (5a) is involved. This delay includes the checking of all the equipment and the possibility of a short wait to determine if any will soon be freed up. After this short wait, the time span since message origination is checked. If more time has passed then permissable for transmission attempts (5b), the message is sent (5c) by courier. If more time has passed than permissable before trying a secondary net (5d) then another net must be chosen (2a).

Should some equipment not be busy, the sender now listens with it. If he is being jammed (4) a similar procedure (4a, 4b, 5c, 4c) takes place to that had the equipment been busy (5a, 5b, 5c, 5d).

Even if not jammed, the net may already be busy with traffic (5). When it is, the exact same procedure is followed as if the equipment had been busy (5a, 5b, 5c, 5d). There are two ways that the net can be busy. It can either be busy with an actual, model generated message or it can be busy with background traffic. This background traffic is a probabilistic representation of those messages that would be flowing on that net, but are not explicitly modeled in TRACE.

At this time, if all tests (1) through (6) have been successful, the sender is ready to try and make contact with the receiver. The model looks to see if the receiver is still alive (6). If the receiver is "dead" this means that the headquarters company has been destroyed and not yet reformed or been replaced. When this happens there is a long wait (6a) because the sender knows only that he is not getting a response. He has no idea why. All the previous adverse results caused only a short wait (4a or 5a) because it was immediately obvious to the sender why he could not get through. After several calls however the determination of what to do next follows the same procedures (5b, 5c, 5d) as the short wait results (with the exception of being jammed).

If the receiver is alive, he must be in range (7), have the proper (8), unbusy (9) equipment and not be jammed (10) at this time. If any of these tests fail there is a long wait while the radio operator continues to try and get a response. Then the usual processing of what to do next (5b, 5c, 5d) occurs.

When tests (1) through (10) all succeed the message may be transmitted. All of the above processing has been handled by 2 subroutines. The first, outside the dotted line merely tries to establish contact. The second, inside the dotted line determines what to do when the message can't get through. It is by varying this second routine and its inputs that SOPs are modeled.

3.2.3.2 Message Tranmission. At this time there are two means of message transmission. Sending a message by courier takes the courier speed divided into the distance between sender and receiver to get the "time of transmission. Sending a message by radio takes a function of the average message tranmission time to get the time of transmission for this message. When a radio is used, one of the sender's radios, one of the receiver's, and the net all become busy. When the message is received they will all become unbusy. The only thing that will prevent a courier message from being received is a dead receiver at time of receipt. Radio messages will be lost if either sender or receiver die at any time during the transmission of the message.

3.2.4 Assumptions

Requests for artillery or CAS support that are over 15 minutes old are considered to be OBE and are discarded without further processing or notifications at any time they are encountered.

3.2.5 Damage to Communications

Conventional - Radios are considered to be in many vehicles of a unit and therefore all rounds fired into a unit can kill radios

Nuclear	-	All units, of both sides, who are within the minimum Zero-PK range of a blast are checked for damage form nuclear effects.
General	-	No damaged radios are repaired or replaced. When a headquarters unit is slain the next maneuver unit is, after a period of time designated as its replacement. However, all radio equipment the slain unit possessed are lost. During this change over time the unit cannot be communicated with.

3.3 CONVENTIONAL WEAPONS EFFECTIVENESS

The purpose of the conventional weapons effects portion of TRACE is to assess both the attrition of weapons platforms and the degradation of communications capability during conventional weapons attack. This effort entails the development of a single shot probability of kill (P_k) for a given weapons system against another weapons system/communications unit. Since this P_k must be representative for all combat conditions, it does not apply to any specific situation, such as firing at a close in, fully exposed target, and it is therefore a weighted average of P_k's for preceived combat conditions. P_k's developed for use in this study appear in Table 2. Because of the continuousness of combat these were adjusted based on rate of fire. The adjusted values appear in Table 3.

3.3.1 Weapons Systems Employed

Both Blue and Red forces are given an indirect fire capability in the form of field artillery and a direct fire capability in the form of tanks and antitank units (ATU's). Specific Blue weapons systems modeled are:

(1) Indirect Fire
- 155 mm howitzer
- 8 inch howitzer
- 175 mm gun

(2) Direct Fire
- M60 tank
- TOW and Dragon ATU's

Table 2. Weighted average P_k.

BLUE P_k	ATU	TANK	ARTY	ROCKET
ATU	.469	.414	.0001	.0001
TANK	.137	.182	.0001	.0001
ARTY	.0029	.00099	.00245	.0001

RED P_k	ATU	TANK	ARTY	ROCKET	JEEP	TRUCK	APC
ATU	.11	.353	.0001	.0001	.177	.29	.26
TANK	.066	.225	.0001	.0001	.15	.166	.166
ARTY	.00027	.000075	.0045	.0001	.0063	.00155	.00027

Table 3. P_k per unit time used in TRACE.

BLUE P_k PER UNIT TIME	ATU	TANK	ARTY	ROCKET
ATU	.134	.114	.0001	.0001
TANK	.124	.165	.0001	.0001
ARTY	.0087	.003	.0073	.0001

RED P_k PER UNIT TIME	ATU	TANK	ARTY	ROCKET	JEEP	TRUCK	APC
ATU	.025	.089	.0001	.0001	.04	.07	.062
TANK	.038	.134	.0001	.0001	.088	.098	.098
ARTY	.00135	.000375	.0075	.0001	.031	.0077	.00135

Corresponding Red weapons systems modeled are:

(1) Indirect Fire

- 122 mm gun
- 130 mm gun
- 152 mm howitzer

(2) Direct Fire

- M62 tank
- Sagger ATU

3.3.2 Communications Systems

All Blue communications elements are assumed to be located either in jeeps, medium-size trucks (2-1/2 ton), or armored personnel carriers (APC's). A basic assumptuon underlying the development of communications equipment is that a kill of the vehicle is identical to a kill of the equipment inside it. This assumption must be made because there is data currently available describing lethal areas of communications equipment mounted in vehicles subject to conventional detonations. All munitions effectiveness manuals available at BDM contain lethality data strictly for personnel and certain types of weapons systems and vehicles. Although some protection to equipment may be afforded by the vehicle's structured members/frame it seems reasonable to conclude that a mobility kill will also either render the equipment inside inoperable or highly vulnerable to complete destruction from ensuing fire.

3.3.3 Indirect Fire

Indirect fire rounds are assumed to be distributed about the aimpoint by a bivariate normal distribution of the form

$$f(x,y) = \frac{1}{\sigma x \sigma y 2N} \exp^{-\frac{1}{2}\left(\frac{X^2}{\sigma x^2} + \frac{Y^2}{\sigma y^2}\right)} \qquad (1)$$

The rectangular x-y coordinate system is oriented here with the origin at the location of the intended target and the x-axis is perpendicular to the line of fire σx and σy represent the standard deviations of the distribution about the x- and y-axes, respectively, and have the formulas:

$$\sigma x = \sqrt{(1.48\ DEP_p)^2 + (1.48\ DEP_M)^2 + (1.48\ (.572)\ TLE)^2} \quad (2)$$

$$\sigma y = \sqrt{(1.48\ REP_p)^2 + (1.48\ REP_M)^2 + (1.48\ (.572)\ TLE)^2} \quad (3)$$

DEP_p = precision deflection error probable

DEP_M = mean point of impact deflection error probable

REP_p = precision range error probable

REP_M = mean point of impact range error probable

TLE = target location error

DEP_p and REP_p are a measure of distance from a single mean point of impact (MPI) along the x- and y-axes, respectively which contains 50 percent of the burst points from a single weapon at any given time. DEP_M and REP_M similarly measure the scatter of MPI's about an aimpoint (i.e., the intended target) where it is assumed that the mean of the MPI's is at the aimpoint and that the MPI's are distributed normally about the aimpoint. TLE is a measure of the error in locating the actual target center, and is assumed circular normally distributed. The constant .572 converts this error to DEP and REP for a bivariate normal distribution. The constant 1.48 converts DEP and REP to standard deviations. Since the errors are bivariate normally distributed, their variances are additive, and σx and σy represent the standard deviations of the convaluated distributions for each individual error.

The DEP's and REP's for specific artillery pieces are provided in references (3) and (4), and evaluated for purposes of this analysis at 2/3 of the weapon's maximum range. A 50 meter TLE is assumed, implying that the intended target is within 50 meters of the aimpoint 50 percent of the time. Since this error represents a measure of reliability of intelligence with regard to actual target location, it can obviously be adjusted as target location information becomes more current, reliable, etc.

Once the above information is known, the only other required information to calculate the intended target's P_k for a bivariate normal distribution requires a rectangular approximation of the target's lethal area. Another assumption made is that the targets' damage distance function is "cookie cutter", i.e., no damage occurs outside the rectangular bounds and a kill occurs for rounds falling within the bounds (see Figure 13).

Letting $t_y = \frac{y_o}{REP_T}$ and $t_x = \frac{x_o}{DEP_T}$, where x and y represent half

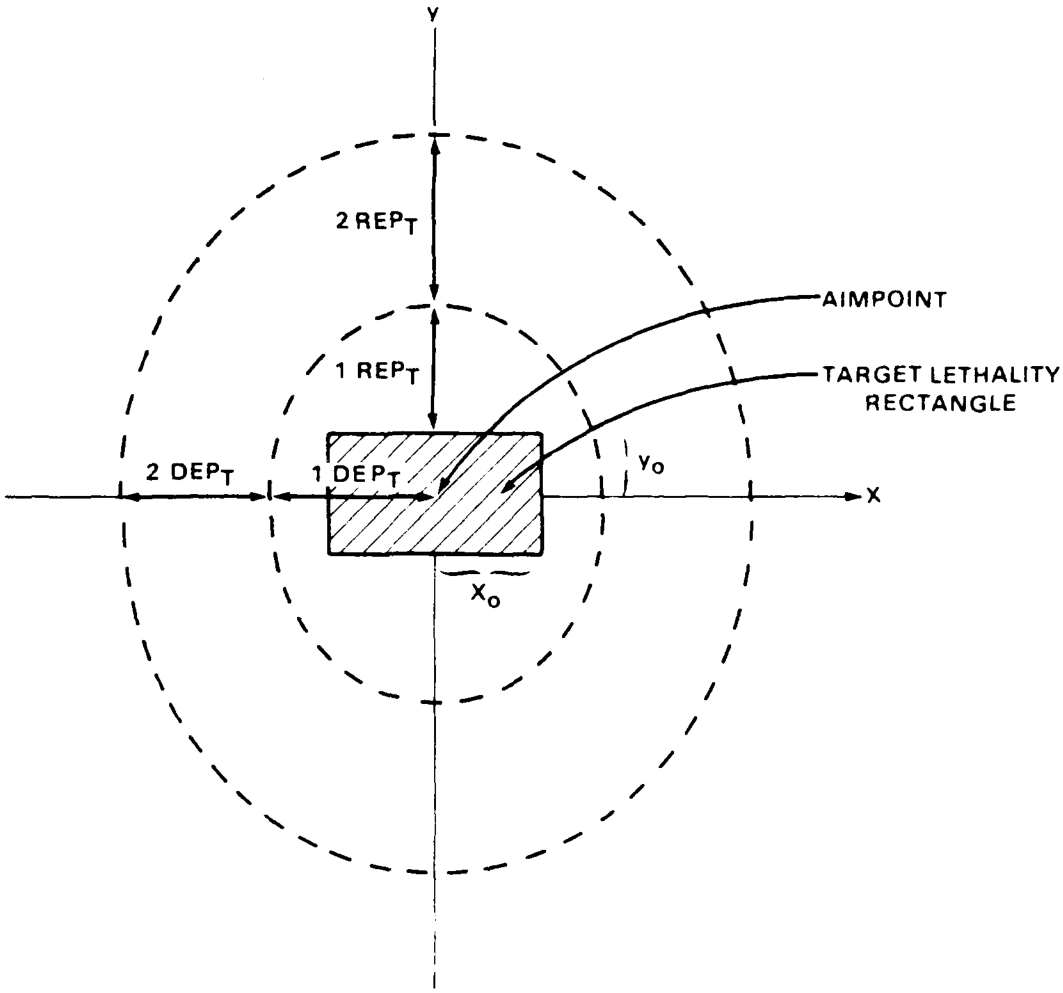
of the lethality rectangle's sides along the x- and y-axes, respectively, the resulting $P_k = P_k(x)\ P_k(y)$ can be calculated from standard normal tables. (Note: $P_k(x)$ is the probability the round falls between $-x_o$ and $+x_o$ and $P_k(y)$ is the probability the round falls between $-y_o$ and $+y_o$.)

For TRACE, the number of kills are calculated at the end of each time interval (= 64 seconds.) Therefore, the P_k per unit of time, $P_k(t)$, is given by the formula:

$$P\ (t) = 1 - (1 - P_k)^{FR_i}, \tag{4}$$

where FR_i represents the firing rate (rounds per 64-second period) of weapon system i.

Because of the relative broad dispersion of burst points about an aimpoint, a weapon firing into a cluster of targets, such as mobile command post elements, all located greater than a lethal radius apart but still relatively close together, will have a probability of killing other units which is directly proportional to their lethal areas. Formula (5) may be used to calculate the probability that target j is killed after being fired at by a battery of M identical weapons for one time interval (each weapon



$$P_K(x) = \int_{-X_o}^{X_o} \frac{1}{\sigma_x \sqrt{2\pi}} e^{-\frac{x^2}{2\sigma_x^2}} dx; \qquad P_K(y) = \int_{-y_o}^{y_o} \frac{1}{\sigma_y \sqrt{2\pi}} e^{-\frac{y^2}{2\sigma_y^2}} dy$$

P_K = PROBABILITY (ROUND FALLS WITHIN LETHALITY RECTANGLE)
$= P_K(X) \times P_K(y)$

Figure 13. Indirect fire lethality pattern

has probability P_k (t) of hitting target j, from equation (4) during time interval t) in the j formula:

$$P_j(t) = 1 - (1 - P_{k_j}(t)^M) \qquad (5)$$

3.3.4 Direct Fire

The problem of determing direct fire probabilities of kill for tanks and anti-tank units (ATU's) is somewhat easier than for the indirect fire case in that it is assumed that 1 direct hit on the target is required in order to register a kill. Also, P_k data based on statistical samples for selected Red and Blue weapons against selected Blue and Red targets is tabulated as a function of range, target aspects, target speed, type of round and target exposure. (References (3) and (5)). For example, ranges are listed for both the M60 and T62 from 500 to 3000 meters in increments of 500 meters. Target aspect is generally given as 0°, 30°, 60°, and 90°, while target exposure is either fully exposed or in hull defilade. The firing weapon is assumed stationary while the target is either stationary, or moving at 10 or 20 KPH. Rounds are either high explosive anti-tank (HEAT) or Armor Piercing.

In order to generate a representative $P_{k_{ij}}$ for weapon i against target j, a weighting scheme was used based on the following assumptions:

(1) All target angles are equally likely,

(2) All target speeds are equally likely,

(3) The target was twice as likely to be in hull defiade as fully exposed,

(4) Opportunties to fire at a target occur 5 percent of the time at t00 and 3000 yards, 15 percent of the time at 1000 and 2500 yards, and 30 percent of the time at 1500 and 2000 yards.

(5) Armor piercing rounds will be used against armored targets such as tanks while high explosive rounds will be used against soft targets.

Of the above assumptions, (3) and (4) have the greatest effect on the representative $P_{k_{ij}}$. All other conditions constant, a target is 10 to 30 times more likely to be hit at 500 yards than at 3000 yards and is 2 to 10 times more likely to be hit fully exposed than in hull defilade. The above weighting scheme implies that a target will attempt to minimize exposure as well as avoid being fired upon at extremely close ranges.

Because of a lack of available data, the P_k's most difficult to estimate are those for Red ATU's and tanks against Blue APC's, trucks and jeeps.

A logical way to estimate these P_k's is to start with some known baseline P_k and then extrapolate from there. In this case, the known baseline P_k's are against Blue tanks. As with artillery, it is reasonable to assure that the ballistic dispersion of ATU and tank rounds obey a bivariate normal distribution in range and deflection. A normal distribution in range implies a normal distribution in height since the axes are only 90° apart. As with artillery, it is not unreasonable to assume a small deflection error (1 meter or less) atthe close ranges (500 - 3000 meters) where tank and anti-tank combat occurs. If deflection error were fixed at 1 meter, then knowledge of the target's (in this case a Blue tank) dimensions plus the P_k allows "working backward" to determine the height probable error. Once this error is known, then the P_k's against Blue APC's, trucks, and jeeps can be computed based on their dimensions.

In summary, a list of factors affecting conventional weapons P_k's would include the following:

- Range
- Target size and area
- Target lethal area
- Weapon system accuracy
- Shell reliability
- Target exposure
- Target identification (camouflage)
- Target movement

- Target location error
- Target counterfire
- Atmospheric conditions/weather/visibility
- Terrain
- Training/readiness of personnel

Some factors, such as range and system accuracy are relatively easy to model, while others, such as terrain and personnel readiness, cannot be easily quantified and incorporated into a general model.

3.4 NUCLEAR WEAPONS EFFECTS

3.4.1 On Communications

No communications related nuclear weapons effects (NWE) existed in the version of TCOR-II used for TRACE. In fact, communications were considered invulnerable to any weapons effects or attrition. In order to provide the simulation with a credible effects of the battle on the communications, other than message traffic load, a nuclear weapons effects (NWE) module was created. This module consisted of seven submodules designed to simulate the effects of low altitude nuclear bursts on all of the communications equipment to be used by Blue forces in this model. Each of these submodules was developed to perform high speed curve fits based on range to DGZ and yield of the weapon. The details of developing one of these, called PKPERS, are completely explained in Appendix B. The other routines were developed in a similar fashion. The seven submodules are:

(1) PKPERS: This submodule calculates the approximate probability that a person will be rendered in operative as a result of exposure to a low altitude detonation.

(2) PKRATT: This submodule calculates the approximate probability that a standard Army RATT man-machine communications system will be rendered inoperatable as a result of exposure to a low altitude detonation.

(3) PKFMRD: This submodular calculates the approximate probability that or FM radio from the AN/VRC-12 family, is rendered inoperative due to exposure to a low altitude detonation. EMP and tree blowdown are implicity included.

(4) PKMICW: This submodule calculates the approximate probability that a standard Army microwave multichannel communication system will become inoperable as a result of exposure to a low altitude detonation.

(5) PKM151: This submodule calculates the approximate probabity that a standard Army M151 vehicle will be overturned from the blast wave from a low altitude nuclear detonation.

(6) PKM35A: This submodule calculates the approximate probability that a standard Army M35A vehcile with an S-280 shelter will be overturned by the blast wave from a low altitude nuclear detonation.

(7) PKM715: This submodule calculates the approximate probability that a standard Army M715 vehicle with an S-250 shelter will be overturned by the blast wave from a low altitude detonation.

3.4.2 In General

Along with the communications NWE, the NWE module was provided with a submodule for general damage to a unit by a nuclear weapon. The general equation shown in equation 1 was developed from the data in references 4, and 6.

$$P_k = 2e^{-\left(.695\frac{df}{\pi R_H^2}\right)} \quad \text{for a random placement} \qquad \text{(Eq.1)}$$

In TCOR-II the radius (R_H) of a level 3 hex is 1.35km. The dispersion factor (df) used in the nuclear environment was 11.5 when companies had to occupy the entire hex. Thus, equation 1 reduces to

$$P_k \cong .50 \qquad \text{(Eq.2)}$$

This was the factor used in the NWE submodule. The basic P_k value could have been modified due to hex occupancy which would vary the dispersion factor. However, all fire support, both nuclear and conventional, on the TCOR-II model was uncorrected. No forward observer guided the fires nor even made sure the target was still there. For this reason the unmodified P_k was deemed to be of an accuracy consistant with the aggregation of the fire support processes.

3.5 POST-PROCESSING

No suitable post-processing or information gathering software existed at the stage in the development of TCOR that the TRACE project used as a starting point. Rather than wait for their development the TRACE project developed a general purposes that allowed close examination of the items believed to be of interest. The information produced proved so valuable that these modules have been inserted into other metric family simulations. Three basic items were developed:

(1) Check point unload and reload

(2) Communications file

(3) Status file

3.5.1 Check Point Unload and Reload

It is extremely valuable when working with a simulation to be able to restart a particular simulation at some point in time other than the beginning. The value of this is no less during the experiments then it is during actual testing and development.

The procedures for doing this is very simple. It requires that all data that the simulation is dependent on be copied to a file at periodic intervals. Each copy or dump is called a checkpoint. Some data items are reconstructed or recalculated each time they are to be used due to the highly dynamic nature of their components. An example of this is a list of targets within direct fire range of a unit. The simulation is not "dependent" on such data, though it may be on their components.

This enhancement included a two associated abilities. First the simulation was able to pick any user specified start time from a file of checkpoints. Second, the periodicity of the checkpoints could be set by the user, to any integral number of seconds at the beginning of any start or restart.

3.5.2 Communications File

To facilitate the study of communications behavior, a file was created that contained all messages recieved by the Blue commander.

Messages were ordered by their receipt time. This time was also stored with the message. By use of this file the order and timeliness of the message traffic received could be studied.

This file proved especially usefull in the conduct of the experiment. It enabled an exact determination of the knowledge available in the command headquarters at any instant. From this information a MITL can be briefed on the situation of friendly and enemy forces. The amount and accuracy of the information is directly related to the state of the communications.

3.5.3 Status File

The status file consisted of "results" from the simulation. A separate post processor module was created to display the data according to user directed formats. One of these display is the map of the battle field. Appendix F shows example of the maps and gives a key for interpretation. Also, available through this module are unit status historys showing resources remaining, message traffic statistics, and unit movement traces. The details of using this module are completely explained in and examples are given of all the possible outputs in reference 2.

This post processor provide most of the data used in the analysis in this study.

3.6 C^3 ENHANCEMENTS

TCOR-II's awareness of its battlefield environment, at the time the TRACE study diverged in development, was at a very mininal level. Movement was affected by the perceived value of chosing between paths and certain responses were programmed to the stimuli of enemy sighting or receipt of direct fire. The following stimuse were ignored:

(1) Nuclear detonations
(2) Unit destruction (friendly or enemy)
(3) Intelligence messages
(4) Loss of headquarters
(5) Receipt of obsolete artillery/CAS requests (the mission was executed anyway)
(6) No orders or inappropriate orders

(7) More targets than can be effectively engaged

(8) Receipt of status reports

(9) Receipt of indirect fire

(10) Orders with regard to reconnaisance or headquarters units.

It was clear that some of these stimuli would have to be reacted to in order to study the effects of communications. Communications is a tool of the C^3I process much more than the physical combat. Previously the sole effect of no communications is that artillery fire would arrive late. However, the TRACE project was a communications study not a simulations development contract. Thus, the amount of perception/plan/replan ability developed would have to limited. The following paragraphs give a briefed explantation of each of the C^3I enhancements implemented.

3.6.1 Stimulus: Nuclear Detonation

Whenever a detonation occurred a description status message was entired into the communications system. Other than the load on communications, no other response was developed.

3.6.2 Stimulus: Unit Destruction

Whenever a unit was observed to be destroyed a report was entered into the communications system. Upon receipt of this message, the destroyed unit was removed from the headquarters perceptions list. The produced more effective planning of orders. The "observing" unit(s) had to be able to perceive the destroyed unit in order to be aware of its destruction.

3.6.3 Stimulus: Intelligence Messages

The enemy unit specified in the message was added to or updated on the receiving headquarters perceptions list. On a probability basis, indirect artillery fire was requested by the headquarters. (This fire proved to be totally ineffective so may be discounted as a result. There was, however, the associated message.)

3.6.4 Stimulus: Loss Of A Headquarters

The loss of a headquarters unit is very serious stimulus, especially in a communications study. When ever this happened one of the units under that headquarters would assume the function of the headquarters after a time delay. During this delay no messages could be sent or received by that organization other than internally or to direct support units. Any messages sent by courier were simply lost.

3.6.5 Stimulus: Receipt Of Obsolite Artillery/CAS Requests

Throughout the simulation, anytime any unit handled a support request that was over 15 minutes old, it considered the request OBE and discarded it from the system. The main effect of this was to reduce the backup of message traffic and to make the FDCs move effective. In conjunction with this a change was made to the support request procedure. Rather than being able to request fire against every enemy target, every combat interval (64 seconds), by every friendly unit in combat, the procedure was changed to permit one request per unit in contract per interval.

3.6.6 Stimulus: Reconnaissance And Headquarters Unit Orders

Prior to this enhancements Reconnaissance and Headquarters units never moved unless they came under direct fire. The had two effects with regard to C^3I. The first was that, in an advance, the headquarters were soon left far behind which gave unrealistic communications saftey and messenger delivery times. It also distorted a higher units perception of where its subordinates were. The second effect was that the intelligence traffic expected from reconnaissance units was nonexistent. The simulation was enhanced such that both of these unit types would follow orders but operated on a fire and flee plan. Before this, they had just fled. In conjunction with this, when a unit took casualties beyond its limit, it no longer retreated away from the enemy. It retreated towards its headquarters. "Away from the enemy" has the possibility of being in any direction at all because the entire world had not been modeled.

SECTION 4
CASES EXAMINED

4.1 GENERAL

The prototype TRACE model was used to conduct four basic experiments that lead to a first-order quantification of tactical communications effectiveness. Specifically, these four cases explore the progress and outcome of ground combat operations for degraded and non-degraded communications in conventional and mixed nuclear-conventional weapons environments. Each of the four cases employs the same conflict scenario, combat resources, and military objectives. This section sets forth the preceding parameters while the results and analysis of the computer runs are presented in the subsequent section. A complete listing of all initial input values to the model is included in Appendix C.

4.2 TRACE PROTOTYPE TEST SCENARIO

In formulating a conflict scenario to test the prototype TRACE model and at the same time gain insight into the value of communications on the tactical battlefield, two main considerations were observed. First, neither side should have an overwhelming force advantage which could easily overshadow the role of communications as well as bring the conflict to a close too quickly. Clearly, whatever force multiplier effect communications may have, there is a point beyond which no amount of communications can overcome a force imbalance. Secondly, the total size of the opposing forces should be kept as small as possible to facilitate validation and checkout of the added capabilities and processes of the TRACE model without compromising the credibility of results from the experimental test cases.

Since the basic TCOR model from which TRACE is derived does not yet incorporate terrain/weather effects on more that a "zeroth-order" basis, the specific geographic location of the conflict is irrelevant as far as the model processes are concerned. Even so, the geographic setting may be taken to be the Fulda gap area in Central Europe.

The scenario represents a Red tank division breaking through the defensive line held by a Blue armored division. The purpose of these runs was to determine the relationship that communications has to the battle outcome. For this reason, standard TO&E divisions have been used in both cases as opposed to modeling any particular divisions.

The Blue division is defending with two balanced brigades forward and an armor-heavy brigade in reserve (see Figure 14). The Red division is breaking through on a shorter frontage (see Figure 15). Red has divided its forces into a division two echelon attack. The Red division has a tank and a motorized rifle regiment in the division first echelon supported by the divisional artillery and one attached artillery brigade from Army assets. After the initial breakthrough, the division second echelon, two tank regiments, assumes the attack and the divisional artillery switches to supporting them.

The Red plan is to contain and pin down the enemy as much as possible while pentrating deep into the rear area. Referring to Figure 3, the division first echelon will penetrate the lines using the infantry to pin the forces on the right flank. The tank regiment will push forward. This happens in the first 1-2 hours of conflict. The division second echelon will swing a little to the right to envelope the pinned forces, contain them, and then link with the division first echelon and press on. The Red plan is to have this breakthrough complete and ready for army second echelon exploitation in 7 hours maximum.

The respective force strengths for each combatant are summarized in Tables 4 and 5. A detailed breakdown of force structures and strengths can be found in Appendix C. Tables 4 and 5 exclude headquarters units because they do not enter combat even though they can defend and be attrited. Finally, Figures 16 and 17 show the respective force structures in military symbology.

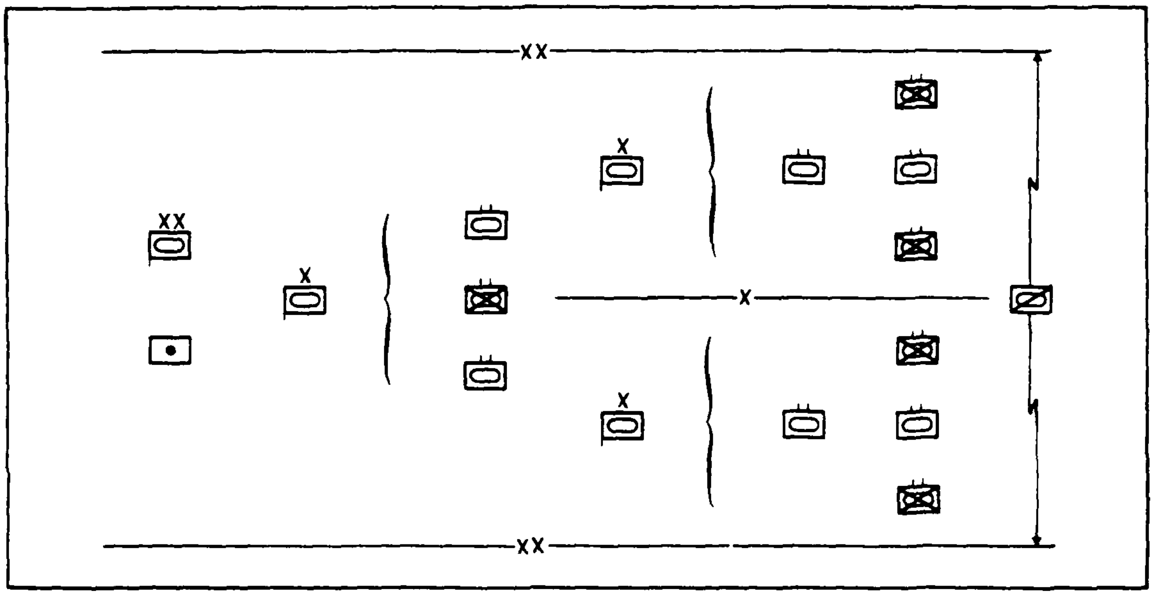


Figure 14. Blue deployment

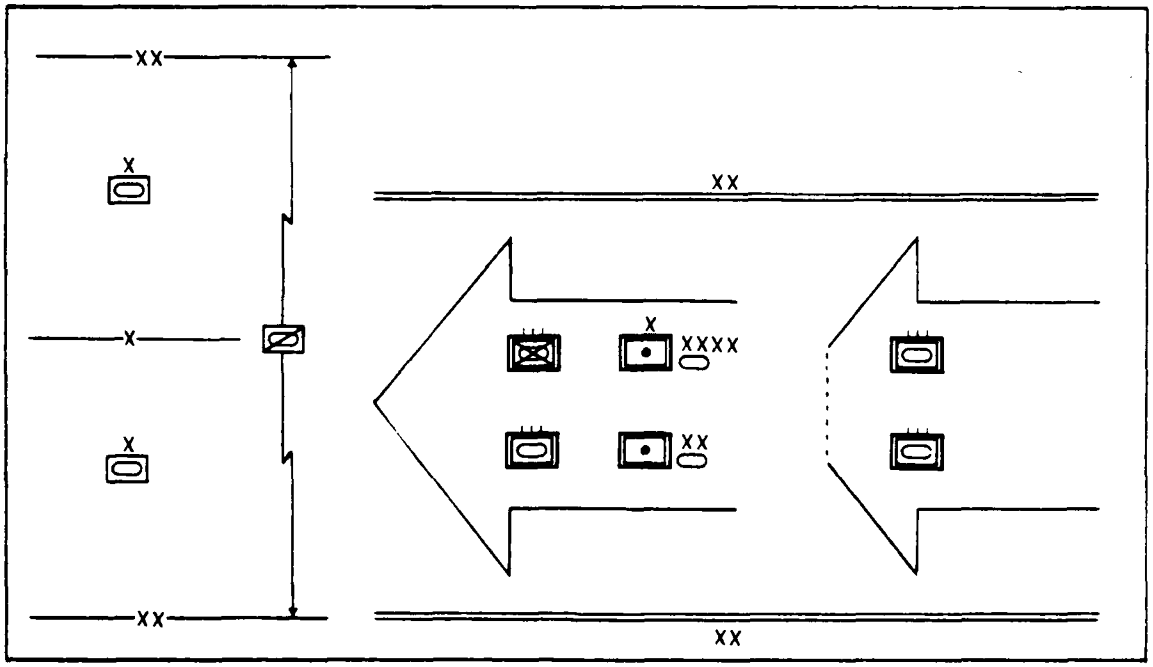


Figure 15. Red deployment

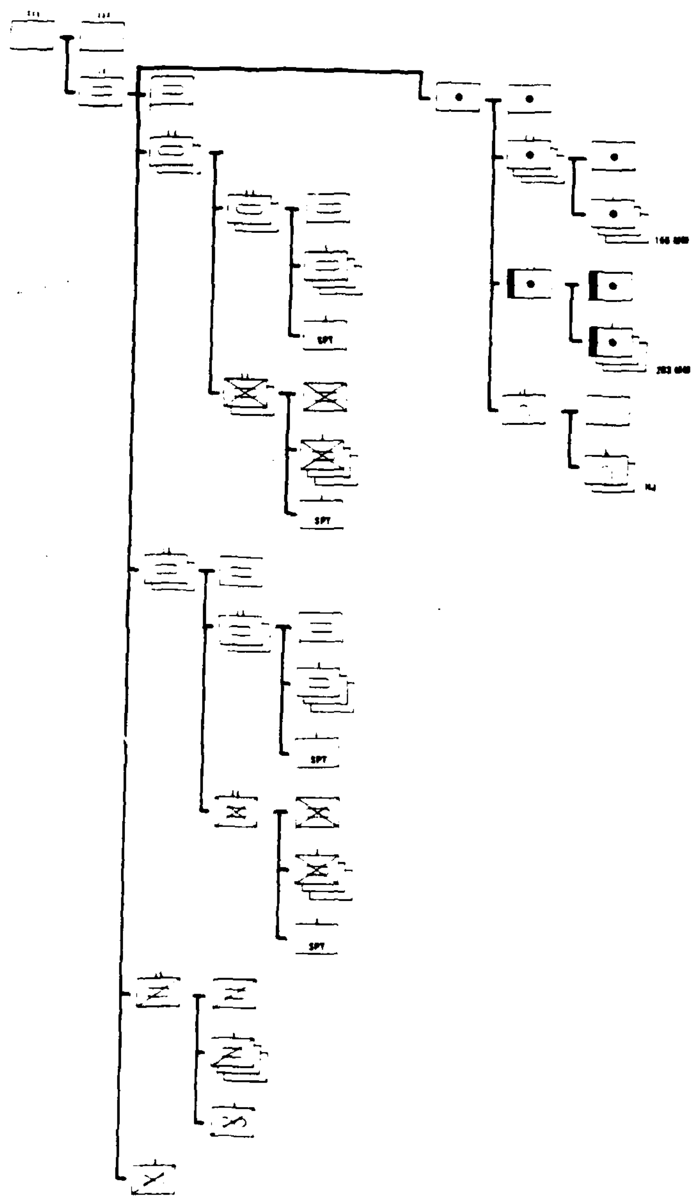


Figure 16. Blue forces.

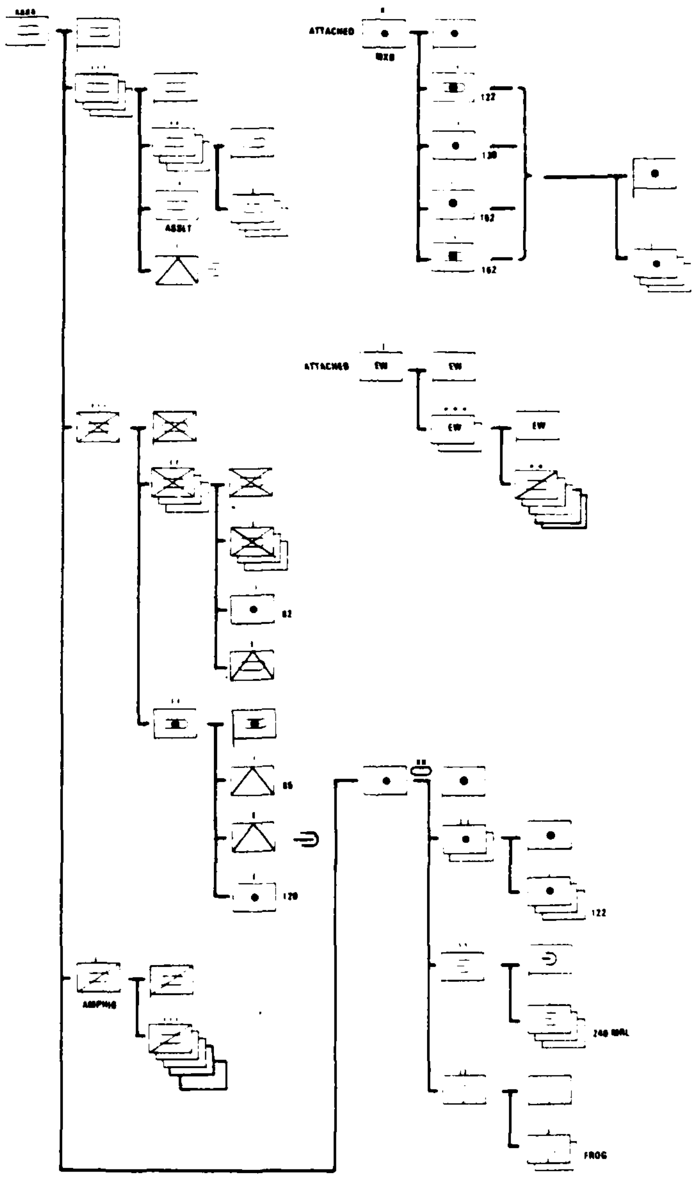


Figure 17. Red Forces.

Table 4. Blue force strength summary.

	Units	APCs	ATUs	Tubes	Tanks	Rounds
1st Bde	16 Co.	78	-	10	142	10994
2nd Bde	16 Co.	78	-	10	142	10994
3rd Bde	12 Co.	39	-	6	132	9550
Div Arty	12 Bty.	-	-	66	-	14316
Recon	5 Co.	54	8	3	27	3453
Totals	61	249	8	95	443	49307

Table 5. Red force strength summary.

First Echelon	Units	APCs	ATUs	Tubes	Tanks	Rounds
1st Reg.	11 Co.	-	6	-	100	4091
2nd Reg.	17 Co. and					
	4 Bty	81	30	12	30	3750
3rd ACS	5 Plt.	-	10	-	15	1500
4th Arty Bde	12 Bty.	-	-	36	-	5100
7th Div Arty	9 Bty.	-	-	54	-	6378
8th Recon. Reg.	10 Co.	-	10	-	-	310
Second Echelon						
5th Tank Reg.	11 Co.	-	6	-	100	4091
6th Tank Reg.	11 Co.	-	6	-	100	4091
Totals	90	81	68	102	345	29311

4.3 MITL INTERFACE

The TCOR model does not have a highly developed capability to automatically assimilate battlefield status and intelligence information and from this make command decisions. Since the ability to make such decisions is intimately related to communications, the Man-in-the-Loop (MITL) capability of the model was employed to provide high level command control decisions. All four experimental cases were conducted in the manner described below.

A BDM staff member with a previous U.S. Army career as a field grade officer and not associated with this project was selected to be the Blue Division commander. His previous experience included many staff and command positions in tactical combat operations. No equivalent was designated for Red; the model would be allowed to conduct all Red operations with human interfaces conducted by the TRACE project staff should they become necessary.

Beginning at time zero, the model was allowed to simulate five hours of combat and halted. In addition to all of the normal statistical data, restart information was written to a storage file every 30 simulated minutes so that the battle could be resumed at any of these time points. Starting at time zero was a matter of convenience since there is no day/night differentiation in the model.

Using a piece of 18 x 24 inch clear acetate and red and blue grease pencils, the project staff generated a situation map overlay at hour two (02:00 hours). The situation thus recorded was deduced strictly from the communications status and intelligence reports received during that two hour interval.

The MITL (Blue Division Commander) was then called to review the situation and redirect the battle as he saw fit with no encouragement from the project staff. After assessing the situation, he transferred his decisions directly to the situation overlay and the project staff subsequently converted these decisions into model inputs. The model was then allowed to simulate another five hours of combat starting at the hour-two MITL interface point.

At hour four (04:00 hours) the entire process was repeated with a new situation map and MITL interface. If the MITL decided at any interface not to change or give any new orders, no computer run would be required because we had allowed for five hours of combat and a new situation map could be generated two hours of combat later immediately. In actuality the MITL did effect changes at each two-hour situation review in all four cases examined. Each case was explored for a total of eight and one-half hours and therefore MITL interfaces occurred at two, four, six, and eight hours. Although a smaller review interval could have been selected at any time (in 30 minute increments because of the restart point written) this was found to be unnecessary by the TRACE staff as each two-hour situation map was generated.

In Cases III and IV, each side was permitted to employ up to 16 tactical nuclear weapons. All Blue nuclear strikes were under the direct control of the MITL while the Red strikes were controlled by the model logic.

SECTION 5
RESULTS AND ANALYSIS

5.1 INTRODUCTION

The results of the four cases examined with the prototype TRACE model are presented in this section. Those cases are:

I Conventional Warfare - Unimpaired Communications

II Conventional Warfare - Degraded Communications

III Nuclear Warfare - Unimpaired Communications

IV Nuclear Warfare - Degraded Communications

The initial conditions, scenario, resources and military objectives are identical for all cases as identified in Section IV. Furthermore, the actions of the Blue Division Commander were effected through human interaction with the model as was also explained in Section IV.

Later in this Section, the reader will notice the appearance of two additional cases denoted by Cases III-FP and IV-FP. The abbreviation FP stands for Free Play and means that both Red and Blue combatants were allowed to employ their sixteen tactical nuclear weapons according to the TRACE model criteria. Furthermore, there was no MITL intervention in these two cases which means that only two computer runs were required and that the model itself made all Blue decisions as well as Red. At first, these runs were only intended as checkout but the results were interesting enough to include in this report for comparison with the MITL interactive cases.

This section contains a large number of full page charts and graphs. To enhance textual continuity and clarity, all figures have been grouped in their order of reference and placed at the end of the section.

5.2 COMBAT RESOURCE DRAWDOWN

It is a generally accepted military belief that good communications permit a more effective use of given resources or mission accomplishment with fewer resources than might otherwise be required in a poor communications environment. The resources (as recognized by the TRACE model) are infantry units, armor units, artillery pieces, and ammunition. Table 6 summarizes Blue Division resources remaining at 05:30 and 08:30 as a percentage of the initial quantities for each of the six TRACE cases examined.

Table 6. Percentage of Blue Division resources remaining at 05:30 and 08:30

Case	05:30				08:30			
	Inf	Armor	Arty	Ammo	Inf	Armor	Arty	Ammo
I	81.7	78.8	93.7	15.0	80.5	72.0	90.5	13.4
II	80.2	74.7	75.8	9.7	79.4	73.4	75.8	6.7
III	72.4	80.8	72.6	34.0	70.8	77.9	67.4	15.7
IV	77.8	74.5	84.2	24.5	76.3	67.7	80.0	12.6
III-FP	78.6	77.2	76.8	31.6	72.8	73.1	69.5	22.7
IV-FP	78.2	78.8	88.4	42.6	73.2	72.2	75.8	23.5

The dynamic drawdown of these resources is shown graphically in 30 minute increments for each of the six cases in Appendix D. The selection of the 05:30 and 08:30 time points for reporting result summaries is based on the Blue defense objectives -- hold a phaseline approximately parallel to, and eight kilometers behind, the initial FEBA until 05:30 and hold a second phaseline coincident with the Division rear boundary.

Although Appendix D portrays ammunition drawdown for the six cases, it is also included here in Figures 18 and 19 to facilitate comparison among them. Note that Cases III and IV appear in both figures so that Figure 18 encompasses the four MITL cases while Figure 19 the four nuclear cases.

Both of these figures clearly demonstrate a significant delay in ammunition expenditure and thus combat engagement due to degraded Blue communications. Figure 18 also shows that ammunition expenditure in the degraded communications cases eventually surpasses that of the non-degraded cases. This effect is attributable to degraded communications in conjunction with the MITL's aggressiveness in trying to halt the Red advance. The Blue Division commander ordered elements of the First and Third Brigades to move into blocking positions that channeled the advancing Red force along his existing route of advance. This would eventually lead to a pinch-off and encirclement of the Red forces. Delayed communications, however, allowed the Red forces to penetrate deeper as well as mass more forces along the march route resulting in a more intense battle with the ensuing greater losses. Referring to Figure 19, we see that the model alone (without MITL intervention) plays a more conservative game and, in the end, shows virtually no difference in ammunition expenditure.

Later in this Section, we will investigate more closely the loss of other resources as well as Red penetration and ground gained.

Referring back to Table 6 and comparing Case I to II and III to IV, we generally see fewer resources expended/lost at the same point in time when Blue communications is unimpaired. The significant exceptions occur in Cases III and IV and this is primarily due to the self-inflicted losses from tactical nuclear weapons employment. Later in this section there is a tabular summary of all losses incurred to both sides by all nuclear strikes. (The 16 nuclear weapons allotted to each side are not included in the ammunition count and are treated separately.) The somewhat surprising result occurs in cases III-FP and IV-FP where, at battle's end, there is virtually no difference in resources expended/lost. Table 7 presents the same resource summary for the Red side.

Table 7. Percentage of Red resources remaining at 05:30 and 08:30

Case	05:30				08:30			
	Inf	Armor	Arty	Ammo	Inf	Armor	Arty	Ammo
I	51.7	77.7	100.	11.8	44.3	71.9	100.	2.8
II	66.4	69.9	98.0	9.3	57.7	68.4	95.1	4.8
III	36.2	73.3	98.0	15.4	28.2	59.7	98.0	5.6
IV	42.3	60.6	97.1	14.4	41.6	51.0	97.1	5.3
III-FP	27.5	63.5	90.2	26.9	22.8	53.3	100.	12.7
IV-FP	57.7	71.6	93.1	31.4	54.5	54.8	93.1	13.0

With the exception of ammunition expenditure, Red generally expends/loses fewer resources when Blue communications is degraded. This effect is most noticeable in the FP cases (e.g., non-MITL) even though there is virtually no difference in ammunition expenditure as was true for Blue. The percentages reported in Tables 6 and 7 were based on the resources of just the combat maneuver units which basically excludes the Headquarters units. Table 8 below summarizes the total combat expendable resources for each side so that numerical quantities may be determined as desired. (A more detailed breakdown of these resources appears in Section 4.)

Table 8. Total initial combat resources that are expendable in combat.

Side	Infantry Units	Armor Units	Artillery Tubes	Ammo Rounds	Nukes
Blue	257	443	95	49300	16
Red	149	354	102	29311	16

5.3 COMBAT UNIT DRAWDOWN

The combat resources (shown in Table 8) of each player are organized into Company and Battery level units. For the Blue side there are 61 of these units capable of engaging in combat initially. The distribution of the 61 units is:

(1) 29 armored companies,

(2) 15 infantry companies,

(3) 12 division artillery batteries,

(4) 3 reconnaissance companies, and

(5) 2 anti-tank companies.

This list excludes the two Lance Batteries each having 16 tactical nuclear weapon rounds.

Figures 20, 21, and 22 show the number of these 61 units that are combat effective over the course of the battle. A combat effective unit is defined here as a unit that is not dead and has ammunition left. This definition is due strictly to the lack of a model post-game processing capability that employs a threshold level to categorize a unit as being combat effective or not. It turns out that at each 30-minute reading and count of units, those assessed as combat effective almost always had at least ten percent of their basic ammunition load.

All three figures demonstrate the initial reduction of Blue losses due to degraded Blue communications. This is primarily attributable to the slower responsiveness of the First and Third brigades to the Red thrust into the Second brigade. Eventually, however, the degraded communications leads to fewer combat effective units remaining after the battle. Once again, it must be remembered that the actions of the MITL played heavily in the results portrayed in Cases I through IV. Somewhat surprisingly, the two FP cases end with the same number of combat effecitve units left while at the same time showing the same degraded communications delay effect. We note also that the more consistent and conservative play of the model in an FP mode leads to a greater number of combat effective units remaining at conflict's end. This is even more striking in view of the low usage of nuclear weapons in Cases III and IV.

5.4 NUCLEAR STRIKES

This section is intended to simply present a summary of the total damages incurred by all tactical nuclear strikes as well as their target locations and timing. Figure 23 shows the dynamic expenditure of the tactical nuclear weapons for both sides of each of the four nuclear cases. Table 9 summarizes the total losses caused by those strikes on both friendly and enemy forces in terms of units of infantry and armor (not companies) and artillery tubes.

Table 9. Summary of total combat losses due to nuclear strikes.

Case	Blue Losses						Red Losses					
	Infantry		Armor		Arty		Infantry		Armor		Arty	
	BS	RS	BS	RS	BS	RS	BS	RS	BS	RS	BS	RS
III	5	15	5	26	1	1	18	10	33	0	0	0
IV	0	7	17	16	0	2	22	0	9	0	0	0
III-FP	6	11	7	48	0	2	33	13	30	9	0	0
IV-FP	0	9	13	13	1	1	15	0	59	0	0	0

BS = Blue Strikes, RS = Red Strikes

Refering to Figure 23, comparison of the free-play cases (III-FP and IV-FP) reveals that fewer nuclear weapons were employed by both sides in the the degraded communications case as well as a delay in their release. There is only one direct effect of communications performance on nuclear artillery (or conventional for that matter) and that is the time for the support request from the requesting unit to be sent to the artillery battery. Refering again to Figure 23, there is an implication that degraded communications results in a lower utilization of tactical nuclear weapons but, this is not necessarily the case although degraded communications is most certainly an indirect factor. In all four cases (III, IV, III-FP, and IV-FP) Red communications is undegraded and Red nuclear strikes are controlled and directed by the TRACE model criteria. Blue strikes, on the other hand, are model controlled only in the free-play cases. The MITL directed strikes in Cases III and IV are both immediate and totally independent of communications. The foregoing caveats are intended to preclude the reader from hastily drawing potentially erroneous conclusions regarding nuclear strikes vis-a-vis the state of Blue communications. We also reiterate that the Blue Division commander (MITL) had directed his six remaining nuclear weapons be used at 06:00 hours in Case IV but that they did not detonate for an undetermined reason.

Finally, we must also consider the model criteria for tactical nuclear weapon strikes. When two opposing units are engaged in combat, their status is updated every 64 seconds (continuous combat within 64 second discrete time intervals). During each of these time intervals there is a 15 percent chance that a unit will request artillery support. If nuclear artillery support is permitted for this unit and the unit is at or above its casualty limit, then a nuclear strike request is issued to the appropriate firing battery. The casualty limit is specified by the user (75 percent for the six TRACE cases) and is compared to the average of the fractional amounts of each initial resource expended/lost for the unit. Each possible resource (infantry, armor, artillery, rockets, and ammunition) has equal weight in determining the casualty average which, in turn, can potentially lead to an occasional unexpected result.

The nuclear strike losses data shown earlier in Table 9 can be reduced and transformed into a percentage of "friendly" losses form as shown in Table10 below.

Table10. Friendly losses as a percentage of total losses incurred by nuclear strikes.

Case	Blue	Red
III	17.7	19.2
IV	35.4	0
III-FP	17.1	26.5
IV-FP	15.9	0

In Case IV, over 35 percent of all losses due to Blue strikes against Red forces resulted in Blue losses. This is primarily attributable to the somewhat fatalistic attitude taken by the MITL toward his virtually neutralized 2nd Brigade forces as well as the failure of the model to detonate the six Blue nuclear weapons at 06:00 whch would have resulted in a greater kill of Red forces and much fewer to Blue. Model directed nuclear strikes do not account for friendly forces in proximity to the target which partially explains the Red results. The fact that Red incurred no damages to himself due to his own strikes against Blue in the degraded Blue communications cases is probably not strongly related to the degrade itself. The result is due primarily to the lower number of Red strikes and strikes at targets where there are no or very few closely located Red units.

In completing this section, we present Table 11 summarizing the precise time and hexagonal coordinate location of each nuclear strike.

5.5 COMMUNICATIONS PERFORMANCE

There are four basic types of communications in TRACE that have a direct and immediate impact on the progress and outcome of a combat operation. They are: combat orders, status and situation reports, intelligence information reports, and artillery support requests. Communications with respect to air operations are not included only because air operations did not play a significant role in the prototype TRACE cases. Other types of communications become increasingly important (such as resupply) in proportion to the duration of the conflict which is not a key factor in the TRACE cases.

Tables 12, 13, 14, and 15 summarize the dynamic flow of communications traffic for each message type respectively for the six TRACE cases examined. The total number of messages successfully completed and the average message delivery time for them are shown over time for each case. It is important to realize that these communications messages are strictly the successful ones excluding all messages that may have been generated but were unsuccessful for any reason. Unfortunately, the TRACE game post-processing capability is insufficient to support report generation of all communications related events independent of their initial or ultimate dispositions.

The columns in Tables 12, 13, 14, and 15 were aggregated and those results are presented in Table 16. Two interesting features are revealed by this table as follows. First, there is roughly an order-of-magnitude increase in message transmission time for orders and reports and

Table 11. Time and target hex location of all nuclear strikes by case.

III			IV			III-FP			IV-FP		
S	Time	Loc	S	Time	Loc	S	Time	Loc	S	Time	Loc
R	1:23:25	72634	R	1:53:57	76375	R	1:23:25	72634	B	1:44:44	76311
R	1:23:25	72634	R	1:53:57	76375	R	1:23:25	72634	B	1:54:41	76317
R	1:25:55	72422	B	2:00:10	72422	R	1:25:55	72422	R	2:11:39	76367
R	1:25:55	72422	B	2:00:10	72426	R	1:25:55	72422	R	2:11:39	76367
R	1:28:25	72644	B	2:00:10	72463	R	1:28:25	72644	R	2:22:13	76314
R	1:28:25	72644	B	2:00:10	76315	R	1:28:25	72644	R	2:22:13	76314
R	1:30:55	72644	B	2:00:10	76311	R	1:30:55	72644	B	2:22:14	76364
R	1:30:55	72644	B	2:00:10	76313	R	1:30:55	72644	B	2:24:44	72426
B	2:01:00	72462	B	2:00:10	76335	B	1:34:56	72676	B	2:27:14	76317
B	2:01:00	72422	B	2:00:10	72644	B	1:34:56	72647	R	2:27:29	76314
B	2:01:00	72643	B	2:00:10	76337	B	1:37:26	72647	R	2:27:29	76314
B	2:01:00	72644	B	2:00:10	76331	B	1:37:26	76311	R	2:29:59	76314
B	2:01:00	72665	R	6:01:00	72766	B	1:39:56	72462	R	2:34:17	76314
B	2:01:00	76351	R	6:03:30	72766	B	1:39:56	72647	B	2:55:24	76373
B	2:01:00	76334				B	1:42:26	72644	B	3:34:16	76311
B	2:01:00	72666				B	1:42:26	76335	B	4:53:56	72422
B	2:01:00	76311				B	1:44:56	72643	B	5:53:16	76331
B	2:01:00	76313				B	1:44:56	76317	B	5:55:04	72431
R	2:09:52	72427				B	1:47:26	76315	B	6:00:47	72431
R	2:09:52	72427				B	1:47:26	76351			
R	2:20:19	72645				B	1:49:56	72647			
R	2:20:19	72645				B	1:49:56	76315			
R	2:28:16	72645				B	1:53:24	72642			
R	2:28:16	72645				B	1:53:24	72641			
R	2:33:58	72645				R	2:09:23	72462			
R	2:33:58	72645				R	2:11:53	72462			
B	6:00:10	72667				R	2:20:36	76314			
B	6:00:10	72742				R	2:25:05	76314			
B	6:00:10	72655				R	2:25:05	76314			
B	6:00:10	72652				R	2:31:49	76314			
B	6:00:10	72762				R	2:32:04	76314			

Table 12. Combat orders message summary.

CASE / TIME	I		II		III		IV		III-FP		IV-FP	
	#	$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$
:30	21	27	13	135	21	27	13	135	21	27	13	135
1:00	0	-	8	121	0	-	8	121	0	-	8	121
1:30	0	-	0	-	0	-	0	-	0	-	0	-
2:00	5	15	3	97	5	37	5	59	5	28	3	90
2:30	7	18	24	357	7	38	12	251	7	37	17	291
3:00	5	17	1	215	0	-	4	281	0	-	1	867
3:30	0	-	0	-	0	-	0	-	0	-	0	-
4:00	0	-	0	-	4	78	0	-	4	22	0	-
4:30	4	23	0	-	5	18	4	91	5	47	0	-
5:00	5	21	2	237	5	17	4	69	5	19	2	146
5:30	12	48	8	106	7	33	13	90	7	18	15	160
6:00	0	-	3	527	0	-	0	-	0	-	0	-
6:30	0	-	4	198	0	-	0	-	0	-	0	-
7:00	0	-	0	-	4	56	0	-	0	-	0	-
7:30	0	-	3	77	0	-	0	-	4	88	4	370
8:00	0	-	0	-	0	-	0	-	0	-	0	-
8:30	4	20	0	-	0	-	0	-	0	-	0	-

t is in seconds

Table 13. Status report message summary.

			II		III		IV		III FF		IV FF	
		:		$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$
			0		0	-	0		0		0	-
[illegible]	[illegible]	19	19	139	38	26.6	19	139	38	26.6	19	139
[illegible]	[illegible]	33	40	152	90	30.7	41	149	90	30.7	41	147
[illegible]	24	33	41	165	108	26.3	42	176	124	39.5	44	171
[illegible]	49	31	67	417	74	32.1	73	512	80	41.7	60	344
3:00	4[illegible]	27	60	430	74	38.9	78	556	70	35.6	61	539
3:30	[illegible]	[illegible]	74	450	46	38.4	56	346	42	52.1	48	403
4:00	25	21	63	385	31	27.1	40	273	32	32.4	30	119
4:30	38	31	54	136	40	40.4	41	160	28	28.2	24	176
5:00	[illegible]	27	48	164	46	37.0	41	158	37	26.6	34	258
5:30	37	34	51	267	42	38.1	38	157	33	40.1	27	221
6:00	25	40	39	259	23	43.4	41	228	33	37.5	37	154
6:30	22	35	26	122	40	41.3	38	249	22	36.7	40	125
7:00	15	34	16	79	55	27.3	22	133	18	40.0	35	135
7:30	21	32	11	201	55	41.8	26	145	21	44.1	41	149
8:00	[illegible]	37	8	99	47	40.2	25	113	24	33.8	59	275
8:30	[illegible]	16	0	0	40	26.8	12	156	30	31.8	36	241

t is in seconds

Table 14. Artillery request message summary.

CASE / TIME	I		II		III		IV		III-FP		IV-FP	
	#	t	#	$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$
:30	0	-	0	-	0	-	0	-	0	-	0	-
1:00	265	31.4	39	96	278	30.6	39	96	278	30.6	39	96
1:30	674	34.0	210	648	844	31.4	205	641	844	31.4	198	669
[illegible]:00	621	32.9	639	849	898	35.0	684	881	926	38.5	671	883
2:30	[illegible]	36.0	757	861	539	36.6	767	904	604	45.8	674	898
[illegible]:00	[illegible]	38.4	378	889	531	33.0	406	909	456	38.1	302	829
[illegible]:30	[illegible]	[illegible]	[illegible]	559	361	37.0	287	679	208	44.8	134	553
4:00	[illegible]	[illegible]	29[illegible]	744	164	41.6	243	658	182	47.4	202	594
4:30	[illegible]	[illegible]	[illegible]	781	180	40.4	189	482	190	39.9	141	430
[illegible]	[illegible]	[illegible]	[illegible]	1051	226	34.6	313	668	122	32.7	165	512
[illegible]	[illegible]	[illegible]	[illegible]	882	264	32.5	300	699	149	33.5	117	342
[illegible]	[illegible]	[illegible]	162	533	106	[illegible]	290	675	154	31.9	229	452
[illegible]:30	[illegible]	[illegible]	[illegible]	229	194	35.7	144	384	100	44.0	352	567
7:00	[illegible]	[illegible]	47	72	292	35.8	103	245	104	36.0	388	606
7:[illegible]	[illegible]	[illegible]	[illegible]	65	350	32.6	73	65	81	28.7	430	631
[illegible]	[illegible]	[illegible]	[illegible]	55	296	29.3	28	64	90	34.6	328	422
[illegible]:30	[illegible]	[illegible]	[illegible]	74	259	33.1	23	73	193	31.4	264	475

$\bar{t}$ is in seconds

Table 15. Intelligence report message summary.

TIME \ CASE	I		II		III		IV		III-FP		IV-FP	
	#	$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$	#	$\bar{t}$
:30	0	-	0	-	0	-	0	-	0	-	0	-
1:00	9	29.0	11	138	15	28.0	11	138	15	28.0	11	138
1:30	28	37.6	18	188	42	28.2	23	180	42	28.2	20	149
2:00	30	34.7	18	374	38	52.5	27	402	38	30.7	16	551
2:30	14	20.4	16	475	15	44.8	23	406	26	39.1	15	442
3:00	15	39.9	11	345	19	44.8	18	323	18	36.6	11	341
3:30	17	34.4	8	389	19	37.5	18	437	9	29.2	12	312
4:00	12	35.0	14	200	10	29.6	11	289	10	54.4	10	149
4:30	9	38.0	11	414	7	58.0	18	466	15	41.7	8	163
5:00	21	36.6	15	307	11	37.8	13	231	8	35.0	4	167
5:30	10	26.2	2	225	8	56.5	14	146	6	12.7	8	263
6:00	6	15.5	4	98	7	49.3	14	156	6	26.5	16	140
6:30	5	51.8	7	207	5	49.4	9	190	7	33.7	16	283
7:00	4	24.0	5	161	6	15.8	4	165	5	38.6	22	236
7:30	3	20.0	4	115	9	28.3	5	128	3	66.0	6	207
8:00	2	10.0	0	-	7	30.1	2	64	1	10.0	11	268
8:30	1	32.0	0	-	6	86.0	2	54	5	65.4	20	136

$\bar{t}$ is in seconds

Table 16. Aggregate communications performance summary by case and message type at 0830.

CASE	ORDERS		STATUS RPTS		ARTY REQS		INTELL RPTS		TOTAL	
	#	t	#	t	#	t	#	t	#	t
I	63	27.2	579	30.6	3615	34.1	177	33.4	4443	33.5
II	69	228	617	281	4050	792	144	289	4880	705
III	58	33.9	846	33.9	5782	34.1	224	40.5	6910	34.3
IV	63	142	633	279	4094	720	212	290	5002	639
III-FP	58	32.2	722	35.4	4681	37.3	214	34.4	5675	37.0
IV-FP	63	206	636	248	4684	659	206	258	5589	592

$\bar{t}$ is in seconds

twice an order-of-magnitude increase for artillery requests when communications is degraded. There are so many artillery requests relative to the other message categories that the "twice an order of magnitude" effect dominates in the "total" column. The second feature is the more consistent message completion rate in the nuclear free-play cases (III-FP and IV-FP). The implication is that while communications experience large time delays, the messages eventually do go through (only 1.5 percent fewer total messages completed in the degraded communications case). Although there is a decrease in both intelligence and status reports in the degraded communications case, this has little effect on the battle because of the rudimentary automated command, control, and intelligence fusion processes in the model.

A graphic display of the communications time delay due to degradation can be developed by accumulating the number of messages completed with increasing time for each of the six cases and comparing the resulting functions in nondegraded and degraded pairs. The three resulting pairs for the six TRACE cases are shown in Figures 24, 25, and 26, respectively.

Case II appears to be the least satisfactory result from a purely intuitive standpoint. Under conditions of degraded communications performance, we see more successful communications taking place after about four and one-half hours and only moderate time delay before that. Implicitly, there are more messages generated in the degraded versus the non-degraded case because not all messages generated were completed and yet all those that were completed are shown in the figure. This result is due in part to the different response of the MITL in Case II wherein a larger number of the Blue combat units engaged in conflict earlier and survived combat longer and thus were able to generate more message traffic over time.

Cases III and IV, on the other hand, show a more intuitive result but should not be arbitrarily accepted as "the truth" on that basis. Two key factors pertaining to these cases must be considered. First, these are the third and fourth times the MITL has seen and played the same basic situation which must have an effect on his objectivity and, secondly, an undiscovered problem caused inappropriate utilization of the tactical nuclear weapons. (Even the automated Red usage seems strange although it could be perfectly correct based on the model criteria for use of nuclear weapons.)

The relationship between Cases III-FP and IV-FP speaks for itself and is entirely consistent with no MITL intervention as well as the utilization of both Red and Blue nuclear resources.

5.6 LOSS EXCHANGE RATIOS

From the resources remaining data presented in Tables 6 and 7 in Section 5.2, we can develop loss exchange ratios (LER). Those ratios, representing Red unit losses per unit Blue loss, are presented in Table 17 below for both 05:30 and 08:30.

Table 17. Combat resource loss exchange ratio summary.

Case	05:30				08:30			
	Inf	Armor	Arty	Ammo	Inf	Armor	Arty	Ammo
I	2.64	1.05	0	1.04	2.86	1.01	0	1.12
II	1.69	1.19	.08	1.00	2.05	1.19	.20	1.02
III	2.31	1.39	.07	1.28	2.46	1.82	.06	1.12
IV	2.60	1.55	.19	1.13	2.46	1.52	.15	1.08
III-FP	3.39	1.60	.42	1.07	2.83	1.74	0	1.13
IV-FP	1.94	1.34	.59	1.19	1.70	1.63	.28	1.14

We are now in a position to make a comparison between the degraded and non-degraded communications cases. On the premise that degraded Blue communications results in poorer or smaller loss exchange ratios, we can take the quotient of the LER for non-degraded communications divided by the LER for degraded communications as a measure of communications effectiveness. These quotients are presented in Table 18 below.

Table 18. Non-degraded to degraded communications LER ratios.

Case	05:30				08:30			
	Inf	Armor	Arty	Ammo	Inf	Armor	Arty	Ammo
Conventional	1.56	.88	0	1.03	1.40	.85	0	1.10
Nuclear	.89	.90	.39	1.13	1.00	1.20	.41	1.03
Nuclear F.P.	1.75	1.20	.72	.90	1.67	1.07	0	.99

An interesting graphic representation of the data in Table 18 is obtained by subtracting one (1.0) from each LER ratio and forming a bar-type chart. This results in a chart where positive values imply benefits of good communications while negative values imply detriments of communications (or advantages of degraded communications). The two charts for 05:30 and 08:30 are shown in Figures 27 and 28 respectively.

Artillery tubes appear to suffer so badly that the LER ratios cannot be conveniently included in the figures. In actuality, we have a numerical quirk due to the loss of very few or no Red artillery tubes as shown in Table 7. In general, however, Blue artillery losses are less under degraded communications conditions because they do not advance as quickly toward the enemy thereby lessening their vulnerability.

The fact that communications had little or no measurable effect on some of the LERs is not directly explicable but there are three known factors influencing this result. The first is quite simply that the course of the battle was influenced heavily by the Blue (MITL) Division Commander who became a little more aggressive in Cases III and IV due to familiarity with the Red attack and his ability to employ tactical nuclear weapons. Secondly, the nuclear weapons themselves were employed in a manner that led to significant self-inflicted damages. In all cases, Blue damages due to Blue strikes occurred to Blue units that for the most part had been already neutralized by the enemy but were far from dead. And finally, Blue attempted to employ his six remaining tactical nuclear weapons in Case IV at 06:00 hours but they failed to detonate in the TRACE model. Unfortunately, there was insufficient time to isolate the problem, solve it, and rerun the Case. We notice, however, that in response, Red did not use all of his nuclear weapons which mitigates the severity of this error.

5.7 GROUND EXCHANGE

Up to this point, we have considered several factors and numerical quantifications characterizing various aspects of the conflict progress and outcome. None of these, however, taken alone or in combination reflect the key issue under contention by the combatants which, in the TRACE scenario, is the control of terrain. From the Blue player's point-of-view, the objective is to successfully defend a phaseline until a specified time and retain control of the area behind that line. Red, on the other hand, wishes to attack, penetrate, gain control of, and reduce or eliminate any threat of the loss of that same piece of terrain. Both sides would ideally like to accomplish their respective missions with a minimum loss of their own resources, particularly personnel.

The scenario used and the graphics generation capability of TRACE readily permitted a determination of the terrain exchange for each of the six cases examined. The positions of all combatant units (not dead or neutralized) were plotted by computer on standard printer paper output medium using letter symbols for Blue players and numbers for Red. These "position maps" were generated at 30-minute intervals throughout the battle and are included in this report in Appendices F through K for Cases I through IV-FP, respectively. Because there is no automated procedure for determining the terrain occupied and controlled by either combatant's forces, three time-points were selected for manual evaluation. These were 0230, 0530, and 0830 corresponding to two combat phases and the end of the conflict scenario. This decision resulted in 18 position maps (three each for six cases) that were evaluated to determine the terrain exchange quantification. The exact procedure used is presented in Appendix L as well as the 18 subject position maps while the results are summarized in Table 19 below.

Table 19. Terrain lost by Blue side at 0230, 0530, and 0830 in square kilometers.

Case	Time		
	0230	0530	0830
I	60.1	68.4	64.5
II	61.3	65.5	66.0
III	48.3	59.4	73.9
IV	53.8	53.9	51.7
III-FP	40.7	62.2	78.9
IV-FP	45.0	76.5	89.8

The data in Table 19 becomes more meaningful if we compare the non-degraded and degraded communications cases via a ratio such that a positive value implies the benefit of unimpaired communications. Those ratios are shown in Table 20 below.

Table 20. Degraded to non-degraded communications terrain exchange comparisons.

Case Ratio	Time		
	0230	0530	0830
II : I	2.0%	-4.2%	2.3%
IV : III	11.4%	-9.3%	-30.0%
IV-FP : III-FP	10.6%	23.0%	13.8%

Refering to the table, it becomes immediately clear that only the free-play cases follow our intuitive expectations. That is, comparing the two FP cases, Blue loses more terrain in the degraded communications case consistently. We note also that the advantage of good communications is less significant at battle's end than it was during the first five and one-half hours of the conflict.

The Case IV to Case III comparison strongly suggests that Blue is much better off with degraded communications! Notice also that the value of communications consistently deteriorates as the battle progresses. One factor strongly influencing this rather disturbing result is the complete familiarity of the MITL with the scenario as well as his awareness of how well (or poorly) he did in previous cases. His displayed aggressiveness in Case IV indicated his desire to "win" (military roots) and he definitely lost some of his objectivity with respect to the study objectives. Secondly, we recall that the nuclear weapons-play in Case IV was not correct per the MITL's directives and this undoubtedly influences the result although we don't know exactly how or the extent to which it does. Little can be said with respect to the comparisons of Cases I and II that would be substantive. The general conclusion would be, of course, that communication didn't make a significant difference and, that after 0230 hours, the battle was for the most part, a standoff. An interesting feature, however, is the fact that Red was able to gain more territory in Case III than in either Case I or II.

5.8 SUMMARY

We have explored several parameters relating to and characterizing the status of the conflict engagement at selected time-points during the battle. None of these alone give us adequate insight into the value of communications other than to say that good communications generally appears to a favorable factor. In order to make a numerically meaningful comparison of the degraded and non-degraded communications cases, we need a measure of the outcome of each case that encompasses all of the key individual factors characterizing that case.

The data presented in Tables 6, 7, and 8 can be combined and transformed into a single table of combat losses which we have presented in Table 21 for the convenience of the reader. Consider the Blue player's point-of-view; he wants to defend his own initial ground, inflict losses to his opponent's resources, and minimize his own losses to the opponent. It seems reasonable then that a measure of success from Blue's point-of-view

Table 21. Combat losses of both players at the end of conflict (0830).

Case	Blue					Red			
	Inf	Armor	Arty	Ammo	Ground	Inf	Armor	Arty	Ammo
I	50	124	9	42,694	64.5	83	97	0	28,490
II	53	118	23	45,997	66.0	63	109	5	27,904
III	75	98	31	41,560	73.9	107	139	2	27,670
IV	61	143	19	43,088	51.7	87	169	3	27,758
III-FP	70	119	29	38,109	78.9	115	161	0	25,589
IV-FP	69	123	23	37,715	89.8	68	156	7	25,501

would minimize his resource and territory losses and maximize his opponent's resource losses. That premise leads to a payoff parameter (P) that takes the form of Red losses per Blue resource loss per defense area loss, i.e.,

$$P = \frac{\text{Red resources lost}}{(\text{Blue resources lost})(\text{Blue ground lost})}$$

The loss of infantry units, armor units, and artillery units is directly related to personnel loss (or vice versa) whereas ammunition expenditure is less directly relatable. Because of this and the very small differences of ammunition expenditure in the paired cases, we will exclude ammunition from the analysis. The data in Table 21 then reduces to that shown in Table 22.

Table 22. Aggregated combat losses at 0830.

Case	Blue		Red
	Inf + Armor + Arty	Ground	Inf + Armor + Arty
I	183	64.5	180
II	194	66.0	177
III	204	73.9	248
IV	223	51.7	259
III-FP	218	78.9	276
IV-FP	215	89.8	231

From the data in Table 22, we can now directly calculate the value of the payoff parameter P given in the equation above. The absolute value of P is not our ultimate goal however, but rather the effect that communications has on P. Assumming that better communication performance yields a greater payoff, we divide the non-degraded communications case payoff by the degraded communications case payoff. These payoff values and their ratios are summarized in Table 23.

Table 23. Case payoff parameters and comparisons.

Case	Payoff	Ratio
I	.0152	1.103
II	.0138	
III	.0165	.732
IV	.0225	
III-FP	.0160	1.341
IV-FP	.0120	

The table reveals a 10 percent better payoff with undegraded communications for conventional warfare and a 34 percent better payoff in nuclear free play. The nuclear MITL cases continue to show the reverse result as we discovered and discussed in the earlier sections.

The nuclear free-play assessment is a very pleasing result as it tends to show numerically, that communications does play a major and significant role in effective combat operations. We must carefully avoid unwarranted acceptance, however, of the absolute magnitude of these numbers. This caveat can surely be mitigated through additional refinement of and exploration with the TRACE model.

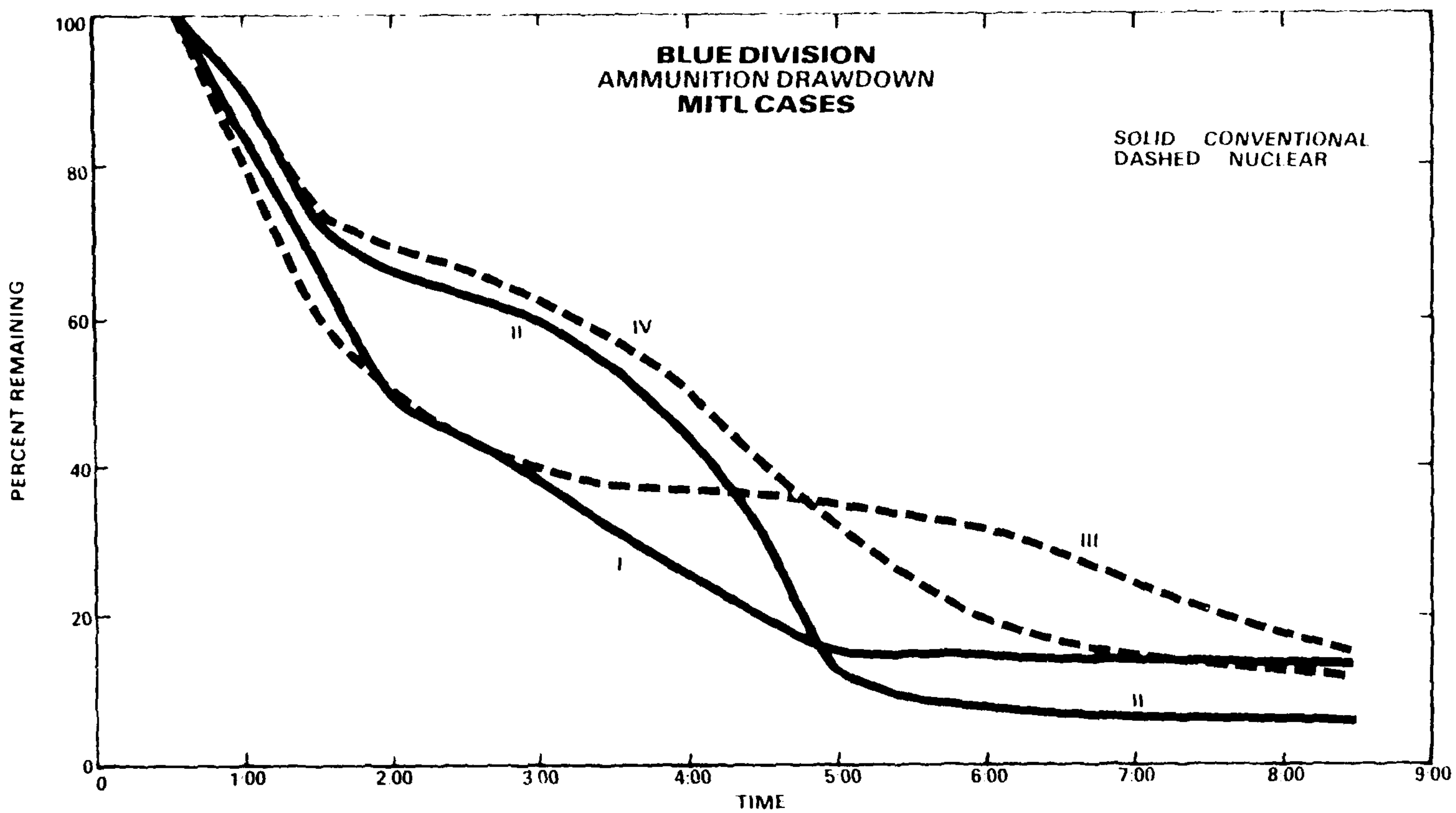


Figure 13. Blue division ammunition drawdown in the four MITL cases.

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DEVELOPMENT AND IMPLEMENTATION OF TCOR COMMO.(U)

FEB 80 D L PORTER, R L ROTHROCK, R H SCHMIDT DNA001-78-C-0175

UNCLASSIFIED BDM/W-80-055-TR DNA-5238F NL

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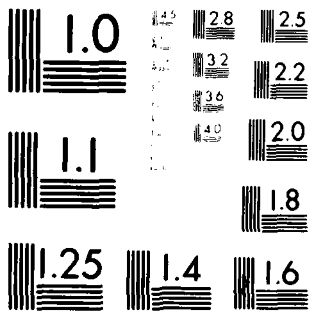

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

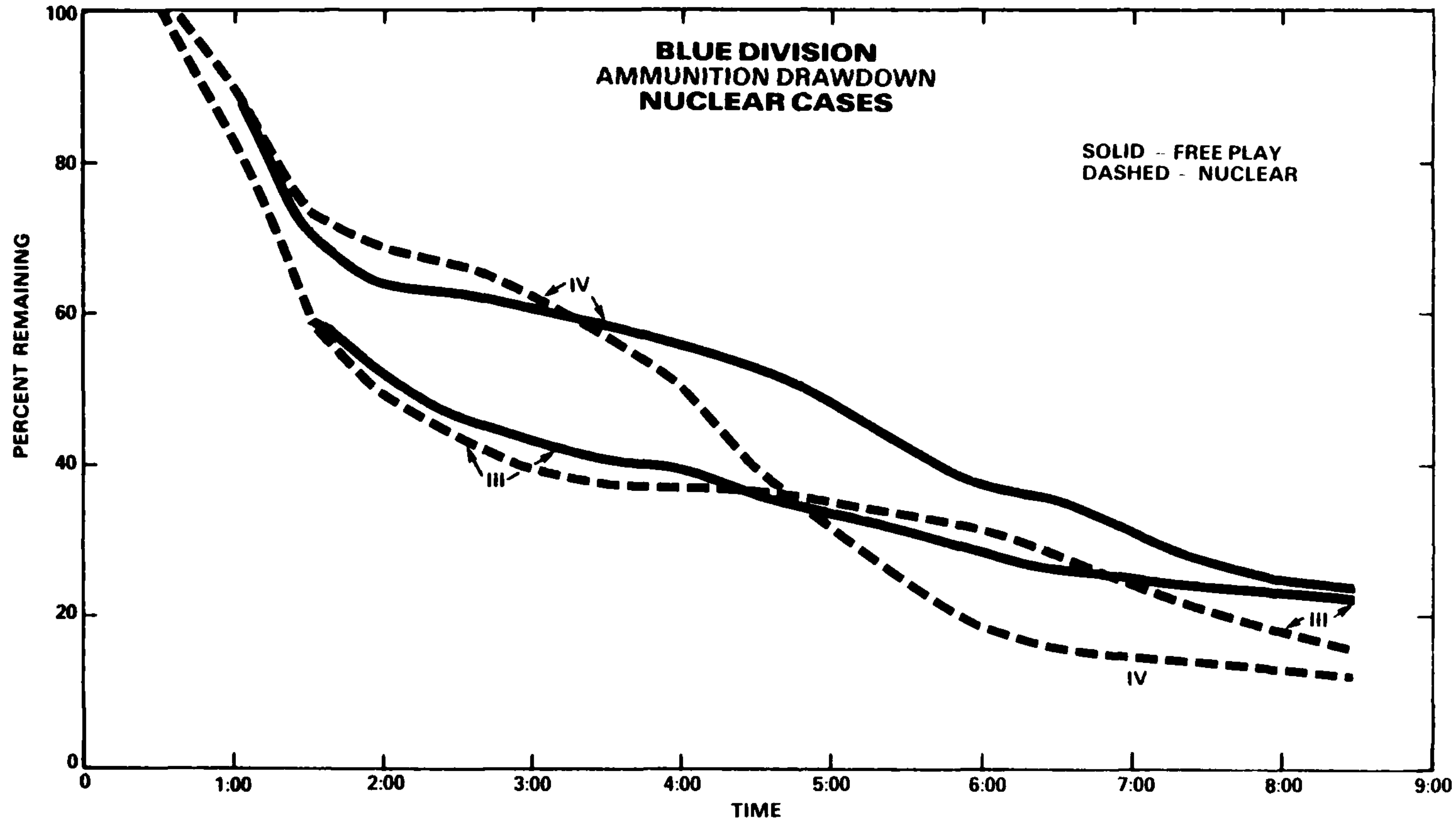

Figure 19. Blue division ammunition drawdown in the four nuclear cases.

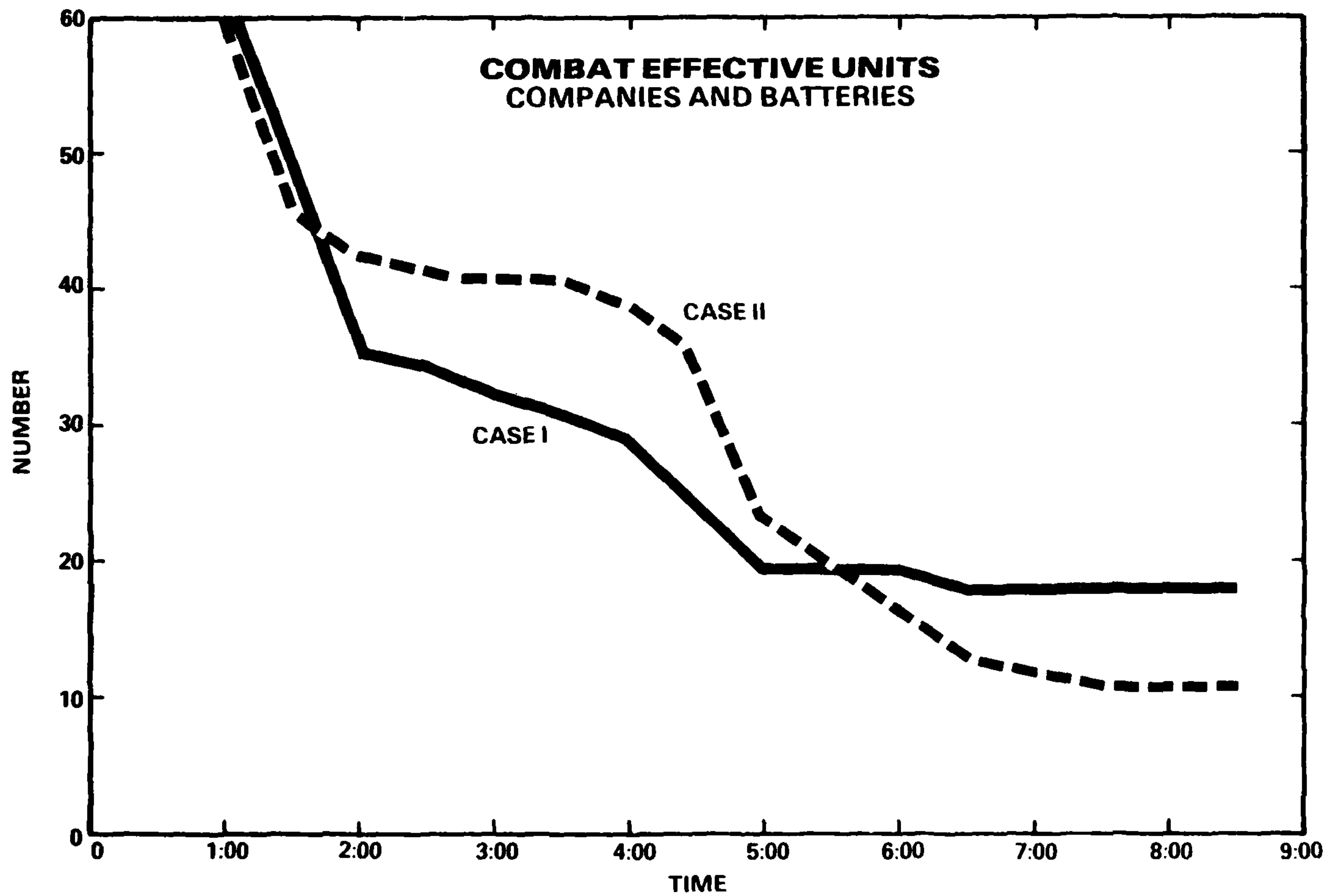

Figure 20. Combat effective units, companies and batteries.

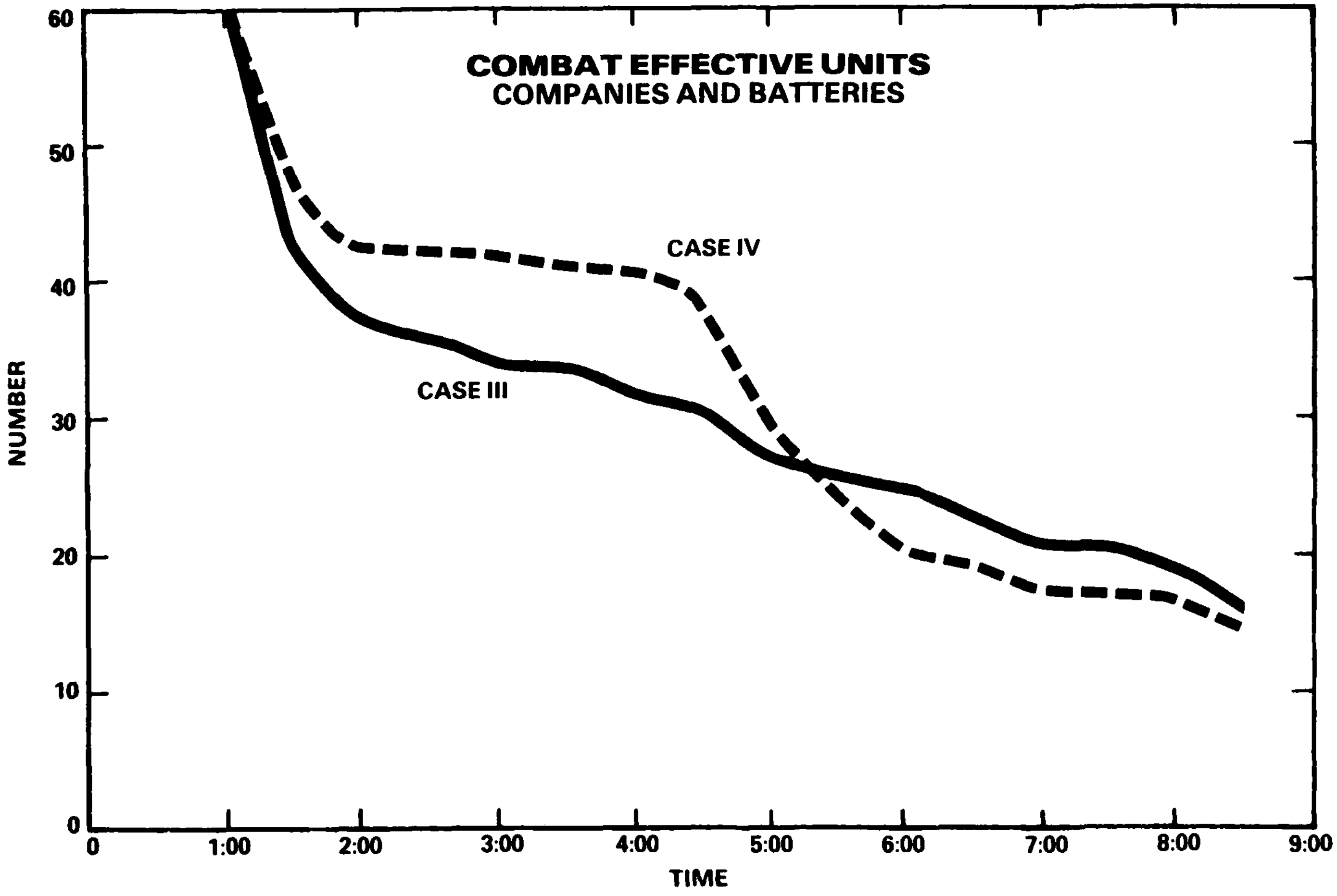

Figure 21. Combat effective units, companies and batteries.

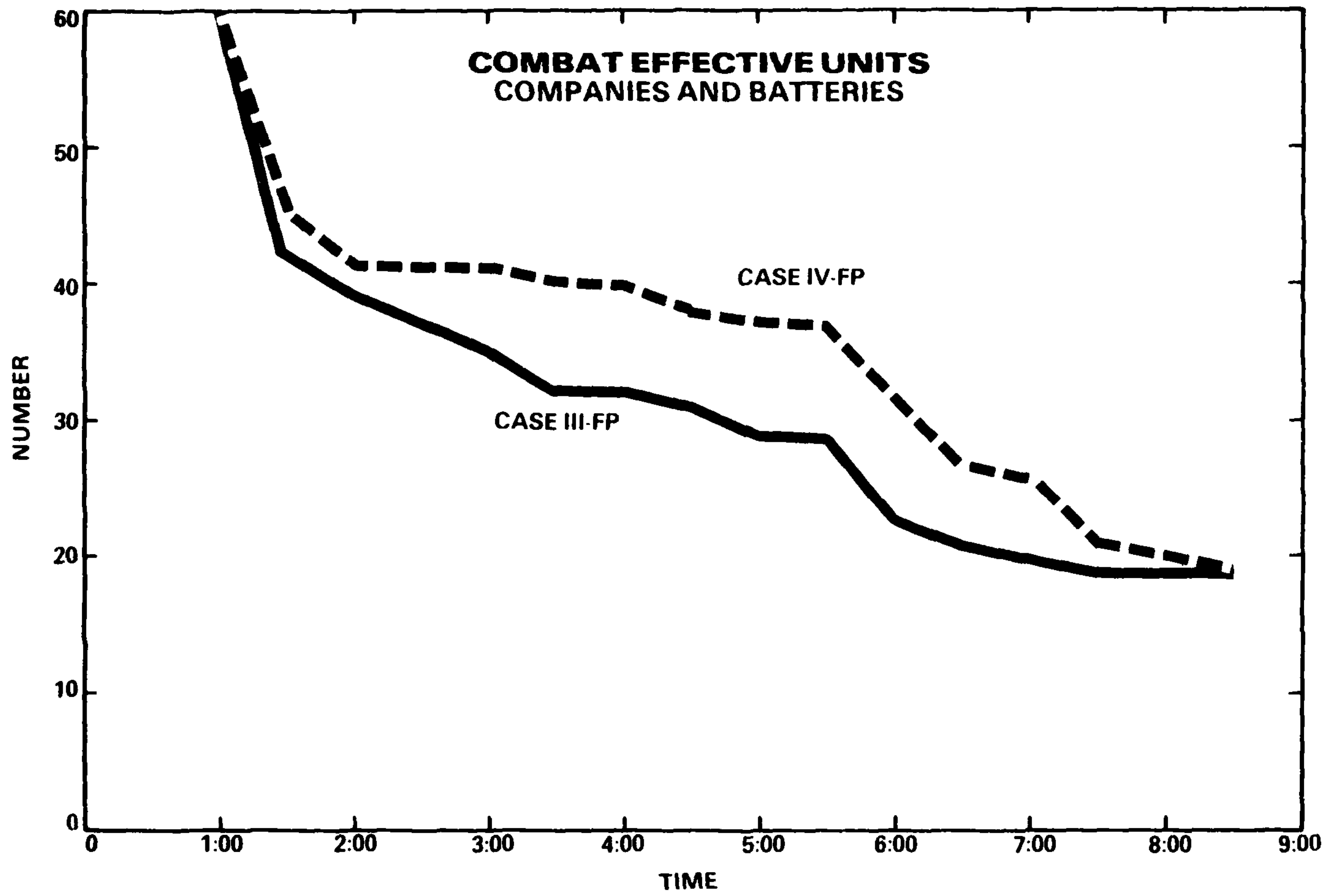

Figure 22. Combat effective units, companies and batteries.

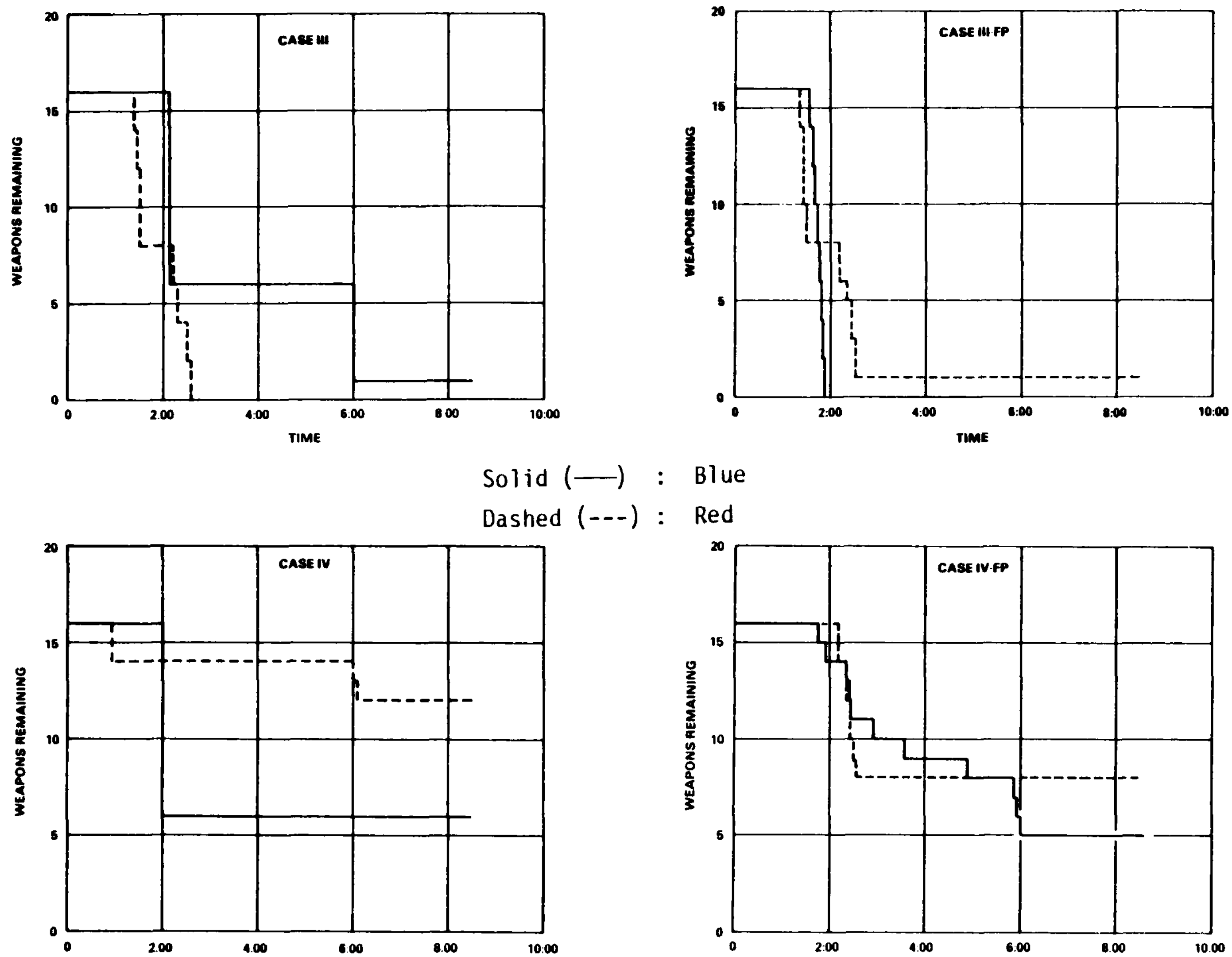

Figure 23. Nuclear weapons drawdown.

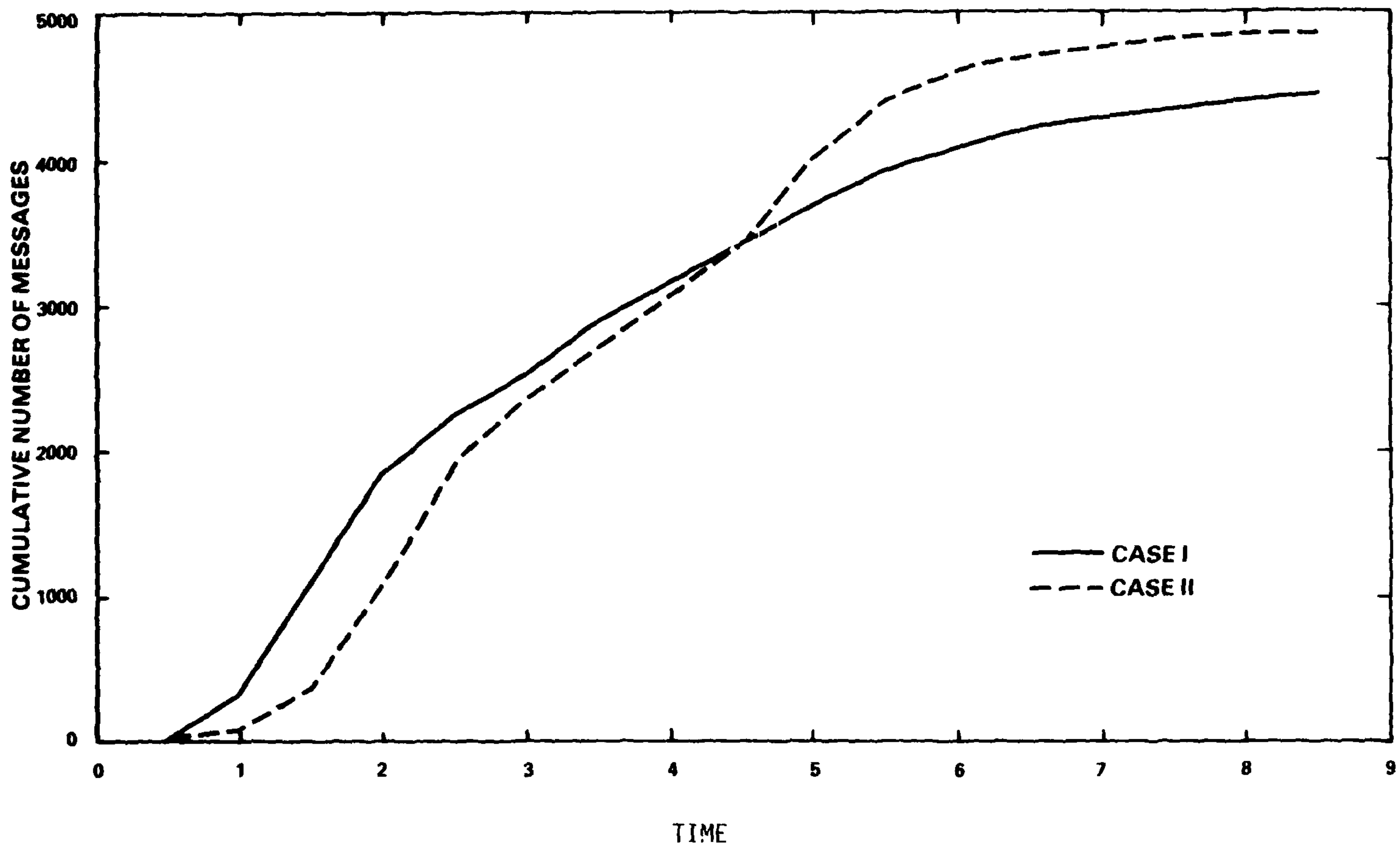

Figure 24. Cumulative message completion versus time for conventional warfare cases.

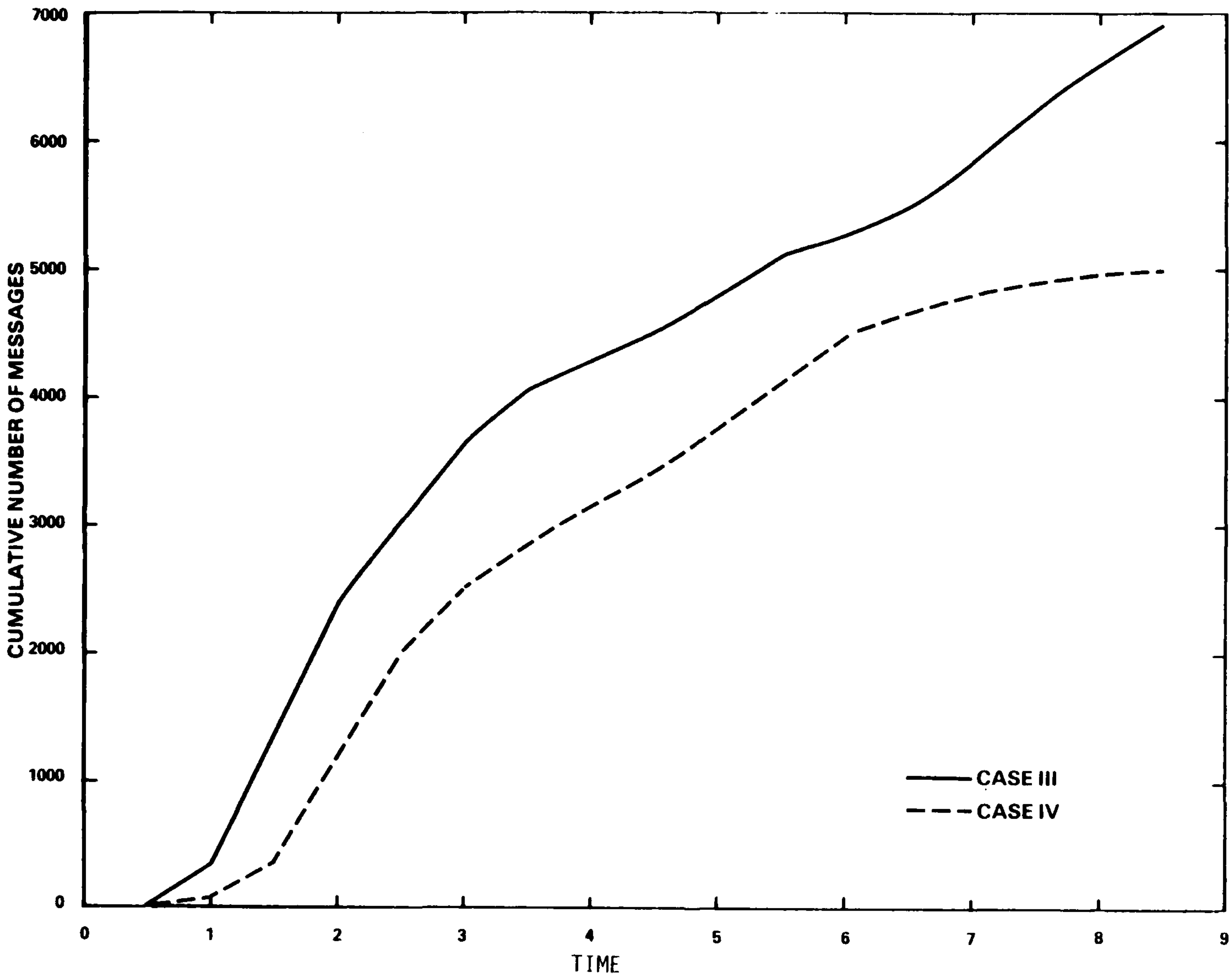

Figure 25. Cumulative message completions versus time for mixed warfare MITL cases.

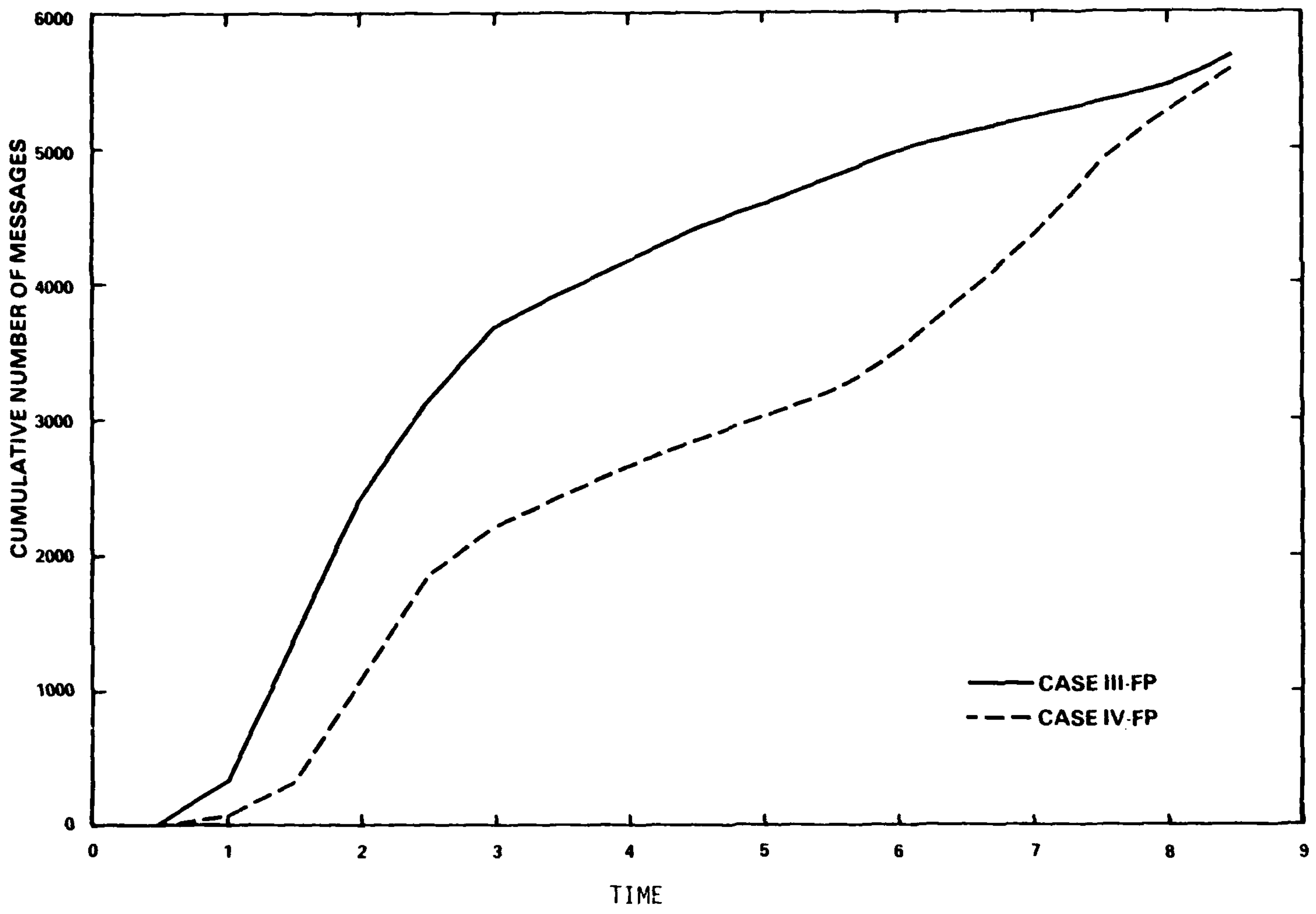

Figure 26. Cumulative message completions versus time for mixed warfare free-play cases.

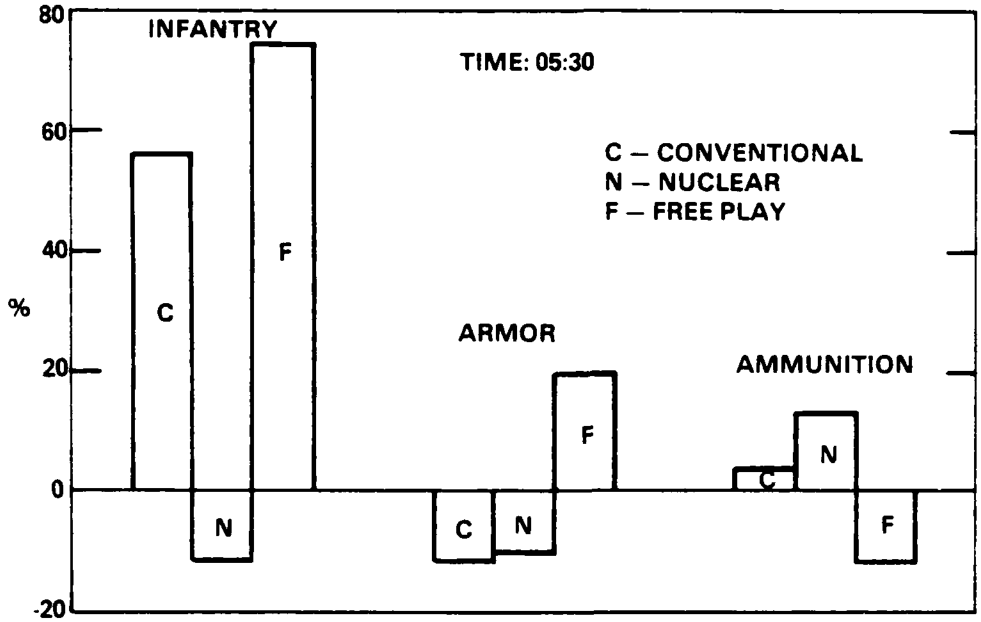

Figure 27. Degraded and non-degraded communications loss exchange ratio comparisons at 0530.

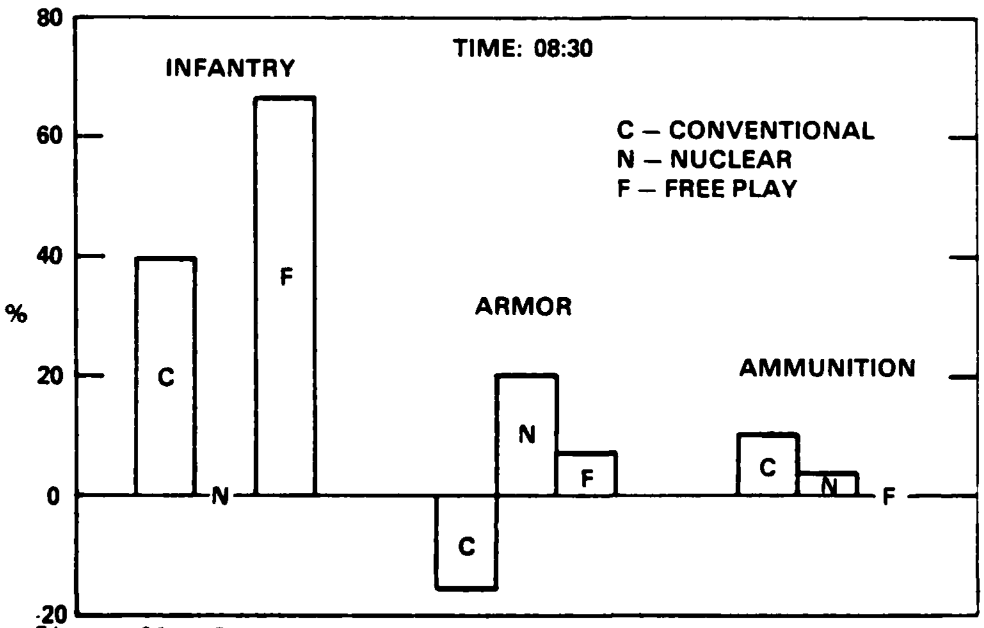

Figure 28. Degraded and non-degraded communications loss exchange ratio comparisons at 0830.

SECTION 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

This study began with the hypothesis that communications aids performance on the battlefield. The study results did not support this hypothesis in a statistically significant way. Assuming we can have some confidence in the case results, results from Section 5 show an improvement of +10.3%, -26.8%, and +34.1% for the three comparison sets conventional, nuclear, and nuclear FP. This gives a mean benefit of +5.9%. Assuming that the benefit of unimpaired communications is normally distributed about the true mean benefit, then it can be said that we are 90% confident that the true mean benefit is between +47.8% and -36.0%, a spread of 83.8%!

Statistically speaking, however, no confidence can be assigned to the values from each comparison for several reasons. The total freedom given the human MITL was too large a parametric variation to consider the compared cases to be simulating the same thing. Intuitively, the only change was the ability to degrade the communications. Statistically, the cases were not independent. Because the perfect communications case was performed first, the MITL gained maximum knowledge of the future in the degraded communications case immediately following. The more the MITL learned or remembered, the more independent of the communications he became. In fact, in one instance, the MITL responded to his briefing that he wanted to issue the same orders he had at this time in the last case. Some learning was expected but the similarity of the cases brought this learning to almost a predictive state. Also, in every case only one simulation was run. The model uses a pseudo-random number generator. The generator produces a stream of numbers, more than needed in a single run, in a sufficiently random pattern. It is not unusual for the same simulation to produce a small number of extreme results by changing the starting point in the generator's stream of numbers. In this study, no repetitive runs were made to test for extremities. In fact, it may have been impossible to run replications because of the uncontrollable, unquantifiable learning by the MITL. To some degree he learned what to expect from the Red attack. (It was felt that changing the Red attack would make the cases too different to compare.)

From looking at the unit locations on the maps one can see that the Blue units are more flexible and responsive in the cases where communications was not degraded. The Blue forces tend to be more sluggish in the other cases, being met by Red forces instead of meeting them. Enemy/unit location on the briefing maps that were shown to the MITL averaged 27 minutes out of date for frontline Red forces in the nondegraded cases. (These maps were acetate overlays, not suitable for reproduction, and are not shown in this report.) In the degraded cases the information averaged over an hour out of date. Thus, whether the MITL was a good commander or a poor one, the information he had to work with was more up-to-date with nondegraded communications. In a subjective (nonstatistical) sense, one can see that communications degradation did make a difference. The amount of difference is obsured by various factors, some of them the same ones that prevented statistical validation:

(1) MITL inexperience (as a MITL), learning, and varience
(2) Undetermined utility/appropriateness of orders and support requests
(3) Lack of an adequate number of comparable cases
(4) Lack of decisive battlefield outcome for either Red or Blue in any of the cases
(5) Unquantified degree of degredation to be used as a weighting factor in the case value parameter.

6.2 RECOMMENDATIONS

This study has shown that improved communications has a measurable effect on the progress of the battle and the C^2 capabilities of the commanders. It gave evidence that good communications acts as a force multiplier but did not produce sufficient statistically sound data to measure this multiplier. It did point out the interfering conditions and the path to parameterizing most of them. Hence, this type of analysis shows promise for isolating and measuring the force multiplier.

Further study should now follow two different directions. Though, when explained, these may seem to be opposite directions, they are not mutually exclusive and should be considered together. The first direction is a proper simulation study totally excluding human induced variance. This requires that the C^3I functions be totally automated. It also requires acceptance of the belief that artifical intelligence (AI) can reasonably reproduce the C^2 thought processes. The Operations Reaction System (ORS) is a C^2 AI system developed by BDM for DNA-TCOR. (ORS was developed after the completion of the TRACE development.) The ORS is a good initial cut at fully automated C^2 but it still reacts primarily to immediate stimule. It has a beginning awareness of its battlefield environment (e.g., is a unit being flanked) but as yet has no awareness of its history (e.g., 50% losses in last 5 minutes and 50% in last 3 days are indistinguishable) or ability to plan/replan based on the situation. These deficiences would have to be corrected before it would be suitable for this direction of study. Once a suitable C^2 AI system is placed into a model like TRACE, autoregressive analysis can be used over a number of sets at similiar cases where each set has a number of runs in it sufficient for statistically sound results. Degradation of communications could then be quantified and tests made to determine the distribution of the communications force multiplier.

The second direction is the gaming approach. This approach does not require belief in the ability of AI techniques. A group of MITLs is selected. (The exact number of them will depend on the sampling technique chosen for the statistical analysis). Each should have experience as a line officer in ground combat situations. Each is trained on a few test cases so they are familiar with the behavior of their simulated commands. Each is then the MITL for about 30 cases -- sufficient number to make small samples techniques applicable. These cases should have varying Red attacks and controlled, varying communications degradation. Mean results can be determined across a MITL's group of cases. By an extension of the Central Limit Therom, it is known that these means are normally distributed. This facilitates meaningful statistical analysis of the crosscorrelations of the degradation parametric variations in a commander's ability to perform his function. In this way, the force mutlipliers can be indirectly measured.

SECTION 7

REFERENCES

1. Statement of Work For Contract DNA001-78-C-0175 "Development and Implementation of TCOR COMMO."

2. "TRACE Computer Model User's Guide", BDM/W-78-776-TR, 12 October 1978.

3. FM 105-5 "Maneuver Control", USAGGSC.

4. FM 101-31 "Staff Officers' Field Manual: Nuclear Weapons Employment Effects Data" (FMFM 11-11), USACGSC.

5. "Tractics: Rules for Modern Warfare", Tactical Studies Rules.

6. "Addendum to Personnel Risks and Casualty Criteria" ACN 22744, March 76.

7. "Approximations for Digital Computers" Hastings C. Princeton University Press, 1955.

APPENDIX A

LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS

The abbreviations, acronyms, and symbols used throughout this report are listed in this appendix. In some cases, an abbreviation used in the report is actually a combination of two other abbreviations. In these cases the combined abbreviation usually does not appear in this appendix while the individual or separate abbreviations do. For example, ARMBDE does not have an entry while ARM and BDE each do.

ACS	Armored Cavalry Squadron
ACSCO	Armored Support Company
ACT	Armored Cavalry Team
ADB	Automated Data Base
ADMIN	Administrative
AI	Artificial Intelligence
AMMO	Ammunition
APC	Armored Personnel Carrier
ARM	Armored
ARTY	Artillery
ATGM	Anti-Tank Guided Missile
ATU	Anti-Tank Unit
AUTO	Automatic Encryption
BDE	Brigade
BN	Brigade
BTY	Battery
BTY122	122mm Artillery Battery
BTY155	155mm Howitzer Battery
BTY203	203mm (8 inch) Artillery Batter
CAS	Close Air Support
CEL	Continuous Event List
CIC	Combat Interaction and Communication
CMD	Command
CO	Company
CY	Cycle
C^2I	Command, Control and Information
C^3I	Command, Control, Communications and Intelligence
DEL	Discrete Event List
DEP	Deflection Error Probable
DF	Direction Finding
DIV	Division
DNA	Defense Nuclear Agency
ENCPH	Enciphered

EW	Electronic Warfare
FAX	Facsimile
FEBA	Forward Edge of the Battle Area
FEL	Furure Event List
FP	Free Play
FROG	NATO Designation of Warsaw Pact Tactical Nuclear Missile
HEX	Hexagon
HHB	Headquarters and Headquarters Battalion
HHC	Headquarters and Headquarters Company
HJBTY	Honest John BYT
HOB	Hieght of Burst
HR	Hour
IP	Input processor
INF	Infantry
INTEL	Intelligence
ITD	Incapacitation for Demanding Tasks
KM	Kilometers
KT	Kilotons
LER	Loss Exchange Ratio
LOG	Logistics
MCP	Module Control Processor
MCSCO	Mechanized Support Company
MECCO	Mechanized CO
MECHBN	Mechanized BN
METRIC	Generic name for all models based on TCOR
MHz	Megahertz
MIN	Minutes/Minimum
MISLBN	Missile BN
MITL	Man in the Loop
mm	milimeter
MR	Motorized Rifle
NATO	North Atlantic Treaty Organization
NET	Network

NWE	Nuclear Weapons Effects
OBE	Overtaken by Events
OPORD	Operations Order
Pk	Probability of Kill
REC	Reconnaissance
REG	Regiment
REP	Range Error Probable
RGT	Regiment
SDS	Simulation Data Structure
SOP	Standard Operating Procedures
SITREP	Situation Report
SSP	Scenario Selection Processor
TA	Tank Army
TCOR	Basic DNA-TCOR Tactical Combat Simulation Model
TK	Tank
TLE	Target Location Error
TRACE	TCOR Revised to Assess Communications Effectiveness
TTY	Teletypewriter
TUBE	Single Artillery Piece
UOIL	User Oriented Input Language
US	United States
WP	Warsaw Pact

APPENDIX B
EXAMPLE NWE DOCUMENTATION FORMAT

Each of the seven subroutines developed for the TRACE model to account for nuclear weapons effects on the operabilities of communications equipments was thoroughly documented. An example of the documentation scheme and format is presented in this appendix along with a graph of the typical probabilistic results generated by the routine that has been used as the example.

A. PKPERS

B. Title - Programmer

Function subroutine PKPERS; programmed by R. L. Rothrock and D. L. Porter, 1978.

C. Purpose and Description

PKPERS is a part of the environmental effects portion of TCOR and is used to calculate the probability of loss of an individual due to exposure to low altitude nuclear detonations in the war game. The probability of loss of an individual can be used by higher level routines which contain information about numbers and locations of personnel to (1) compute the expected number of personnel lost and/or (2) to conduct random draws to determine the number of personnel who will be considered lost due to this war game event.

D. Assumptions

(1) PKPERS considers loss of personnel due to exposure to nuclear detonations to be only a function of the initial radiation total dose (tissue) levels which would occur with negligible shielding against initial radiation.

(2) Loss of personnel due to total dose is considered to be synonymous with initial transient incapacitation for demanding tasks (ITD) as defined in "Addendum to Personnel Risks and Casualty Criteria".

(3) Height of burst (HOB) for low altitude tactical nuclear detonations is assumed to be 60 $W^{1/3}$ meters, where W is the yield of the weapon in kilotons.

E. Inputs

The inputs to PKPERS are:

(1) YIELD - the weapon yield in kilotons

(2) RNG - the range from the person to the ground zero point of the detonation in meters.

F. Output

The output is [illegible] PKPERS, the probability that an individual will be lost.

G. Methodology

1. Introduction

The methodology underlying the PKPERS routine is a curve fitting of the probability of loss of individual personnel as a function of yield and range curves found in "Assessment and Models of Mobile Command Post Survivability in a Tactical Nuclear Environment (U)", BDM/W-78-084-TR. These curves are shown in Figure B-1. The fit to the yield parameter is continuous for yields between 1 and 100 KT and discrete for yields of 200 and 300 KT.

The curves tend to be highly linear in the parameter range and the slope of the curves with range is approximately constant for yields under 100 KT. The curves, however, are very nonlinear in the parameter yield.

2. Dependent on Yield Parameter for $1 \leq W \leq 100$ KT

Since the curves of probability of loss of individual personnel are linear with range for any given yield, the yield dependence can be defined if the range corresponding to a particular probability percentile can be expressed as a function of yield. The probability level used is .5, the fifty percentile level. The range R in kilometers corresponding to a given yield W in kilotons and total dose level D in rads (tissue) can be computed using the standard INCA algorithm.

$$R = 2.10 \left(\frac{D}{W}\right)^{-.135} * \exp\left[-2.78 \times 10^{-5} \left(\frac{D}{W}\right)\right] \qquad \text{(Eq.-1)}$$

The 50 percentile total dose level for ITD is 2250 rads (tissue). Using this value for D in Eq. 1, the equation for R_{50} is

$$R_{50} = .741\, W^{-.135} * \exp\left[\frac{-6.26 \times 10}{W}\right] \qquad \text{(Eq.-2)}$$

Computation of time consuming transcendental functions can be minimized if the logarithm of R_{50} is computed and then the inverse taken. Further efficiency can be gained by using approximation to the $\log_{10}$ and inverse functions since very high accuracy is not called for.

The approximations used here are the Chebyshev criteria fits given by Hastings on sheets 1 and 17 of "Approximations for Digital Computers". The approximation on sheet 17 for 10^x is valid for $0 \leq x \leq 1$. Therefore, to use this approximation we must compute the logarithm base ten of some multiple C of R_{50} which meets the criteria $0 \leq \log_{10}(CR_{50}) \leq 1$ for all yields between one and one hundred kilotons. If we let C = 5.0 these conditions will be met. Hence
we compute

$$X = \log_{10}(5.0\ R_{50})$$
$$= .569 + .135 \log_{10}W - \frac{6.25 \times 10^{-2}}{W} \qquad \text{(Eq.-3)}$$

and hence

$$R_{50} = (.20)\ 10^X \qquad \text{(Eq.-4)}$$

This procedure permits computation of R_{50} by using very fast running approximations for transcendental functions. Ranges for yields of 200 and 300 KT need not be fitted, since these are discrete yields, and thus can be taken directly from the curves.

3. Dependence on Range Parameter

Given the 50 percentile range R_{50} the probability of loss P_K is given by the linear fit in range RNG

$$P_K = (RNG - R_{50})m + 0.5 \qquad \text{(Eq.-5)}$$

where m is the slope. The obvious correction is then made to set the probability to one if $P_K \geq 1$ and to set it to zero if $P_K \leq 0$.

A single slope is used for yields of 1 to 100 KT but different slopes are used for yields of 200 and 300 KT.

4. Other Streamlining Techniques

Since yields are limited to values between 1 and 300 KT inclusive, a range input of less than .63 kilometers will assure loss of personnel and a range greater than 1.73 kilometers will assure survival of personnel. These range tests are done first to achieve overall efficiency of the algorithm by avoiding unnecessary calculations. Testing for permissible yields is also done at the start of the routine.

H. Limitations

The range input can be any value but the yield input must be a value between 1 and 100 or else 200 or 300. Other values of yield, such as 150, will cause the routine to default to PKPERS = 0.0 and will print an error message. This limitation of the routine should not be significant since the permissible yields cover most yields of interest.

Personnel in the open may be vulnerable to thermal radiation and blast at high yields. This routine does not model these phenomena.

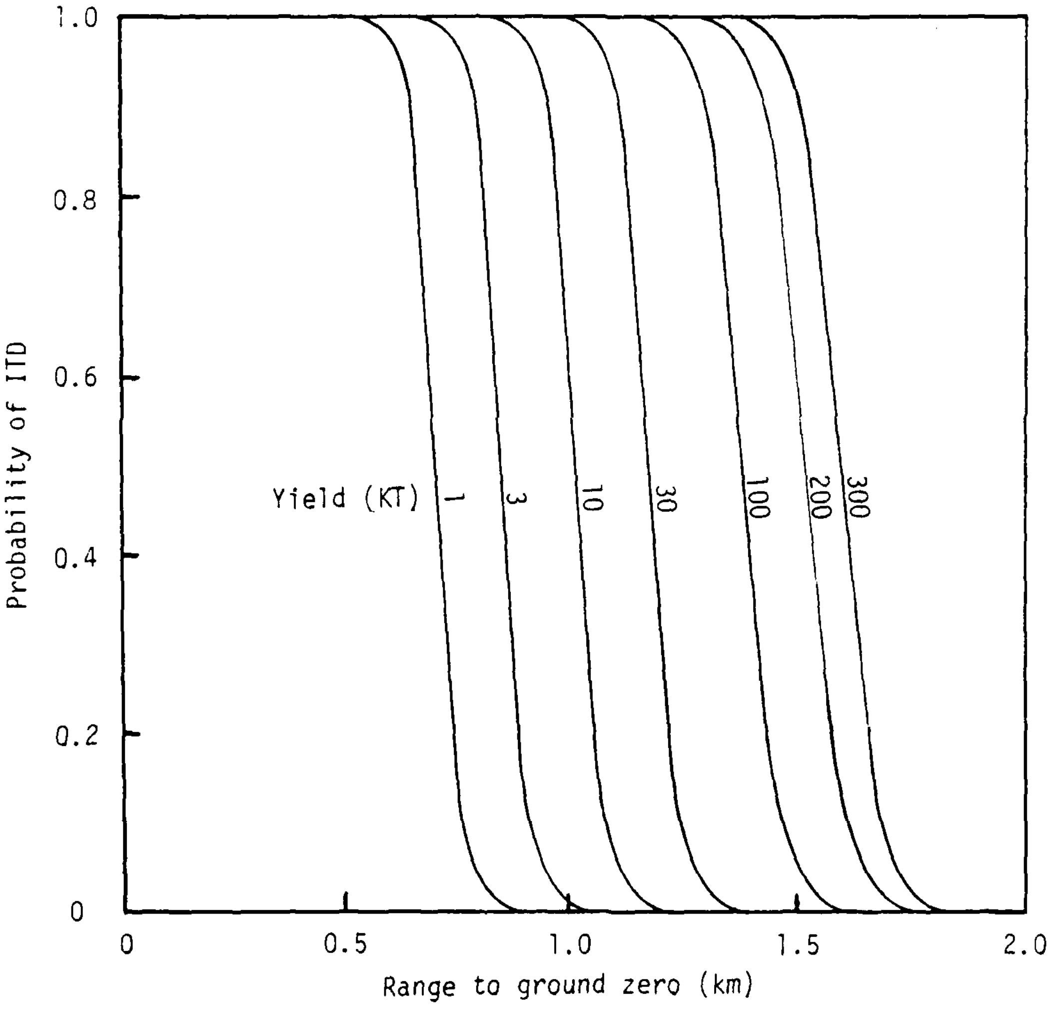

Figure B-1. Probability that an individual person experiences ITD (or worse forms of incapacitation) as a function of range and weapon yield.

APPENDIX C
TRACE BASIC INPUT LISTING

All of the input parameters to the TRACE model are listed in card image form in this appendix. Although the combat orders specified toward the end of the listing were valid for the duration of the conflict engagement, they were overridden (changed) by the Blue Commander at approximately two-hour intervals. This basic input listing does specify, however, the starting conditions for all six TRACE cases examined. A thorough discussion of all parameters in this listing is available in reference 2.

PART I

EW AND COMMUNICATIONS DATA IN CARD IMAGE FORMAT

```
C*********************************************************************
BLUE CORPS CAS NET
C*********************************************************************
     5                       NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     7                       NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                       SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     1                       TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
 28000    CHANNELS           NUMBER OF CHANNELS
    23    STATIONS           NUMBER OF STATIONS IN NET
   15.272 MHZ                NET FREQUENCY
   30.00  MHZ                MAX FREQUENCY
    2.00  MHZ                MIN FREQUENCY
    5.00  PERCENT            DUTY CYCLE
    5.00  PERCENT            BACKROUND TRAFFIC
    5.00  PERCENT            BREAK SECURITY
 2400.00  KM                 MAX EFFECTIVE COMMUNICATION RANGE
   35.00  KM/HR              COURIER SPEED
    2.0   MINUTES            AVERAGE MESSAGE LENGTH
     .25  MINUTES            CONNECT TIME DELAY
   30.0   MINUTES            TIME AT WHICH TO USE COURIER
   15.0   MINUTES            TIME BEFORE USING ALTERNATE ROUTE
   0.00   MIN                TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS   0 DIV    0 BDE     0 BN      0 CO      56.0 PERCENT DUTY CY
  5 CORPS   3 DIV    0 BDE     0 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    1 BDE     0 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    1 BDE    11 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    1 BDE    12 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    1 BDE    13 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    1 BDE    14 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    2 BDE     0 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    2 BDE    21 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    2 BDE    22 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    2 BDE    23 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    2 BDE    24 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    3 BDE     0 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    3 BDE    31 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    3 BDE    32 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    3 BDE    33 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    4 BDE     0 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    4 BDE    41 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    4 BDE    42 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    4 BDE    43 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    4 BDE    44 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    4 BDE    45 BN      0 CO       2.0 PERCENT DUTY CY
  5 CORPS   3 DIV    0 BDE     5 BN      0 CO       2.0 PERCENT DUTY CY
```

```
C**********************************************************************
BLUE CORPS ARTY NET
C**********************************************************************
     3                        NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     7                        NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                        SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     1                        TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
   920     CHANNELS           NUMBER OF CHANNELS
     9     STATIONS           NUMBER OF STATIONS IN NET
  52.37    MHZ                NET FREQUENCY
  75.95    MHZ                MAX FREQUENCY
  30.00    MHZ                MIN FREQUENCY
  18.00    PERCENT            DUTY CYCLE
   5.00    PERCENT            BACKROUND TRAFFIC
   5.00    PERCENT            BREAK SECURITY
  40.00    KM                 MAX EFFECTIVE COMMUNICATION RANGE
  35.00    KM/HR              COURIER SPEED
   1.0     MINUTES            AVERAGE MESSAGE LENGTH
    .25    MINUTES            CONNECT TIME DELAY
  30.0     MINUTES            TIME AT WHICH TO USE COURIER
  15.0     MINUTES            TIME BEFORE USING ALTERNATE ROUTE
  0.00     MIN                TIME BEFORE ALTERNATE IF JAMMED
 5 CORPS    0 DIV    0 BDE     0 BN     0 CO      4.0 PERCENT DUTY CY
 5 CORPS    3 DIV    0 BDE     0 BN     0 CO     12.0 PERCENT DUTY CY
 5 CORPS    3 DIV    0 BDE     5 BN     0 CO     12.0 PERCENT DUTY CY
 5 CORPS    3 DIV    4 BDE     0 BN     0 CO     12.0 PERCENT DUTY CY
 5 CORPS    3 DIV    4 BDE    41 BN     0 CO     12.0 PERCENT DUTY CY
 5 CORPS    3 DIV    4 BDE    42 BN     0 CO     12.0 PERCENT DUTY CY
 5 CORPS    3 DIV    4 BDE    43 BN     0 CO     12.0 PERCENT DUTY CY
 5 CORPS    3 DIV    4 BDE    44 BN     0 CO     12.0 PERCENT DUTY CY
 5 CORPS    3 DIV    4 BDE    45 BN     0 CO     12.0 PERCENT DUTY CY
C**********************************************************************
BLUE 3 DIV COMMAND NET
C**********************************************************************
     1                        NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     6                        NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                        SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     1                        TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
   920     CHANNELS           NUMBER OF CHANNELS
     6     STATIONS           NUMBER OF STATIONS IN NET
  65.05    MHZ                NET FREQUENCY
  75.95    MHZ                MAX FREQUENCY
  30.00    MHZ                MIN FREQUENCY
  40.00    PERCENT            DUTY CYCLE
   5.00    PERCENT            BACKROUND TRAFFIC
   5.00    PERCENT            BREAK SECURITY
  40.00    KM                 MAX EFFECTIVE COMMUNICATION RANGE
  35.00    KM/HR              COURIER SPEED
   2.0     MINUTES            AVERAGE MESSAGE LENGTH
    .25    MINUTES            CONNECT TIME DELAY
  30.0     MINUTES            TIME AT WHICH TO USE COURIER
  15.0     MINUTES            TIME BEFORE USING ALTERNATE ROUTE
  0.00     MIN                TIME BEFORE ALTERNATE IF JAMMED
 5 CORPS    3 DIV    0 BDE     0 BN     0 CO     50.0 PERCENT DUTY CY
 5 CORPS    3 DIV    1 BDE     0 BN     0 CO     10.0 PERCENT DUTY CY
 5 CORPS    3 DIV    2 BDE     0 BN     0 CO     10.0 PERCENT DUTY CY
 5 CORPS    3 DIV    3 BDE     0 BN     0 CO     10.0 PERCENT DUTY CY
 5 CORPS    3 DIV    4 BDE     0 BN     0 CO     10.0 PERCENT DUTY CY
 5 CORPS    3 DIV    0 BDE     5 BN     0 CO     10.0 PERCENT DUTY CY
```

```
C***********************************************************************
BLUE 3 DIV ADMIN/LOG NET
C***********************************************************************
     2                       NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     6                       NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                       SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     2                       TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
 28000      CHANNELS         NUMBER OF CHANNELS
     6      STATIONS         NUMBER OF STATIONS IN NET
    4.263 MHZ                NET FREQUENCY
   30.00  MHZ                MAX FREQUENCY
    2.00  MHZ                MIN FREQUENCY
   50.00  PERCENT            DUTY CYCLE
   10.00  PERCENT            BACKROUND TRAFFIC
    5.00  PERCENT            BREAK SECURITY
 2400.00  KM                 MAX EFFECTIVE COMMUNICATION RANGE
   25.00  KM/HR              COURIER SPEED
    1.5   MINUTES            AVERAGE MESSAGE LENGTH
     .25  MINUTES            CONNECT TIME DELAY
  120.0   MINUTES            TIME AT WHICH TO USE COURIER
   45.0   MINUTES            TIME BEFORE USING ALTERNATE ROUTE
   0.00   MIN                TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS    3 DIV     0 BDE      0 BN       0 CO       50.0 PERCENT DUTY CY
  5 CORPS    3 DIV     1 BDE      0 BN       0 CO       10.0 PERCENT DUTY CY
  5 CORPS    3 DIV     2 BDE      0 BN       0 CO       10.0 PERCENT DUTY CY
  5 CORPS    3 DIV     3 BDE      0 BN       0 CO       10.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE      0 BN       0 CO       10.0 PERCENT DUTY CY
  5 CORPS    3 DIV     0 BDE      5 BN       0 CO       10.0 PERCENT DUTY CY
C***********************************************************************
BLUE 3 DIV INTEL NET
C***********************************************************************
     4                       NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     6                       NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                       SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     2                       TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
 28000      CHANNELS         NUMBER OF CHANNELS
     6      STATIONS         NUMBER OF STATIONS IN NET
    5.593 MHZ                NET FREQUENCY
   30.00  MHZ                MAX FREQUENCY
    2.00  MHZ                MIN FREQUENCY
   60.00  PERCENT            DUTY CYCLE
   20.00  PERCENT            BACKROUND TRAFFIC
    5.00  PERCENT            BREAK SECURITY
 2400.00  KM                 MAX EFFECTIVE COMMUNICATION RANGE
   35.00  KM/HR              COURIER SPEED
    2.5   MINUTES            AVERAGE MESSAGE LENGTH
     .25  MINUTES            CONNECT TIME DELAY
   45.0   MINUTES            TIME AT WHICH TO USE COURIER
   20.0   MINUTES            TIME BEFORE USING ALTERNATE ROUTE
   0.00   MIN                TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS    3 DIV     0 BDE      0 BN       0 CO       50.0 PERCENT DUTY CY
  5 CORPS    3 DIV     1 BDE      0 BN       0 CO       10.0 PERCENT DUTY CY
  5 CORPS    3 DIV     2 BDE      0 BN       0 CO       10.0 PERCENT DUTY CY
  5 CORPS    3 DIV     3 BDE      0 BN       0 CO       10.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE      0 BN       0 CO       10.0 PERCENT DUTY CY
  5 CORPS    3 DIV     0 BDE      5 BN       0 CO       10.0 PERCENT DUTY CY
```

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C*********************************************************************
BLUE 1 BDE COMMAND NET
C*********************************************************************
     1                        NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     5                        NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                        SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     1                        TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
   920     CHANNELS           NUMBER OF CHANNELS
     5     STATIONS           NUMBER OF STATIONS IN NET
   67.71   MHZ                NET FREQUENCY
   75.95   MHZ                MAX FREQUENCY
   30.00   MHZ                MIN FREQUENCY
   50.00   PERCENT            DUTY CYCLE
   10.00   PERCENT            BACKROUND TRAFFIC
    5.00   PERCENT            BREAK SECURITY
   40.00   KM                 MAX EFFECTIVE COMMUNICATION RANGE
   35.00   KM/HR              COURIER SPEED
    2.1    MINUTES            AVERAGE MESSAGE LENGTH
     .10   MINUTES            CONNECT TIME DELAY
   15.0    MINUTES            TIME AT WHICH TO USE COURIER
    5.0    MINUTES            TIME BEFORE USING ALTERNATE ROUTE
   0.00    MIN                TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS    3 DIV     1 BDE      0 BN       0 CO       52.0 PERCENT DUTY CY
  5 CORPS    3 DIV     1 BDE     11 BN       0 CO       12.0 PERCENT DUTY CY
  5 CORPS    3 DIV     1 BDE     12 BN       0 CO       12.0 PERCENT DUTY CY
  5 CORPS    3 DIV     1 BDE     13 BN       0 CO       12.0 PERCENT DUTY CY
  5 CORPS    3 DIV     1 BDE     14 BN       0 CO       12.0 PERCENT DUTY CY
C*********************************************************************
BLUE 1 BDE ADMIN/LOG NET
C*********************************************************************
     2                        NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     5                        NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                        SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     1                        TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
   920     CHANNELS           NUMBER OF CHANNELS
     5     STATIONS           NUMBER OF STATIONS IN NET
   35.95   MHZ                NET FREQUENCY
   75.95   MHZ                MAX FREQUENCY
   30.00   MHZ                MIN FREQUENCY
   43.00   PERCENT            DUTY CYCLE
   10.00   PERCENT            BACKROUND TRAFFIC
    5.00   PERCENT            BREAK SECURITY
   35.00   KM                 MAX EFFECTIVE COMMUNICATION RANGE
   25.00   KM/HR              COURIER SPEED
    3.0    MINUTES            AVERAGE MESSAGE LENGTH
     .25   MINUTES            CONNECT TIME DELAY
   60.0    MINUTES            TIME AT WHICH TO USE COURIER
   30.0    MINUTES            TIME BEFORE USING ALTERNATE ROUTE
   0.00    MIN                TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS    3 DIV     1 BDE      0 BN       0 CO       52.0 PERCENT DUTY CY
  5 CORPS    3 DIV     1 BDE     11 BN       0 CO       12.0 PERCENT DUTY CY
  5 CORPS    3 DIV     1 BDE     12 BN       0 CO       12.0 PERCENT DUTY CY
  5 CORPS    3 DIV     1 BDE     13 BN       0 CO       12.0 PERCENT DUTY CY
  5 CORPS    3 DIV     1 BDE     14 BN       0 CO       12.0 PERCENT DUTY CY
```

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C*****************************************************************************
BLUE 1 BDE ARTY NET
C*****************************************************************************
     3                     NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     5                     NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                     SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     1                     TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
   920    CHANNELS         NUMBER OF CHANNELS
    10    STATIONS         NUMBER OF STATIONS IN NET
   55.55  MHZ              NET FREQUENCY
   75.95  MHZ              MAX FREQUENCY
   30.00  MHZ              MIN FREQUENCY
   40.00  PERCENT          DUTY CYCLE
    5.00  PERCENT          BACKROUND TRAFFIC
    5.00  PERCENT          BREAK SECURITY
   40.00  KM               MAX EFFECTIVE COMMUNICATION RANGE
   35.00  KM/HR            COURIER SPEED
    1.0   MINUTES          AVERAGE MESSAGE LENGTH
     .25  MINUTES          CONNECT TIME DELAY
   30.0   MINUTES          TIME AT WHICH TO USE COURIER
   15.0   MINUTES          TIME BEFORE USING ALTERNATE ROUTE
    0.00  MIN              TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS   3 DIV     1 BDE     0 BN       0 CO        1.0 PERCENT DUTY CY
  5 CORPS   3 DIV     1 BDE    11 BN       0 CO       11.0 PERCENT DUTY CY
  5 CORPS   3 DIV     1 BDE    12 BN       0 CO       11.0 PERCENT DUTY CY
  5 CORPS   3 DIV     1 BDE    13 BN       0 CO       11.0 PERCENT DUTY CY
  5 CORPS   3 DIV     1 BDE    14 BN       0 CO       11.0 PERCENT DUTY CY
  5 CORPS   3 DIV     4 BDE    41 BN       0 CO       11.0 PERCENT DUTY CY
  5 CORPS   3 DIV     4 BDE    42 BN       0 CO       11.0 PERCENT DUTY CY
  5 CORPS   3 DIV     4 BDE    43 BN       0 CO       11.0 PERCENT DUTY CY
  5 CORPS   3 DIV     4 BDE    44 BN       0 CO       11.0 PERCENT DUTY CY
  5 CORPS   3 DIV     4 BDE    45 BN       0 CO       11.0 PERCENT DUTY CY
C*****************************************************************************
BLUE 1 BDE INTEL NET
C*****************************************************************************
     4                     NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     5                     NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                     SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     1                     TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
   920    CHANNELS         NUMBER OF CHANNELS
     5    STATIONS         NUMBER OF STATIONS IN NET
   37.80  MHZ              NET FREQUENCY
   75.95  MHZ              MAX FREQUENCY
   30.00  MHZ              MIN FREQUENCY
   18.00  PERCENT          DUTY CYCLE
    5.00  PERCENT          BACKROUND TRAFFIC
    5.00  PERCENT          BREAK SECURITY
   40.00  KM               MAX EFFECTIVE COMMUNICATION RANGE
   30.00  KM/HR            COURIER SPEED
    2.3   MINUTES          AVERAGE MESSAGE LENGTH
     .10  MINUTES          CONNECT TIME DELAY
   20.0   MINUTES          TIME AT WHICH TO USE COURIER
   10.0   MINUTES          TIME BEFORE USING ALTERNATE ROUTE
    0.00  MIN              TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS   3 DIV     1 BDE     0 BN       0 CO       52.0 PERCENT DUTY CY
  5 CORPS   3 DIV     1 BDE    11 BN       0 CO       12.0 PERCENT DUTY CY
  5 CORPS   3 DIV     1 BDE    12 BN       0 CO       12.0 PERCENT DUTY CY
  5 CORPS   3 DIV     1 BDE    13 BN       0 CO       12.0 PERCENT DUTY CY
  5 CORPS   3 DIV     1 BDE    14 BN       0 CO       12.0 PERCENT DUTY CY
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C***************************************************************************
BLUE 2 BDE COMMAND NET
C***************************************************************************
      1                        NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
      5                        NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
      1                        SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
      1                        TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
    920     CHANNELS           NUMBER OF CHANNELS
      5     STATIONS           NUMBER OF STATIONS IN NET
   61.50    MHZ                NET FREQUENCY
   75.95    MHZ                MAX FREQUENCY
   30.00    MHZ                MIN FREQUENCY
   50.00    PERCENT            DUTY CYCLE
   10.00    PERCENT            BACKROUND TRAFFIC
    5.00    PERCENT            BREAK SECURITY
   40.00    KM                 MAX EFFECTIVE COMMUNICATION RANGE
   35.00    KM/HR              COURIER SPEED
    2.1     MINUTES            AVERAGE MESSAGE LENGTH
     .10    MINUTES            CONNECT TIME DELAY
   15.0     MINUTES            TIME AT WHICH TO USE COURIER
    5.0     MINUTES            TIME BEFORE USING ALTERNATE ROUTE
   0.00     MIN                TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS   3 DIV     2 BDE     0 BN      0 CO      52.0 PERCENT DUTY CY
  5 CORPS   3 DIV     2 BDE    21 BN      0 CO      12.0 PERCENT DUTY CY
  5 CORPS   3 DIV     2 BDE    22 BN      0 CO      12.0 PERCENT DUTY CY
  5 CORPS   3 DIV     2 BDE    23 BN      0 CO      12.0 PERCENT DUTY CY
  5 CORPS   3 DIV     2 BDE    24 BN      0 CO      12.0 PERCENT DUTY CY
C***************************************************************************
BLUE 2 BDE ADMIN/LOG NET
C***************************************************************************
      2                        NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
      5                        NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
      1                        SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
      1                        TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
    920     CHANNELS           NUMBER OF CHANNELS
      5     STATIONS           NUMBER OF STATIONS IN NET
   44.15    MHZ                NET FREQUENCY
   75.95    MHZ                MAX FREQUENCY
   30.00    MHZ                MIN FREQUENCY
   43.00    PERCENT            DUTY CYCLE
   10.00    PERCENT            BACKROUND TRAFFIC
    5.00    PERCENT            BREAK SECURITY
   35.00    KM                 MAX EFFECTIVE COMMUNICATION RANGE
   25.00    KM/HR              COURIER SPEED
    3.0     MINUTES            AVERAGE MESSAGE LENGTH
     .25    MINUTES            CONNECT TIME DELAY
   60.0     MINUTES            TIME AT WHICH TO USE COURIER
   30.0     MINUTES            TIME BEFORE USING ALTERNATE ROUTE
   0.00     MIN                TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS   3 DIV     2 BDE     0 BN      0 CO      52.0 PERCENT DUTY CY
  5 CORPS   3 DIV     2 BDE    21 BN      0 CO      12.0 PERCENT DUTY CY
  5 CORPS   3 DIV     2 BDE    22 BN      0 CO      12.0 PERCENT DUTY CY
  5 CORPS   3 DIV     2 BDE    23 BN      0 CO      12.0 PERCENT DUTY CY
  5 CORPS   3 DIV     2 BDE    24 BN      0 CO      12.0 PERCENT DUTY CY
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C*******************************************************************
BLUE 2 BDE ARTY NET
C*******************************************************************
    3                      NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
    5                      NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
    1                      SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
    1                      TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
  920    CHANNELS          NUMBER OF CHANNELS
   10    STATIONS          NUMBER OF STATIONS IN NET
  55.75  MHZ               NET FREQUENCY
  75.95  MHZ               MAX FREQUENCY
  30.00  MHZ               MIN FREQUENCY
  40.00  PERCENT           DUTY CYCLE
   5.00  PERCENT           BACKROUND TRAFFIC
   5.00  PERCENT           BREAK SECURITY
  40.00  KM                MAX EFFECTIVE COMMUNICATION RANGE
  35.00  KM/HR             COURIER SPEED
   1.0   MINUTES           AVERAGE MESSAGE LENGTH
    .25  MINUTES           CONNECT TIME DELAY
  30.0   MINUTES           TIME AT WHICH TO USE COURIER
  15.0   MINUTES           TIME BEFORE USING ALTERNATE ROUTE
  0.00   MIN               TIME BEFORE ALTERNATE IF JAMMED
 5 CORPS   3 DIV    2 BDE     0 BN      0 CO       1.0 PERCENT DUTY CY
 5 CORPS   3 DIV    2 BDE    21 BN      0 CO      11.0 PERCENT DUTY CY
 5 CORPS   3 DIV    2 BDE    22 BN      0 CO      11.0 PERCENT DUTY CY
 5 CORPS   3 DIV    2 BDE    23 BN      0 CO      11.0 PERCENT DUTY CY
 5 CORPS   3 DIV    2 BDE    24 BN      0 CO      11.0 PERCENT DUTY CY
 5 CORPS   3 DIV    4 BDE    41 BN      0 CO      11.0 PERCENT DUTY CY
 5 CORPS   3 DIV    4 BDE    42 BN      0 CO      11.0 PERCENT DUTY CY
 5 CORPS   3 DIV    4 BDE    43 BN      0 CO      11.0 PERCENT DUTY CY
 5 CORPS   3 DIV    4 BDE    44 BN      0 CO      11.0 PERCENT DUTY CY
 5 CORPS   3 DIV    4 BDE    45 BN      0 CO      11.0 PERCENT DUTY CY
C*******************************************************************
BLUE 2 BDE INTEL NET
C*******************************************************************
    4                      NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
    5                      NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
    1                      SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
    1                      TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
  920    CHANNELS          NUMBER OF CHANNELS
    5    STATIONS          NUMBER OF STATIONS IN NET
  44.05  MHZ               NET FREQUENCY
  75.95  MHZ               MAX FREQUENCY
  30.00  MHZ               MIN FREQUENCY
  18.00  PERCENT           DUTY CYCLE
   5.00  PERCENT           BACKROUND TRAFFIC
   5.00  PERCENT           BREAK SECURITY
  40.00  KM                MAX EFFECTIVE COMMUNICATION RANGE
  30.00  KM/HR             COURIER SPEED
   2.3   MINUTES           AVERAGE MESSAGE LENGTH
    .10  MINUTES           CONNECT TIME DELAY
  20.0   MINUTES           TIME AT WHICH TO USE COURIER
  10.0   MINUTES           TIME BEFORE USING ALTERNATE ROUTE
  0.00   MIN               TIME BEFORE ALTERNATE IF JAMMED
 5 CORPS   3 DIV    2 BDE     0 BN      0 CO      52.0 PERCENT DUTY CY
 5 CORPS   3 DIV    2 BDE    21 BN      0 CO      12.0 PERCENT DUTY CY
 5 CORPS   3 DIV    2 BDE    22 BN      0 CO      12.0 PERCENT DUTY CY
 5 CORPS   3 DIV    2 BDE    23 BN      0 CO      12.0 PERCENT DUTY CY
 5 CORPS   3 DIV    2 BDE    24 BN      0 CO      12.0 PERCENT DUTY CY
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C*****************************************************************************
BLUE 3 BDE COMMAND NET
C*****************************************************************************
      1                          NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
      5                          NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
      1                          SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
      1                          TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
    920     CHANNELS             NUMBER OF CHANNELS
      4     STATIONS             NUMBER OF STATIONS IN NET
  46.75     MHZ                  NET FREQUENCY
  75.95     MHZ                  MAX FREQUENCY
  30.00     MHZ                  MIN FREQUENCY
  50.00     PERCENT              DUTY CYCLE
  10.00     PERCENT              BACKROUND TRAFFIC
   5.00     PERCENT              BREAK SECURITY
  40.00     KM                   MAX EFFECTIVE COMMUNICATION RANGE
  35.00     KM/HR                COURIER SPEED
   2.1      MINUTES              AVERAGE MESSAGE LENGTH
    .10     MINUTES              CONNECT TIME DELAY
  15.0      MINUTES              TIME AT WHICH TO USE COURIER
   5.0      MINUTES              TIME BEFORE USING ALTERNATE ROUTE
   0.00     MIN                  TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS    3 DIV      3 BDE     0 BN       0 CO        55.0 PERCENT DUTY CY
  5 CORPS    3 DIV      3 BDE    31 BN       0 CO        15.0 PERCENT DUTY CY
  5 CORPS    3 DIV      3 BDE    32 BN       0 CO        15.0 PERCENT DUTY CY
  5 CORPS    3 DIV      3 BDE    33 BN       0 CO        15.0 PERCENT DUTY CY
C*****************************************************************************
BLUE 3 BDE ADMIN/LOG NET
C*****************************************************************************
      2                          NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
      5                          NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
      1                          SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
      1                          TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
    920     CHANNELS             NUMBER OF CHANNELS
      4     STATIONS             NUMBER OF STATIONS IN NET
  72.50     MHZ                  NET FREQUENCY
  75.95     MHZ                  MAX FREQUENCY
  30.00     MHZ                  MIN FREQUENCY
  43.00     PERCENT              DUTY CYCLE
  10.00     PERCENT              BACKROUND TRAFFIC
   5.00     PERCENT              BREAK SECURITY
  35.00     KM                   MAX EFFECTIVE COMMUNICATION RANGE
  25.00     KM/HR                COURIER SPEED
   3.0      MINUTES              AVERAGE MESSAGF LENGTH
    .25     MINUTES              CONNECT TIME DELAY
  60.0      MINUTES              TIME AT WHICH TO USE COURIER
  30.0      MINUTES              TIME BEFORE USING ALTERNATE ROUTE
   0.00     MIN                  TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS    3 DIV      3 BDE     0 BN       0 CO        55.0 PERCENT DUTY CY
  5 CORPS    3 DIV      3 BDE    31 BN       0 CO        15.0 PERCENT DUTY CY
  5 CORPS    3 DIV      3 BDE    32 BN       0 CO        15.0 PERCENT DUTY CY
  5 CORPS    3 DIV      3 BDE    33 BN       0 CO        15.0 PERCENT DUTY CY
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C*********************************************************************
BLUE 3 BDE ARTY NET
C*********************************************************************
     3                        NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     5                        NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                        SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     1                        TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
   920     CHANNELS           NUMBER OF CHANNELS
     9     STATIONS           NUMBER OF STATIONS IN NET
   58.30   MHZ                NET FREQUENCY
   75.95   MHZ                MAX FREQUENCY
   30.00   MHZ                MIN FREQUENCY
   40.00   PERCENT            DUTY CYCLE
    5.00   PERCENT            BACKROUND TRAFFIC
    5.00   PERCENT            BREAK SECURITY
   40.00   KM                 MAX EFFECTIVE COMMUNICATION RANGE
   35.00   KM/HR              COURIER SPEED
    1.0    MINUTES            AVERAGE MESSAGE LENGTH
     .25   MINUTES            CONNECT TIME DELAY
   30.0    MINUTES            TIME AT WHICH TO USE COURIER
   15.0    MINUTES            TIME BEFORE USING ALTERNATE ROUTE
   0.00    MIN                TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS    3 DIV     3 BDE     0 BN       0 CO       4.0 PERCENT DUTY CY
  5 CORPS    3 DIV     3 BDE    31 BN       0 CO      12.0 PERCENT DUTY CY
  5 CORPS    3 DIV     3 BDE    32 BN       0 CO      12.0 PERCENT DUTY CY
  5 CORPS    3 DIV     3 BDE    33 BN       0 CO      12.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE    41 BN       0 CO      12.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE    42 BN       0 CO      12.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE    43 BN       0 CO      12.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE    44 BN       0 CO      12.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE    45 BN       0 CO      12.0 PERCENT DUTY CY
C*********************************************************************
BLUE 3 BDE INTEL NET
C*********************************************************************
     4                        NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     5                        NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                        SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     1                        TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
   920     CHANNELS           NUMBER OF CHANNELS
     4     STATIONS           NUMBER OF STATIONS IN NET
   72.85   MHZ                NET FREQUENCY
   75.95   MHZ                MAX FREQUENCY
   30.00   MHZ                MIN FREQUENCY
   18.00   PERCENT            DUTY CYCLE
    5.00   PERCENT            BACKROUND TRAFFIC
    5.00   PERCENT            BREAK SECURITY
   40.00   KM                 MAX EFFECTIVE COMMUNICATION RANGE
   30.00   KM/HR              COURIER SPEED
    2.3    MINUTES            AVERAGE MESSAGE LENGTH
     .10   MINUTES            CONNECT TIME DELAY
   20.0    MINUTES            TIME AT WHICH TO USE COURIER
   10.0    MINUTES            TIME BEFORE USING ALTERNATE ROUTE
   0.00    MIN                TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS    3 DIV     3 BDE     0 BN       0 CO      55.0 PERCENT DUTY CY
  5 CORPS    3 DIV     3 BDE    31 BN       0 CO      15.0 PERCENT DUTY CY
  5 CORPS    3 DIV     3 BDE    32 BN       0 CO      15.0 PERCENT DUTY CY
  5 CORPS    3 DIV     3 BDE    33 BN       0 CO      15.0 PERCENT DUTY CY
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C*****************************************************************
BLUE 4 BDE COMMAND NET
C*****************************************************************
     1                       NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     5                       NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                       SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     1                       TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
   920     CHANNELS          NUMBER OF CHANNELS
     6     STATIONS          NUMBER OF STATIONS IN NET
  39.10   MHZ                NET FREQUENCY
  75.95   MHZ                MAX FREQUENCY
  30.00   MHZ                MIN FREQUENCY
  50.00   PERCENT            DUTY CYCLE
  10.00   PERCENT            BACKROUND TRAFFIC
   5.00   PERCENT            BREAK SECURITY
  40.00   KM                 MAX EFFECTIVE COMMUNICATION RANGE
  30.00   KM/HR              COURIER SPEED
   2.1    MINUTES            AVERAGE MESSAGE LENGTH
    .10   MINUTES            CONNECT TIME DELAY
  15.0    MINUTES            TIME AT WHICH TO USE COURIER
   5.0    MINUTES            TIME BEFORE USING ALTERNATE ROUTE
  0.00    MIN                TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS   3 DIV   4 BDE    0 BN     0 CO     50.0 PERCENT DUTY CY
  5 CORPS   3 DIV   4 BDE   41 BN     0 CO     10.0 PERCENT DUTY CY
  5 CORPS   3 DIV   4 BDE   42 BN     0 CO     10.0 PERCENT DUTY CY
  5 CORPS   3 DIV   4 BDE   43 BN     0 CO     10.0 PERCENT DUTY CY
  5 CORPS   3 DIV   4 BDE   44 BN     0 CO     10.0 PERCENT DUTY CY
  5 CORPS   3 DIV   4 BDE   45 BN     0 CO     10.0 PERCENT DUTY CY
C*****************************************************************
BLUE 4 BDE ADMIN/LOG NET
C*****************************************************************
     2                       NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     5                       NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                       SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     1                       TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
   920     CHANNELS          NUMBER OF CHANNELS
     6     STATIONS          NUMBER OF STATIONS IN NET
  56.95   MHZ                NET FREQUENCY
  75.95   MHZ                MAX FREQUENCY
  30.00   MHZ                MIN FREQUENCY
  43.00   PERCENT            DUTY CYCLE
  10.00   PERCENT            BACKROUND TRAFFIC
   5.00   PERCENT            BREAK SECURITY
  35.00   KM                 MAX EFFECTIVE COMMUNICATION RANGE
  25.00   KM/HR              COURIER SPEED
   3.0    MINUTES            AVERAGE MESSAGE LENGTH
    .25   MINUTES            CONNECT TIME DELAY
  60.0    MINUTES            TIME AT WHICH TO USE COURIER
  30.0    MINUTES            TIME BEFORE USING ALTERNATE ROUTE
  0.00    MIN                TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS   3 DIV   4 BDE    0 BN     0 CO     50.0 PERCENT DUTY CY
  5 CORPS   3 DIV   4 BDE   41 BN     0 CO     10.0 PERCENT DUTY CY
  5 CORPS   3 DIV   4 BDE   42 BN     0 CO     10.0 PERCENT DUTY CY
  5 CORPS   3 DIV   4 BDE   43 BN     0 CO     10.0 PERCENT DUTY CY
  5 CORPS   3 DIV   4 BDE   44 BN     0 CO     10.0 PERCENT DUTY CY
  5 CORPS   3 DIV   4 BDE   45 BN     0 CO     10.0 PERCENT DUTY CY
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C****************************************************************************
BLUE 4 BDE ARTY NET
C****************************************************************************
     3                        NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     5                        NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                        SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     1                        TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
   920     CHANNELS           NUMBER OF CHANNELS
     6     STATIONS           NUMBER OF STATIONS IN NET
   56.25   MHZ                NET FREQUENCY
   75.95   MHZ                MAX FREQUENCY
   30.00   MHZ                MIN FREQUENCY
   40.00   PERCENT            DUTY CYCLE
    5.00   PERCENT            BACKROUND TRAFFIC
    5.00   PERCENT            BREAK SECURITY
   40.00   KM                 MAX EFFECTIVE COMMUNICATION RANGE
   35.00   KM/HR              COURIER SPEED
    1.0    MINUTES            AVERAGE MESSAGE LENGTH
     .25   MINUTES            CONNECT TIME DELAY
   30.0    MINUTES            TIME AT WHICH TO USE COURIER
   15.0    MINUTES            TIME BEFORE USING ALTERNATE ROUTE
   0.00    MIN                TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS    3 DIV     4 BDE      0 BN       0 CO        5.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE     41 BN       0 CO       19.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE     42 BN       0 CO       19.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE     43 BN       0 CO       19.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE     44 BN       0 CO       19.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE     45 BN       0 CO       19.0 PERCENT DUTY CY
C****************************************************************************
BLUE 4 BDE INTEL NET
C****************************************************************************
     4                        NET TYPE 1-CMD/2-ADMIN/3-ARTY/4-INTELL/5-CAS
     5                        NET LEVEL  7-CORPS/6-DIV/5-BDE/4-BN
     1                        SECURITY MODE 1-CLEAR/2-AUTO/3-ENCPH
     1                        TRANSMISSION MODE 1-VOICE/2-TTY/3-FAX
   920     CHANNELS           NUMBER OF CHANNELS
     6     STATIONS           NUMBER OF STATIONS IN NET
   57.15   MHZ                NET FREQUENCY
   75.95   MHZ                MAX FREQUENCY
   30.00   MHZ                MIN FREQUENCY
   18.00   PERCENT            DUTY CYCLE
    5.00   PERCENT            BACKROUND TRAFFIC
    5.00   PERCENT            BREAK SECURITY
   40.00   KM                 MAX EFFECTIVE COMMUNICATION RANGE
   30.00   KM/HR              COURIER SPEED
    2.3    MINUTES            AVERAGE MESSAGE LENGTH
     .10   MINUTES            CONNECT TIME DELAY
   20.0    MINUTES            TIME AT WHICH TO USE COURIER
   10.0    MINUTES            TIME BEFORE USING ALTERNATE ROUTE
   0.00    MIN                TIME BEFORE ALTERNATE IF JAMMED
  5 CORPS    3 DIV     4 BDE      0 BN       0 CO       50.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE     41 BN       0 CO       10.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE     42 BN       0 CO       10.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE     43 BN       0 CO       10.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE     44 BN       0 CO       10.0 PERCENT DUTY CY
  5 CORPS    3 DIV     4 BDE     45 BN       0 CO       10.0 PERCENT DUTY CY
```

```
C**********************************************
RED VHF JAMMER
C**********************************************
     1     TYPE            TYPE EQUIPMENT 1-JAM,2-LISTEN,3-DF
     0     SCANNERS        NUMBER OF SCANNERS
     0     NETS            NUMBER OF PRIMARY NETS TARGETED AGAINST
     0     POLICY          EW POLICY FOR THIS EQUIPMENT
     2     UNITS           NUMBER OF UNITS WITH THIS TYPE EQUIPMENT
   25.     KM              MAXIMUM EFFECTIVE DISTANCE
   75.95   MHZ             MAXIMUM FREQUENCY
   30.05   MHZ             MINIMUM FREQUENCY
    5.00   MHZ             BANDWIDTH
    0.0    SECONDS         MINIMUM TIME TO SCAN/DF A SIGNAL
    0.0    SECONDS         SCAN TIME PER CHANNEL
  1 TA       9 DIV     8 REG     81 BN     814 CO
  1 TA       9 DIV     8 REG     81 BN     815 CO
C**********************************************
RED HF JAMMER
C**********************************************
     1     TYPE            TYPE EQUIPMENT 1-JAM,2-LISTEN,3-DF
     0     SCANNERS        NUMBER OF SCANNERS
     0     NETS            NUMBER OF PRIMARY NETS TARGETED AGAINST
     0     POLICY          EW POLICY FOR THIS EQUIPMENT
     2     UNITS           NUMBER OF UNITS WITH THIS TYPE EQUIPMENT
  500.     KM              MAXIMUM EFFECTIVE DISTANCE
   30.0    MHZ             MAXIMUM FREQUENCY
    2.0    MHZ             MINIMUM FREQUENCY
    5.00   MHZ             BANDWIDTH
    0.0    SECONDS         MINIMUM TIME TO SCAN/DF A SIGNAL
    0.0    SECONDS         SCAN TIME PER CHANNEL
  1 TA       9 DIV     8 REG     82 BN     824 CO
  1 TA       9 DIV     8 REG     82 BN     825 CO
C**********************************************
RED VHF LISTENER
C**********************************************
     2     TYPE            TYPE EQUIPMENT 1-JAM,2-LISTEN,3-DF
     5     SCANNERS        NUMBER OF SCANNERS
     0     NETS            NUMBER OF PRIMARY NETS TARGETED AGAINST
     0     POLICY          EW POLICY FOR THIS EQUIPMENT
     1     UNITS           NUMBER OF UNITS WITH THIS TYPE EQUIPMENT
   30.0    KM              MAXIMUM EFFECTIVE DISTANCE
   75.95   MHZ             MAXIMUM FREQUENCY
   30.05   MHZ             MINIMUM FREQUENCY
   00.00   MHZ             BANDWIDTH
   30.0    SECONDS         MINIMUM TIME TO SCAN/DF A SIGNAL
     .5    SECONDS         SCAN TIME PER CHANNEL
  1 TA       9 DIV     8 REG     81 BN     810 CO
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C*********************************************
RED HF LISTENER
C*********************************************
     2     TYPE            TYPE EQUIPMENT 1-JAM,2-LISTEN,3-DF
    10     SCANNERS        NUMBER OF SCANNERS
     0     NETS            NUMBER OF PRIMARY NETS TARGETED AGAINST
     0     POLICY          EW POLICY FOR THIS EQUIPMENT
     1     UNITS           NUMBER OF UNITS WITH THIS TYPE EQUIPMENT
  700.0    KM              MAXIMUM EFFECTIVE DISTANCE
   30.0    MHZ             MAXIMUM FREQUENCY
    2.0    MHZ             MINIMUM FREQUENCY
   00.00   MHZ             BANDWIDTH
   45.0    SECONDS         MINIMUM TIME TO SCAN/DF A SIGNAL
     .5    SECONDS         SCAN TIME PER CHANNEL
  1 TA        9 DIV     8 REG     82 BN     820 CO
C*********************************************
RED VHF DF
C*********************************************
     3     TYPE            TYPE EQUIPMENT 1-JAM,2-LISTEN,3-DF
     0     SCANNERS        NUMBER OF SCANNERS
     0     NETS            NUMBER OF PRIMARY NETS TARGETED AGAINST
     0     POLICY          EW POLICY FOR THIS EQUIPMENT
     3     UNITS           NUMBER OF UNITS WITH THIS TYPE EQUIPMENT
   25.0    KM              MAXIMUM EFFECTIVE DISTANCE
   75.95   MHZ             MAXIMUM FREQUENCY
   30.05   MHZ             MINIMUM FREQUENCY
   00.00   MHZ             BANDWIDTH
   30.0    SECONDS         MINIMUM TIME TO SCAN/DF A SIGNAL
    0.0    SECONDS         SCAN TIME PER CHANNEL
  1 TA        9 DIV     8 REG     81 BN     811 CO
  1 TA        9 DIV     8 REG     81 BN     812 CO
  1 TA        9 DIV     8 REG     81 BN     813 CO
C*********************************************
RED HF DF
C*********************************************
     3     TYPE            TYPE EQUIPMENT 1-JAM,2-LISTEN,3-DF
     0     SCANNERS        NUMBER OF SCANNERS
     0     NETS            NUMBER OF PRIMARY NETS TARGETED AGAINST
     0     POLICY          EW POLICY FOR THIS EQUIPMENT
     3     UNITS           NUMBER OF UNITS WITH THIS TYPE EQUIPMENT
  700.0    KM              MAXIMUM EFFECTIVE DISTANCE
   30.0    MHZ             MAXIMUM FREQUENCY
    2.0    MHZ             MINIMUM FREQUENCY
   00.00   MHZ             BANDWIDTH
   45.0    SECONDS         MINIMUM TIME TO SCAN/DF A SIGNAL
    0.0    SECONDS         SCAN TIME PER CHANNEL
  1 TA        9 DIV     8 REG     82 BN     821 CO
  1 TA        9 DIV     8 REG     82 BN     822 CO
  1 TA        9 DIV     8 REG     82 BN     823 CO
```

PART II

UNIT KILL, MOVEMENT, AND AQUISITION CAPABILITIES

Because the input is just a string of numbers on cards, the model's echo check of the data is presented.

WEAPON SYSTEM CHARACTERISTICS:

BLUE SYSTEMS:

- ATTRITION FACTORS (PROBABILITIES OF KILL PER UNIT TIME)

CONVENTIONAL WEAPONS

		INFANTRY	ARMOR	TUBE	ROCKET
BLUE	INFANTRY AGAINST	.00300	.00260	.00010	.00010
BLUE	ARMOR AGAINST	.00970	.00165	.00010	.00010
BLUE	TUBES AGAINST	.00900	.00900	.00200	.00910
BLUE	ROCKETS AGAINST	0.00000	0.00000	0.00000	0.00000

NUCLEAR WEAPONS

		INFANTRY	ARMOR	TUBE	ROCKET
BLUE	TUBES AGAINST	.44000	.35000	.90000	.49000
BLUE	ROCKETS AGAINST	.55000	.45000	.63000	.61000

- MAXIMUM FIRING RANGE (IN METERS)

INFANTRY	ARMOR	TUBE	ROCKET
3000	3000	19200	95000

- MAXIMUM RATE OF FIRE (IN ROUNDS/MIN/WEAPON)

INFANTRY	ARMOR	TUBE	ROCKET
.22700	.89600	3.86000	1.00000

- MAXIMUM RATE OF MOVEMENT (IN CM/SEC)

INFANTRY	ARMOR	TUBE	ROCKET	HHC
666	666	666	666	666

- MAXIMUM ACQUISITION RANGE (IN METERS)

INFANTRY	ARMOR	TUBE	ROCKET	HHC
3000	3000	3000	3000	18000

RED SYSTEMS:

- ATTRITION FACTORS (PROBABILITIES OF KILL PER UNIT TIME)

CONVENTIONAL WEAPONS

	INFANTRY	ARMOR	TUBE	ROCKET
RED INFANTRY AGAINST	.00580	.00580	.00010	.00010
RED ARMOR AGAINST	.00580	.00700	.00010	.00010
RED TUBES AGAINST	.00300	.00400	.00110	.00010
RED ROCKETS AGAINST	0.00000	0.00000	0.00000	0.00000

NUCLEAR WEAPONS

	INFANTRY	ARMOR	TUBE	ROCKET
RED TUBES AGAINST	.42000	.32000	.90000	.70000
RED ROCKETS AGAINST	.59000	.48000	.75000	.32000

- MAXIMUM FIRING RANGE (IN METERS)

INFANTRY	ARMOR	TUBE	ROCKET
3000	2000	18000	75000

- MAXIMUM RATE OF FIRE (IN ROUNDS/MIN/WEAPON)

INFANTRY	ARMOR	TUBE	ROCKET
.21400	.56800	2.64000	1.00000

- MAXIMUM RATE OF MOVEMENT (IN CM/SEC)

INFANTRY	ARMOR	TUBE	ROCKET	HHC
666	666	666	666	666

- MAXIMUM ACQUISITION RANGE (IN METERS)

INFANTRY	ARMOR	TUBE	ROCKET	HHC
3000	3000	3000	3000	18000

PART III

BLUE AND RED FORCE DESCRIPTIONS, RESOURCES,
AND LOCATIONS IN CARD IMAGE FORMAT.

```
NATO.
   US.
      5 CORPS COMMANDS 5 HHC.
         5 HHC IS AT HEX 777773277 .
         5 HHC HAS 1 APC, 40 ROUNDS, 100 RADIOS.
      5 CORPS COMMANDS 3 ARMDIV.
         3 ARMDIV COMMANDS 3 HHC.
            3 HHC IS AT HEX 777773663 .
            3 HHC HAS 1 APC, 40 ROUNDS, 14 RADIOS.
         3 ARMDIV COMMANDS 1 ARMBDE.
            1 ARMBDE COMMANDS 10 HHC.
               10 HHC IS AT HEX 777772777 .
               10 HHC HAS 1 APC, 40 ROUNDS, 20 RADIOS.
            1 ARMBDE COMMANDS 11 MECHBN.
               11 MECHBN COMMANDS 110 HHC.
                  110 HHC IS AT HEX 777772762 .
                  110 HHC HAS 1 APC, 40 ROUNDS, 25 RADIOS.
               11 MECHBN COMMANDS 111 MECCO.
                  111 MECCO IS AT HEX 777772677 .
                  111 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
               11 MECHBN COMMANDS 112 MECCO.
                  112 MECCO IS AT HEX 777772673 .
                  112 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
               11 MECHBN COMMANDS 113 MECCO.
                  113 MECCO IS AT HEX 777772634 .
                  113 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
               11 MECHBN COMMANDS 114 MCSCO.
                  114 MCSCO IS AT HEX 777772671 .
                  114 MCSCO HAS 10 TANKS, 1 TUBE, 556 ROUNDS.
            1 ARMBDE COMMANDS 12 MECHBN.
               12 MECHBN COMMANDS 120 HHC.
                  120 HHC IS AT HEX 777772721 .
                  120 HHC HAS 1 APC, 40 ROUNDS, 25 RADIOS.
               12 MECHBN COMMANDS 121 MECCO.
                  121 MECCO IS AT HEX 777772631 .
                  121 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
               12 MECHBN COMMANDS 122 MECCO.
                  122 MECCO IS AT HEX 777772264 .
                  122 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
               12 MECHBN COMMANDS 123 MECCO.
                  123 MECCO IS AT HEX 777772265 .
                  123 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
               12 MECHBN COMMANDS 124 MCSCO.
                  124 MCSCO IS AT HEX 777772242 .
                  124 MCSCO HAS 10 TANKS, 1 TUBE, 556 ROUNDS.
            1 ARMBDE COMMANDS 13 ARMBN.
               13 ARMBN COMMANDS 130 HHC.
                  130 HHC IS AT HEX 777772724 .
                  130 HHC HAS 3 TANKS, 189 ROUNDS, 30 RADIOS.
               13 ARMBN COMMANDS 131 ARMCO.
                  131 ARMCO IS AT HEX 777772612 .
                  131 ARMCO HAS 17 TANKS, 1055 ROUNDS.
               13 ARMBN COMMANDS 132 ARMCO.
                  132 ARMCO IS AT HEX 777772635 .
                  132 ARMCO HAS 17 TANKS, 1055 ROUNDS.
               13 ARMBN COMMANDS 133 ARMCO.
                  133 ARMCO IS AT HEX 777772246 .
                  133 ARMCO HAS 17 TANKS, 1055 ROUNDS.
               13 ARMBN COMMANDS 134 ACSCO.
                  134 ACSCO IS AT HEX 777772613 .
                  134 ACSCO HAS 10 TANKS, 1 TUBE, 888 ROUNDS.
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      1 ARMBDE COMMANDS 14 ARMBN.
        14 ARMBN COMMANDS 140 HHC.
           140 HHC IS AT HEX 777772772 .
           140 HHC HAS 3 TANKS, 189 ROUNDS, 30 RADIOS.
        14 ARMBN COMMANDS 141 ARMCO.
           141 ARMCO IS AT HEX 777772727 .
           141 ARMCO HAS 17 TANKS, 1055 ROUNDS.
        14 ARMBN COMMANDS 142 ARMCO.
           142 ARMCO IS AT HEX 777772726 .
           142 ARMCO HAS 17 TANKS, 1055 ROUNDS.
        14 ARMBN COMMANDS 143 ARMCO.
           143 ARMCO IS AT HEX 777772763 .
           143 ARMCO HAS 17 TANKS, 1055 ROUNDS.
        14 ARMBN COMMANDS 144 ACSCO.
           144 ACSCO IS AT HEX 777772724 .
           144 ACSCO HAS 10 TANKS, 1 TUBE, 888 ROUNDS.
   3 ARMDIV COMMANDS 2 ARMBDE.
      2 ARMBDE COMMANDS 20 HHC.
        20 HHC IS AT HEX 777772542 .
        20 HHC HAS 1 APC, 40 ROUNDS, 20 RADIOS.
      2 ARMBDE COMMANDS 21 MECHBN.
        21 MECHBN COMMANDS 210 HHC.
           210 HHC IS AT HEX 777772442 .
           210 HHC HAS 1 APC, 40 ROUNDS, 25 RADIOS.
        21 MECHBN COMMANDS 211 MECCO.
           211 MECCO IS AT HEX 777776375 .
           211 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
        21 MECHBN COMMANDS 212 MECCO.
           212 MECCO IS AT HEX 777776371 .
           212 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
        21 MECHBN COMMANDS 213 MECCO.
           213 MECCO IS AT HEX 777776312 .
           213 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
        21 MECHBN COMMANDS 214 MCSCO.
           214 MCSCO IS AT HEX 777776316 .
           214 MCSCO HAS 10 TANKS, 1 TUBE, 556 ROUNDS.
      2 ARMBDE COMMANDS 22 MECHBN.
        22 MECHBN COMMANDS 220 HHC.
           220 HHC IS AT HEX 777772435 .
           220 HHC HAS 1 APC, 40 ROUNDS, 25 RADIOS.
        22 MECHBN COMMANDS 221 MECCO.
           221 MECCO IS AT HEX 777772646 .
           221 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
        22 MECHBN COMMANDS 222 MECCO.
           222 MECCO IS AT HEX 777772642 .
           222 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
        22 MECHBN COMMANDS 223 MECCO.
           223 MECCO IS AT HEX 777772643 .
           223 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
        22 MECHBN COMMANDS 224 MCSCO.
           224 MCSCO IS AT HEX 777772647 .
           224 MCSCO HAS 10 TANKS, 1 TUBE, 556 ROUNDS.
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2 ARMBDE COMMANDS 23 ARMBN.
  23 ARMBN COMMANDS 230 HHC.
     230 HHC IS AT HEX 777772443 .
     230 HHC HAS 3 TANKS, 189 ROUNDS, 30 RADIOS.
  23 ARMBN COMMANDS 231 ARMCO.
     231 ARMCO IS AT HEX 777776351 .
     231 ARMCO HAS 17 TANKS, 1055 ROUNDS.
  23 ARMBN COMMANDS 232 ARMCO.
     232 ARMCO IS AT HEX 777776314 .
     232 ARMCO HAS 17 TANKS, 1055 ROUNDS.
  23 ARMBN COMMANDS 233 ARMCO.
     233 ARMCO IS AT HEX 777776315 .
     233 ARMCO HAS 17 TANKS, 1055 ROUNDS.
  23 ARMBN COMMANDS 234 ACSCO.
     234 ACSCO IS AT HEX 777776315 .
     234 ACSCO HAS 10 TANKS, 1 TUBE, 888 ROUNDS.
2 ARMBDE COMMANDS 24 ARMBN.
  24 ARMBN COMMANDS 240 HHC.
     240 HHC IS AT HEX 777772435 .
     240 HHC HAS 3 TANKS, 189 ROUNDS, 30 RADIOS.
  24 ARMBN COMMANDS 241 ARMCO.
     241 ARMCO IS AT HEX 777772422 .
     241 ARMCO HAS 17 TANKS, 1055 ROUNDS.
  24 ARMBN COMMANDS 242 ARMCO.
     242 ARMCO IS AT HEX 777772645 .
     242 ARMCO HAS 17 TANKS, 1055 ROUNDS.
  24 ARMBN COMMANDS 243 ARMCO.
     243 ARMCO IS AT HEX 777772656 .
     243 ARMCO HAS 17 TANKS, 1055 ROUNDS.
  24 ARMBN COMMANDS 244 ACSCO.
     244 ACSCO IS AT HEX 777772422 .
     244 ACSCO HAS 10 TANKS, 1 TUBE, 888 ROUNDS.
3 ARMDIV COMMANDS 3 ARMBDE.
  3 ARMBDE COMMANDS 30 HHC.
    30 HHC IS AT HEX 777772571 .
    30 HHC HAS 1 APC, 40 ROUNDS, 20 RADIOS.
  3 ARMBDE COMMANDS 31 MECHBN.
    31 MECHBN COMMANDS 310 HHC.
       310 HHC IS AT HEX 777727573 .
       310 HHC HAS 1 APC, 40 ROUNDS, 25 RADIOS.
    31 MECHBN COMMANDS 311 MECCO.
       311 MECCO IS AT HEX 777727413 .
       311 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
    31 MECHBN COMMANDS 312 MECCO.
       312 MECCO IS AT HEX 777772744 .
       312 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
    31 MECHBN COMMANDS 313 MECCO.
       313 MECCO IS AT HEX 777772747 .
       313 MECCO HAS 13 APC, 1 TUBE, 296 ROUNDS.
    31 MECHBN COMMANDS 314 MCSCO.
       314 MCSCO IS AT HEX 777772744 .
       314 MCSCO HAS 10 TANKS, 1 TUBE, 556 ROUNDS.
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      3 ARMBDE COMMANDS 32 ARMBN.
        32 ARMBN COMMANDS 320 HHC.
           320 HHC IS AT HEX 777772534 .
           320 HHC HAS 3 TANKS, 189 ROUNDS, 30 RADIOS.
        32 ARMBN COMMANDS 321 ARMCO.
           321 ARMCO IS AT HEX 777772775 .
           321 ARMCO HAS 17 TANKS, 1048 ROUNDS.
        32 ARMBN COMMANDS 322 ARMCO.
           322 ARMCO IS AT HEX 777772771 .
           322 ARMCO HAS 17 TANKS, 1055 ROUNDS.
        32 ARMBN COMMANDS 323 ARMCO.
           323 ARMCO IS AT HEX 777772734 .
           323 ARMCO HAS 17 TANKS, 1055 ROUNDS.
        32 ARMBN COMMANDS 324 ACSCO.
           324 ACSCO IS AT HEX 777772734 .
           324 ACSCO HAS 10 TANKS, 1 TUBE, 888 ROUNDS.
      3 ARMBDE COMMANDS 33 ARMBN.
        33 ARMBN COMMANDS 330 HHC.
           330 HHC IS AT HEX 777772544 .
           330 HHC HAS 3 TANKS, 189 ROUNDS, 30 RADIOS.
        33 ARMBN COMMANDS 331 ARMCO.
           331 ARMCO IS AT HEX 777772451 .
           331 ARMCO HAS 17 TANKS, 1055 ROUNDS.
        33 ARMBN COMMANDS 332 ARMCO.
           332 ARMCO IS AT HEX 777772457 .
           332 ARMCO HAS 17 TANKS, 1055 ROUNDS.
        33 ARMBN COMMANDS 333 ARMCO.
           333 ARMCO IS AT HEX 777772456 .
           333 ARMCO HAS 17 TANKS, 1055 ROUNDS.
        33 ARMBN COMMANDS 334 ACSCO.
           334 ACSCO IS AT HEX 777772456 .
           334 ACSCO HAS 10 TANKS, 1 TUBE, 888 ROUNDS.
   3 ARMDIV COMMANDS 4 DIVARTY.
      4 DIVARTY COMMANDS 40 HHC.
        40 HHC IS AT HEX 777772571 .
        40 HHC HAS 1 APC, 40 ROUNDS, 43 RADIOS.
      4 DIVARTY COMMANDS 41 ARTYBN.
        41 ARTYBN COMMANDS 410 HHB.
           410 HHB IS AT HEX 777772777 .
           410 HHB HAS 1 APC, 40 ROUNDS, 31 RADIOS.
        41 ARTYBN COMMANDS 411 BTY155.
           411 BTY155 IS AT HEX 777772243 .
           411 BTY155 HAS 6 TUBES, 1404 ROUNDS.
        41 ARTYBN COMMANDS 412 BTY155.
           412 BTY155 IS AT HEX 777772635 .
           412 BTY155 HAS 6 TUBES, 1404 ROUNDS.
        41 ARTYBN COMMANDS 413 BTY155.
           413 BTY155 IS AT HEX 777772675 .
           413 BTY155 HAS 6 TUBES, 1404 ROUNDS.
      4 DIVARTY COMMANDS 42 ARTYBN.
        42 ARTYBN COMMANDS 420 HHB.
           420 HHB IS AT HEX 777772477 .
           420 HHB HAS 1 APC, 40 ROUNDS, 31 RADIOS.
        42 ARTYBN COMMANDS 421 BTY155.
           421 BTY155 IS AT HEX 777772645 .
           421 BTY155 HAS 6 TUBES, 1404 ROUNDS.
        42 ARTYBN COMMANDS 422 BTY155.
           422 BTY155 IS AT HEX 777772426 .
           422 BTY155 HAS 6 TUBES, 1404 ROUNDS.
        42 ARTYBN COMMANDS 423 BTY155.
           423 BTY155 IS AT HEX 777776314 .
           423 BTY155 HAS 6 TUBES, 1404 ROUNDS.
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 4 DIVARTY COMMANDS 43 ARTYBN.
   43 ARTYBN COMMANDS 430 HHB.
      430 HHB IS AT HEX 777773662 .
      430 HHB HAS 1 APC, 40 ROUNDS, 31 RADIOS.
   43 ARTYBN COMMANDS 431 BTY155.
      431 BTY155 IS AT HEX 777772725 .
      431 BTY155 HAS 6 TUBES, 1404 ROUNDS.
   43 ARTYBN COMMANDS 432 BTY155.
      432 BTY155 IS AT HEX 777772764 .
      432 BTY155 HAS 6 TUBES, 1404 ROUNDS.
   43 ARTYBN COMMANDS 433 BTY155.
      433 BTY155 IS AT HEX 777772477 .
      433 BTY155 HAS 6 TUBES, 1404 ROUNDS.
 4 DIVARTY COMMANDS 44 ARTYBN.
   44 ARTYBN COMMANDS 440 HHB.
      440 HHB IS AT HEX 777772512 .
      440 HHB HAS 1 APC, 40 ROUNDS, 16 RADIOS.
   44 ARTYBN COMMANDS 441 BTY203.
      441 BTY203 IS AT HEX 777772761 .
      441 BTY203 HAS 4 TUBES, 560 ROUNDS.
   44 ARTYBN COMMANDS 442 BTY203.
      442 BTY203 IS AT HEX 777772434 .
      442 BTY203 HAS 4 TUBES, 560 ROUNDS.
   44 ARTYBN COMMANDS 443 BTY203.
      443 BTY203 IS AT HEX 777772522 .
      443 BTY203 HAS 4 TUBES, 560 ROUNDS.
 4 DIVARTY COMMANDS 45 MISLBN.
   45 MISLBN COMMANDS 450 HHB.
      450 HHB IS AT HEX 777772571 .
      450 HHB HAS 1 APC, 40 ROUNDS, 16 RADIOS.
   45 MISLBN COMMANDS 451 HJBTY.
      451 HJBTY IS AT HEX 77772757 .
      451 HJBTY HAS 2 ROCKETS, 8 GROUNDNUKES.
   45 MISLBN COMMANDS 452 HJBTY.
      452 HJBTY IS  AT HEX 777772562 .
      452 HJBTY HAS 2 ROCKETS, 8 GROUNDNUKES.
3 ARMDIV COMMANDS 5 RECBN.
   5 RECBN COMMANDS 50 HHC.
     50 HHC IS AT HEX 777772433 .
     50 HHC HAS 4 APC, 160 ROUNDS, 34 RADIOS.
   5 RECBN COMMANDS 51 RECCO.
     51 RECCO IS AT HEX 777776334 .
     51 RECCO HAS 18 APC, 9 TANKS, 1 TUBE, 1109 ROUNDS.
   5 RECBN COMMANDS 52 RECCO.
     52 RECCO IS AT HEX 777772665 .
     52 RECCO HAS 18 APC, 9 TANKS, 1 TUBE, 1109 ROUNDS.
   5 RECBN COMMANDS 53 RECCO.
     53 RECCO IS AT HEX 777772621 .
     53 RECCO HAS 18 APC, 9 TANKS, 1 TUBE, 1109 ROUNDS.
   5 RECBN COMMANDS 54 RECCO.
     54 RECCO IS AT HEX 777761115 .
     54 RECCO HAS 4 ATU, 63 ROUNDS.
3 ARMDIV COMMANDS 6 RECCO.
   6 RECCO IS AT HEX 777772446 .
   6 RECCO HAS 4 ATU, 63 ROUNDS.
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WP.
   RUSSIAN.
      1 TA COMMANDS 10 TKDIV.
         10 TKDIV COMMANDS 10 HHC.
            10 HHC IS AT HEX 777761646 .
            10 HHC HAS 1 ATU, 31 ROUNDS.
         10 TKDIV COMMANDS 5 TKRGT.
            5 TKRGT COMMANDS 50 HHC.
              50 HHC IS AT HEX 777761674 .
              50 HHC HAS 3 APC, 2 TANKS, 125 ROUNDS.
            5 TKRGT COMMANDS 51 TKBN.
              51 TKBN COMMANDS 510 HHC.
                 510 HHC IS AT HEX 777761675 .
                 510 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.
              51 TKBN COMMANDS 511 TKCO.
                 511 TKCO IS AT HEX 777761764 .
                 511 TKCO HAS 10 TANKS, 400 ROUNDS.
              51 TKBN COMMANDS 512 TKCO.
                 512 TKCO IS AT HEX 777761764 .
                 512 TKCO HAS 10 TANKS, 400 ROUNDS.
              51 TKBN COMMANDS 513 TKCO.
                 513 TKCO IS AT HEX 777761766 .
                 513 TKCO HAS 10 TANKS, 400 ROUNDS.
            5 TKRGT COMMANDS 52 TKBN.
              52 TKBN COMMANDS 520 HHC.
                 520 HHC IS AT HEX 777761652 .
                 520 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.
              52 TKBN COMMANDS 521 TKCO.
                 521 TKCO IS  AT HEX 777761431 .
                 521 TKCO HAS 10 TANKS, 400 ROUNDS.
              52 TKBN COMMANDS 522 TKCO.
                 522 TKCO IS AT HEX 777761431 .
                 522 TKCO HAS  10 TANKS, 400 ROUNDS.
              52 TKBN COMMANDS 523 TKCO.
                 523 TKCO IS AT HEX 777761433 .
                 523 TKCO HAS 10 TANKS, 400 ROUNDS.
            5 TKRGT COMMANDS 53 TKBN.
              53 TKBN COMMANDS 530 HHC.
                 530 HHC IS AT HEX 777761641 .
                 530 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.
              53 TKBN COMMANDS 531 TKCO.
                 531 TKCO IS AT HEX 777761437 .
                 531 TKCO HAS 10 TANKS, 400 ROUNDS.
              53 TKBN COMMANDS 532 TKCO.
                 532 TKCO IS AT HEX 777761437 .
                 532 TKCO HAS 10 TANKS, 400 ROUNDS.
              53 TKBN COMMANDS 533 TKCO.
                 533 TKCO IS AT HEX 777761432 .
                 533 TKCO HAS 10 TANKS, 400 ROUNDS.
            5 TKRGT COMMANDS 541 TKCO.
                 541 TKCO IS AT HEX 777761473 .
                 541 TKCO HAS 10 TANKS, 400 ROUNDS.
            5 TKRGT COMMANDS 551 CO.
                 551 CO IS AT HEX 777761473 .
                 551 CO HAS 6 ATU, 91 ROUNDS.
```

```
10 TKDIV COMMANDS 6 TKRGT.
   6  TKRGT COMMANDS 60 HHC.
     60 HHC IS AT HEX 777765312 .
     60 HHC HAS 3 APC, 2 TANKS, 125 ROUNDS.
   6 TKRGT COMMANDS 61 TKBN.
     61 TKBN COMMANDS 610 HHC.
        610 HHC IS AT HEX 777765317 .
        610 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.
     61 TKBN COMMANDS 611 TKCO.
        611 TKCO IS AT HEX 777761476 .
        611 TKCO HAS 10 TANKS, 400 ROUNDS.
     61 TKBN COMMANDS 612 TKCO.
        612 TKCO IS AT HEX 777761476 .
        612 TKCO HAS 10 TANKS, 400 ROUNDS.
     61 TKBN COMMANDS 613 TKCO.
        613 TKCO IS AT HEX 777761461 .
        613 TKCO HAS 10 TANKS, 400 ROUNDS.
   6 TKRGT COMMANDS 62 TKBN.
     62 TKBN COMMANDS 620 HHC.
        620 HHC IS AT HEX 777765314 .
        620 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.
     62 TKBN COMMANDS 621 TKCO.
        621 TKCO IS AT HEX 777761442 .
        621 TKCO HAS 10 TANKS, 400 ROUNDS.
     62 TKBN COMMANDS 622 TKCO.
        622 TKCO IS AT HEX 777761442 .
        622 TKCO HAS 10 TANKS, 400 ROUNDS.
     62 TKBN COMMANDS 623 TKCO.
        623 TKCO IS AT HEX 777761465 .
        623 TKCO HAS 10 TANKS, 400 ROUNDS.
   6 TKRGT COMMANDS 63 TKBN.
     63 TKBN COMMANDS 630 HHC.
        630 HHC IS AT HEX 777765316 .
        630 HHC HAS 2 APC, 1 TANK, 70 ROUNDS.
     63 TKBN COMMANDS 631  TKCO.
        631 TKCO IS AT HEX 777761442 .
        631 TKCO HAS 10 TANKS, 400 ROUNDS.
     63 TKBN COMMANDS 632 TKCO.
        632 TKCO IS AT HEX 777761442 .
        632 TKCO HAS 10 TANKS, 400 ROUNDS.
     63 TKBN COMMANDS 633 TKCO.
        633 TKCO IS AT HEX 777761464 .
        633 TKCO HAS 10 TANKS, 400 ROUNDS.
   6 TKRGT COMMANDS 641 TKCO.
        641 TKCO IS AT HEX 777761472 .
        641 TKCO HAS 10 TANKS, 400 ROUNDS.
   6 TKRGT COMMANDS 651 CO.
        651 CO IS AT HEX 777761472 .
        651 CO HAS 6 ATU, 91 ROUNDS.
```

```
1 TA COMMANDS 9 TKDIV.
   9 TKDIV COMMANDS 9 HHC.
      9 HHC IS AT HEX 777761436 .
      9 HHC HAS 1 ATU. 31 ROUNDS.
   9 TKDIV COMMANDS 1 TKRGT.
      1 TKRGT COMMANDS 10 HHC.
        10 HHC IS AT HEX 777761415 .
        10 HHC HAS 3 APC. 2 TANKS. 125 ROUNDS.
      1 TKRGT COMMANDS 11 TKBN.
        11 TKBN COMMANDS 110 HHC.
           110 HHC IS AT  HEX 777776217 .
           110 HHC HAS 2 APC. 1 TANK. 70 ROUNDS.
        11 TKBN COMMANDS 111 TKCO.
           111 TKCO IS AT HEX 777776361 .
           111 TKCO HAS 10 TANKS. 400 ROUNDS.
        11 TKBN COMMANDS 112 TKCO.
           112 TKCO IS AT HEX 777776361 .
           112 TKCO HAS 10 TANKS. 400 ROUNDS.
        11 TKBN COMMANDS 113 TKCO.
           113 TKCO IS AT HEX 777776324 .
           113 TKCO HAS 10 TANKS. 400 ROUNDS.
      1 TKRGT COMMANDS 12 TKBN.
        12 TKBN COMMANDS 120 HHC.
           120 HHC IS AT HEX 777761544 .
           120 HHC HAS 2 APC. 1 TANK. 70 ROUNDS.
        12 TKBN COMMANDS  121 TKCO.
           121 TKCO IS AT HEX 777776325 .
           121 TKCO HAS 10 TANKS. 400 ROUNDS.
        12 TKBN COMMANDS 122 TKCO.
           122 TKCO IS AT HEX 777776325 .
           122 TKCO HAS  10 TANKS. 400 ROUNDS.
        12 TKBN COMMANDS 123 TKCO.
           123 TKCO IS AT HEX 777776321 .
           123 TKCO HAS 10 TANKS. 400 ROUNDS.
      1 TKRGT COMMANDS 13 TKBN.
        13 TKBN COMMANDS 130 HHC.
           130 HHC IS AT HEX 777761541 .
           130 HHC HAS 2 APC. 1 TANK. 70 ROUNDS.
        13 TKBN COMMANDS 131 TKCO.
           131 TKCO IS AT HEX 777761554 .
           131 TKCO HAS 10 TANKS. 400 ROUNDS.
        13 TKBN COMMANDS 132 TKCO.
           132 TKCO IS AT HEX 777761555 .
           132 TKCO HAS 10 TANKS. 400 ROUNDS.
        13 TKBN COMMANDS 133 TKCO.
           133 TKCO IS AT HEX 777761555 .
           133 TKCO HAS 10 TANKS. 400 ROUNDS.
      1 TKRGT COMMANDS 141 TKCO.
           141 TKCO IS AT HEX 777776332 .
           141 TKCO HAS 10 TANKS. 400 ROUNDS.
      1 TKRGT COMMANDS 151 CO.
           151 CO IS AT HEX 777776332 .
           151 CO HAS 6 ATU. 91 ROUNDS.
```

```
9 TKDIV COMMANDS 2 MRRGT.
   2 MRRGT COMMANDS 20 HHC.
     20 HHC IS AT HEX 777761411 .
     20 HHC HAS 6 APC, 91 ROUNDS.
   2 MRRGT COMMANDS 21 MRBN.
     21 MRBN COMMANDS 210 HHC.
        210 HHC IS AT HEX 777761572 .
        210 HHC HAS 1 APC, 31 ROUNDS.
     21 MRBN COMMANDS 211 MRCO.
        211 MRCO IS AT HEX 777772666 .
        211 MRCO HAS 9 APC, 86 ROUNDS.
     21 MRBN COMMANDS 212 MRCO.
        212 MRCO IS AT HEX 777772666 .
        212 MRCO HAS 9 APC, 86 ROUNDS.
     21 MRBN COMMANDS 213 MRCO.
        213 MRCO IS AT HEX 777761551 .
        213 MRCO HAS 9 APC, 86 ROUNDS.
     21 MRBN COMMANDS 214 BTY.
        214 BTY IS AT HEX 777761551 .
        214 BTY HAS 2 TUBES, 238 ROUNDS.
     21 MRBN COMMANDS 215 MCSCO.
        215 MCSCO IS AT HEX 777761553 .
        215 MCSCO HAS 6 ATU, 58 ROUNDS.
   2 MRRGT COMMANDS 22 MRBN.
     22 MRBN COMMANDS 220 HHC.
        220 HHC IS AT HEX 777761536 .
        220 HHC HAS 1 APC 31 ROUNDS.
     22 MRBN COMMANDS 221 MRCO.
        221 MRCO IS AT HEX 777772662 .
        221 MRCO HAS 9 APC, 86 ROUNDS.
     22 MRBN COMMANDS 222 MRCO.
        222 MRCO IS AT HEX 777772662 .
        222 MRCO HAS 9 APC, 86 ROUNDS.
     22 MRBN COMMANDS 223 MRCO.
        223 MRCO IS AT HEX 777761514 .
        223 MRCO HAS 9 APC, 86 ROUNDS.
     22 MRBN COMMANDS 224 BTY.
        224 BTY IS AT HEX  777761514 .
        224 BTY HAS 2 TUBES, 238 ROUNDS.
     22 MRBN COMMANDS 225 MCSCO.
        225 MCSCO IS AT HEX 777761516 .
        225 MCSCO HAS 6 ATU, 58 ROUNDS.
   2 MRRGT COMMANDS 23 MRBN.
     23 MRBN COMMANDS 230 HHC.
        230 HHC IS AT HEX 777761533 .
        230 HHC HAS 1 APC, 31 ROUNDS.
     23 MRBN COMMANDS 231 MRCO.
        231 MRCO IS AT HEX 777772626 .
        231 MRCO HAS 9 APC, 86 ROUNDS.
     23 MRBN COMMANDS 232 MRCO.
        232 MRCO IS AT HEX 777772626 .
        232 MRCO HAS 9 APC, 86 ROUNDS.
     23 MRBN COMMANDS 233 MRCO.
        233 MRCO IS AT HEX 777761511 .
        233 MRCO HAS 9 APC, 86 ROUNDS.
     23 MRBN COMMANDS 234 BTY.
        234 BTY IS AT HEX  777772622 .
        234 BTY HAS 2 TUBES, 238 ROUNDS.
     23 MRBN COMMANDS 235 MCSCO.
        235 MCSCO IS AT HEX 777772622 .
        235 MCSCO HAS 6 ATU, 58 ROUNDS.
```

```
  2 MRRGT COMMANDS 24 TKBN.
    24 TKBN COMMANDS 240 HHC.
       240 HHC IS AT HEX 777761537 .
       240 HHC HAS 3 APC, 2 TANKS, 125 ROUNDS.
    24 TKBN COMMANDS 241 TKCO.
       241 TKCO IS AT HEX 777761515 .
       241 TKCO HAS 10 TANKS, 400 ROUNDS.
    24 TKBN COMMANDS 242 TKCO.
       242 TKCO IS AT HEX 777761515 .
       242 TKCO HAS 10 TANKS, 400 ROUNDS.
    24 TKBN COMMANDS 243 TKCO.
       243 TKCO IS AT HEX 777761517 .
       243 TKCO HAS 10 TANKS, 400 ROUNDS.
  2 MRRGT COMMANDS 25 ARTYBN.
    25 ARTYBN COMMANDS 250 HHB.
       250 HHB IS AT HEX 777761525 .
       250 HHB HAS 1 APC, 31 ROUNDS.
    25 ARTYBN COMMANDS 251 MCSCO.
       251 MCSCO IS AT HEX 777761512 .
       251 MCSCO HAS 6 ATU, 90 ROUNDS.
    25 ARTYBN COMMANDS 252 MCSCO.
       252 MCSCO IS AT HEX 777761517 .
       252 MCSCO HAS 6 ATU, 90 ROUNDS.
    25 ARTYBN COMMANDS 253 BTY.
       253 BTY IS AT HEX 777761513 .
       253 BTY HAS 6 TUBES, 708 ROUNDS.
9 TKDIV  COMMANDS 3 ACS.
  3 ACS COMMANDS 30 HHC.
    30 HHC IS AT HEX 777761574 .
    30 HHC HAS 2 ATU, 30 ROUNDS.
  3 ACS COMMANDS 31 ACT.
    31 ACT IS AT HEX 777776376 .
    31 ACT HAS 2 ATU, 3 TANKS, 300 ROUNDS.
  3 ACS COMMANDS 32 ACT.
    32 ACT IS AT HEX 777776373 .
    32 ACT HAS 2 ATU,  3 TANKS, 300 ROUNDS.
  3 ACS COMMANDS 33 ACT.
    33 ACT IS AT HEX 777776337 .
    33 ACT HAS 2 ATU, 3 TANKS, 300 ROUNDS.
  3 ACS COMMANDS 34 ACT.
    34 ACT IS AT HEX 777772664 .
    34 ACT HAS 2 ATU, 3 TANKS, 300 ROUNDS.
  3 ACS COMMANDS 35 ACT.
    35 ACT IS AT HEX 777772624 .
    35 ACT HAS 2 ATU, 3 TANKS, 300 ROUNDS.
```

```
9 TKDIV COMMANDS 4 ARTYBDE.
    4 ARTYBDE COMMANDS 40 HHB.
       40 HHB IS AT HEX 777761747 .
       40 HHB HAS 2 APC, 31 ROUNDS.
    4 ARTYBDE  COMMANDS 41 ARTYBN.
       41 ARTYBN COMMANDS 410 HHB.
          410 HHB IS AT HEX 777761754 .
          410 HHB HAS 1 APC, 31 ROUNDS.
       41 ARTYBN COMMANDS 411 BTY.
          411 BTY IS AT HEX 777761144 .
          411 BTY HAS 2 TUBES, 450 ROUNDS.
       41 ARTYBN COMMANDS 412 BTY.
          412 BTY IS AT HEX 777761144 .
          412 BTY HAS 2 TUBES, 450 ROUNDS.
       41 ARTYBN  COMMANDS 413 BTY.
          413 BTY IS AT HEX 777761513 .
          413 BTY HAS 2 TUBES, 450 ROUNDS.
  4 ARTYBDE COMMANDS 42 ARTYBN.
       42 ARTYBN COMMANDS 420 HHB.
          420 HHB IS AT HEX 777761522 .
          420 HHB HAS 1 APC, 31 ROUNDS.
       42 ARTYBN COMMANDS 421 BTY.
          421 BTY IS AT HEX 777761553 .
          421 BTY HAS 2 TUBES, 450 ROUNDS.
       42 ARTYBN COMMANDS 422 BTY.
          422 BTY IS AT HEX 777761516 .
          422 BTY HAS 2 TUBES, 450 ROUNDS.
       42 ARTYBN COMMANDS 423 BTY.
          423 BTY IS AT HEX 777761512 .
          423  BTY HAS 2 TUBES, 430 ROUNDS.
    4 ARTYBDE COMMANDS 43 ARTYBN.
       43 ARTYBN COMMANDS 430 HHB.
          430 HHB IS AT HEX 777761524 .
          430 HHB HAS 1 APC, 31 ROUNDS.
       43 ARTYBN COMMANDS 431 BTY.
          431 BTY IS AT HEX 777761511 .
          431 BTY HAS 4 TUBES, 400 ROUNDS.
       43 ARTYBN COMMANDS 432 BTY.
          432 BTY IS  AT HEX 777761534 .
          432 BTY HAS 4 TUBES, 400 ROUNDS.
       43 ARTYBN COMMANDS 433 BTY.
          433 BTY IS AT HEX 777761534 .
          433 BTY HAS 4 TUBES, 400 ROUNDS.
    4 ARTYBDE COMMANDS 44 ARTYBN.
       44 ARTYBN COMMANDS 440 HHB.
          440 HHB IS AT HEX 777761521 .
          440 HHB HAS 1 APC, 31 ROUNDS.
       44 ARTYBN COMMANDS 441 BTY203.
          441 BTY203 IS AT HEX 777761146 .
          441 BTY203 HAS 4 TUBES, 400 ROUNDS.
       44 ARTYBN COMMANDS 442 BTY203.
          442 BTY203 IS AT HEX 777761535 .
          442 BTY203 HAS 4 TUBES, 400 ROUNDS.
       44 ARTYBN COMMANDS 443 BTY203.
          443 BTY203 IS AT HEX 777761535 .
          443 BTY203 HAS 4 TUBES, 400 ROUNDS.
```

```
9 TKDIV COMMANDS 7 DIVARTY.
  7 DIVARTY COMMANDS 70 HHB.
    70 HHB IS AT HEX 777776223 .
    70 HHB HAS 2 APC, 31 ROUNDS.
  7 DIVARTY COMMANDS 71 ARTYBN.
    71 ARTYBN COMMANDS 710 HHB.
       710 HHB IS AT HEX 777776234 .
       710 HHB HAS 2 APC, 31 ROUNDS.
    71 ARTYBN COMMANDS 711 BTY122.
       711 BTY122 IS AT HEX 777776363 .
       711 BTY122 HAS 6 TUBES. 471 ROUNDS.
    71 ARTYBN COMMANDS 712 BTY122.
       712 BTY122 IS AT HEX 777776363 .
       712  BTY122 HAS 6 TUBES, 471 ROUNDS.
    71 ARTYBN COMMANDS 713 BTY122.
       713 BTY122 IS AT HEX 777776324 .
       713 BTY122 HAS 6 TUBES. 471 ROUNDS.
  7 DIVARTY COMMANDS 72 ARTYBN.
    72 ARTYBN COMMANDS 720 HHB.
       720 HHB IS AT HEX 777776231 .
       720 HHB HAS 2 APC, 31 ROUNDS.
    72 ARTYBN COMMANDS 721 BTY122.
       721 BTY122 IS AT HEX 777776321 .
       721 BTY122 HAS 6 TUBES, 471 ROUNDS.
    72 ARTYBN COMMANDS 722 BTY122.
       722 BTY122 IS AT HEX 777776323 .
       722 BTY122 HAS 6 TUBES, 471 ROUNDS.
    72 ARTYBN COMMANDS 723 BTY122.
       723 BTY122 IS AT HEX 777776323 .
       723 BTY122 HAS 6 TUBES, 471 ROUNDS.
  7 DIVARTY COMMANDS 73 MRLBN.
    73 MRLBN COMMANDS 730 HHB.
       730 HHB IS AT HEX 777776235 .
       730 HHB HAS 2 APC, 31 ROUNDS.
    73 MRLBN COMMANDS 731 MRLBTY.
       731 MRLBTY IS AT HEX 777776327 .
       731 MRLBTY HAS 6 TUBES, 1184 ROUNDS.
    73 MRLBN COMMANDS 732 MRLBTY.
       732 MRLBTY IS AT HEX 777776327 .
       732 MRLBTY HAS 6 TUBES, 1184 ROUNDS.
    73 MRLBN COMMANDS 733 MRLBTY.
       733 MRLBTY IS AT HEX 777761554 .
       733 MRLBTY HAS 6 TUBES. 1184 ROUNDS.
  7 DIVARTY COMMANDS 74 MRLBN.
    74 MRLBN COMMANDS 740 HHB.
       740 HHB IS AT HEX 777761562 .
       740 HHB HAS 2 APC, 31 ROUNDS.
    74 MRLBN COMMANDS 741 FROGBTY.
       741 FROGBTY IS AT HEX 777761571 .
       741 FROGBTY HAS 2 ROCKETS, 8 GROUNDNUKES.
    74 MRLBN COMMANDS 742 FROGBTY.
       742 FROGBTY IS AT HEX 777761557 .
       742 FROGBTY HAS 2 ROCKETS, 8 GROUNDNUKES.
```

```
9 TKDIV COMMANDS 8 RECRGT.
    8 RECRGT COMMANDS 80 HHC.
        80 HHC IS AT HEX 777761562 .
        80 HHC HAS 1 ATU, 31 ROUNDS.
    8 RECRGT COMMANDS 81 RECBN.
        81 RECBN COMMANDS 810 HHC.
            810 HHC IS AT HEX 777761556 .
            810 HHC HAS 1 ATU, 31 ROUNDS.
        81 RECBN COMMANDS 811 RECCO.
            811 RECCO IS AT HEX 777761556 .
            811 RECCO HAS 1 ATU, 31 ROUNDS.
        81 RECBN COMMANDS 812 RECCO.
            812 RECCO IS AT HEX 777776215 .
            812 RFCCO HAS 1 ATU, 31 ROUNDS.
        81 RECBN COMMANDS 813 RECCO.
            813 RECCO IS AT HEX 777761511 .
            813 RECCO HAS 1 ATU, 31 ROUNDS.
        81 RECBN COMMANDS 814 RECCO.
            814 RECCO IS AT HEX 777776322 .
            814 RFCCO HAS 1 ATU, 31 ROUNDS.
        81 RECBN COMMANDS 815 RECCO.
            815 RECCO IS AT HEX 777761553 .
            815 RECCO HAS 1 ATU, 31 ROUNDS.
    8 RECRGT COMMANDS 82 RECBN.
        82 RECBN COMMANDS 820 HHC.
            820 HHC IS AT HEX 777767477 .
            820 HHC HAS 1 ATU, 31 ROUNDS.
        82 RECBN COMMANDS 821 RECCO.
            821 RECCO IS AT HEX 777761456 .
            821 RECCO HAS 1 ATU, 31 ROUNDS.
        82 RECBN COMMANDS 822 RECCO.
            822 RECCO IS AT HEX 777767737 .
            822 RECCO HAS 1 ATU, 31 ROUNDS.
        82 RECBN COMMANDS 823 RECCO.
            823 RECCO IS AT HEX 777764117 .
            823 RECCO HAS 1 ATU, 31 ROUNDS.
        82 RECBN COMMANDS 824 RECCO.
            824 RECCO IS AT HEX 777761562 .
            824 RECCO HAS 1 ATU, 31 ROUNDS.
        82 RECBN COMMANDS 825 RECCO.
            825 RECCO IS AT HEX 777761451 .
            825 RECCO HAS 1 ATU, 31 ROUNDS.
```

PART IV

MITL INITIAL ORDERS (OPORDS). THE MITL ROUTINES ARE SET UP TO BE INTERACTIVE. THOSE LINES WITH A SQUARE (□) NEXT TO THEM ARE USER INPUTS. THE OTHERS ARE COMPUTER RESPONSES.

```
ENTER TIME POINT TO HOOK ORDERS TO
(ENTER TIME IN SECONDS)
■0
```

```
     01/03/79      09.00.09.            MAN-IN-LOOP OPORD INPUT

     ENTER LEVEL FOR INSTRUCTION(FULL/PARTIAL)
■FULL
     ENTER LENGTH OF NEXT RUN(MINUTES)
■72000
      WHICH SIDE (RED/BLUE/NONE) FOR NUCLEAR STRIKE
      NONE
      WHICH SIDE (RED/BLUE/NONE)
■RED
      ENTER UNIT TO BE MOVED
     INPUT UNIT DESIGNATION:
       CORPS/CAA,DIV,BDE/REG,BN
       WITH ZERO (0) WHERE NO UNIT AT THAT ECHELON
■1 9 7 0
      ENTER OLD COMMANDER
     INPUT UNIT DESIGNATION:
       CORPS/CAA,DIV,BDE/REG,BN
       WITH ZERO (0) WHERE NO UNIT AT THAT ECHELON
■1 9 0 0
      ENTER NEW COMMANDER
     INPUT UNIT DESIGNATION:
       CORPS/CAA,DIV,BDE/REG,BN
       WITH ZERO (0) WHERE NO UNIT AT THAT ECHELON
■1 10 0 0
      ENTER EFFECTIVE TIME (IN SECONDS) OF GAME
■10600
      REVIEWING WHAT YOU HAVE ENTERED
      DO YOU WANT TO USE THIS REASSIGNMENT (YES/NO)
■YES
      WHICH SIDE (RED/BLUE/NONE)
■NONE
     WHICH SIDE (RED/BLUE/NONE)
■RED
     INPUT UNIT DESIGNATION:
       CORPS/CAA,DIV,BDE/REG,BN
       WITH ZERO (0) WHERE NO UNIT AT THAT ECHELON
■1 9 0 0
     INPUT OPERATION(ATK/DEF)
■ATK
     INPUT INITIAL,FINAL TIMES AS INTEGER DHHMM
■10000 11200
     INPUT GS PRIORITY AS INTEGER PERCENT
■50
     ARE NUCLEAR WEAPONS PERMITTED
■YES
```

```
     INPUT ACCEPTABLE CASUALTY LIMIT, AND
  MIN SUPPLY LEVEL AS INTEGER PERCENTS
     INPUT MIN,MAX SPEED LIMITS AS INTEGER PERCENT
  OF UNIT THEORETICAL BEST SPEED
■90 5 90 10
     INPUT LEFT BOUNDARY HEXES(AS FACE DIRECTION OF MOVEMENT)
     REAR TO FRONT,FOLLOWED BY ZERO(0)
     THEN RIGHT BOUNDARY HEXES-REAR TO FRONT
     TERMINATE LIST BY A NINE (9)
■777761446
■777776343
■777776351
■777772441
■777772454
■777772564
■777772515
■0
■777761632
■777772623
■777772625
■7777724422
■777772436
■777772715
■777772113
■9
 DO YOU NEED INSTRUCTIONS FOR INPUT OF PHASELINES(YES/NO)
■NO
   INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME
  OF PHASE AS INTEGER DHHMM
■2 10200
     INPUT HEX LIST AS INTEGERS
■777776351
■777772467
■777772472
■777776313
■777772625
■9
   INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME
  OF PHASE AS INTEGER DHHMM
■2 10400
     INPUT HEX LIST AS INTEGERS
■777772441
■777772475
■777772417
■777772434
■777772436
■9
   INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME
  OF PHASE AS INTEGER DHHMM
■2 10600
     INPUT HEX LIST AS INTEGERS
■777772564
■777772527
■777772757
■777772715
■9
```

```
  INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME
 OF PHASE AS INTEGER DHHMM
■0 0
    END OF PHASE INPUT FOR THIS UNIT


    INPUT ORDERS FOR UNIT  4523
    (   1,   9,   0,   0)


    OPERATION: ATK      START: 10000      STOP: 11200
    MIN SPEED: 90%      MAX SPEED: 10%
    MAX CASUALTIES: 90%      MIN SUPPLIES:  5%
    LEFT BOUNDARY:
                 777761446
                 777776343
                 777776351
                 777772441
                 777772454
                 777772564
                 777772515
    RIGHT BOUNDARY:
                 777761632
                 777772623
                 777772625
                7777724422
                 777772436
                 777772715
                 777772113
    PHASE NUMBER:  1
    TYPE PHASE:  2     END OF PHASE: 10200
    PHASELINE:
                 777776351
                 777772467
                 777772472
                 777776313
                 777772625
    PHASE NUMBER:  2
    TYPE PHASE:  2     END OF PHASE: 10400
    PHASELINE:
                 777772441
                 777772475
                 777772417
                 777772434
                 777772436
    PHASE NUMBER:  3
    TYPE PHASE:  2     END OF PHASE: 10600
    PHASELINE:
                 777772564
                 777772527
                 777772757
                 777772715
    DO YOU WANT TO USE THE LAST OPORD (YES/NO)
■YES
```

```
     WHICH SIDE (RED/BLUE/NONE)
■RED
     INPUT UNIT DESIGNATION:
       CORPS/CAA,DIV,BDE/REG,BN
       WITH ZERO (0) WHERE NO UNIT AT THAT ECHELON
■1 10 0 0
     INPUT OPERATION(ATK/DEF)
■ATK
     INPUT INITIAL,FINAL TIMES AS INTEGER DHHMM
■10000 11200
     INPUT GS PRIORITY AS INTEGER PERCENT
■50
     ARE NUCLEAR WEAPONS PERMITTED
■YES
     INPUT ACCEPTABLE CASUALTY LIMIT, AND
  MIN SUPPLY LEVEL AS INTEGER PERCENTS
     INPUT MIN,MAX SPEED LIMITS AS INTEGER PERCENT
  OF UNIT THEORETICAL BEST SPEED
■90 5 90 10
     INPUT LEFT BOUNDARY HEXES(AS FACE DIRECTION OF MOVEMENT)
     REAR TO FRONT,FOLLOWED BY ZERO(0)
     THEN RIGHT BOUNDARY HEXES-REAR TO FRONT
     TERMINATE LIST BY A NINE (9)
■777761446
■777776343
■777776316
■777772422
■777772436
■777772431
■777772142
■777772155
■0
■777761632
■777772623
■777772276
■777772257
■777772125
■777772113
■9
 DO YOU NEED INSTRUCTIONS FOR INPUT OF PHASELINES(YES/NO)
■NO
   INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME
  OF PHASE AS INTEGER DHHMM
■2 10530
     INPUT HEX LIST AS INTEGERS
■777776343
■777772664
■777772623
■9
   INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME
  OF PHASE AS INTEGER DHHMM
■2 10730
     INPUT HEX LIST AS INTEGERS
■777776316
■777772643
■777772244
■777772276
■9
   INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME
  OF PHASE AS INTEGER DHHMM
■2 10930
     INPUT HEX LIST AS INTEGERS
```

```
■777772431
■777772775
■777772257
■9
   INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME
  OF PHASE AS INTEGER DHHMM
■2 11130
     INPUT HEX LIST AS INTEGERS
■777772142
■777772177
■777772125
■9
   INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME
  OF PHASE AS INTEGER DHHMM
■0 0
     END OF PHASE INPUT FOR THIS UNIT



     INPUT ORDERS FOR UNIT  3413
     (   1,  10,   0,   0)


     OPERATION: ATK      START: 10000      STOP: 11200
     MIN SPEED: 90%      MAX SPEED: 10%
     MAX CASUALTIES: 90%      MIN SUPPLIES:  5%
     LEFT BOUNDARY:
                    777761446
                    777776343
                    777776316
                    777772422
                    777772436
                    777772431
                    777772142
                    777772155
     RIGHT BOUNDARY:
                    777761632
                    777772623
                    777772276
                    777772257
                    777772125
                    777772113
     PHASE NUMBER:  1
     TYPE PHASE:  2      END OF PHASE: 10530
     PHASELINE:
                    777776343
                    777772664
                    777772623
     PHASE NUMBER:  2
     TYPE PHASE:  2      END OF PHASE: 10730
     PHASELINE:
                    777776316
                    777772643
                    777772244
                    777772276
```

```
     PHASE NUMBER:  3
     TYPE PHASE:  2     END OF PHASE: 10930
     PHASELINE:
                    777772431
                    777772775
                    777772257
     PHASE NUMBER:  4
     TYPE PHASE:  2     END OF PHASE: 11130
     PHASELINE:
                    777772142
                    777772177
                    777772125
     DO YOU WANT TO USE THE LAST OPORD (YES/NO)
■YES
     WHICH SIDE (RED/BLUE/NONE)
■BLUE
     INPUT UNIT DESIGNATION:
       CORPS/CAA,DIV,BDE/REG,BN
       WITH ZERO (0) WHERE NO UNIT AT THAT ECHELON
■5 3 0 0
     INPUT OPERATION(ATK/DEF)
■DEF
     INPUT INITIAL,FINAL TIMES AS INTEGER DHHMM
■10100 20000
     INPUT GS PRIORITY AS INTEGER PERCENT
■50
     ARE NUCLEAR WEAPONS PERMITTED
■YES
     INPUT ACCEPTABLE CASUALTY LIMIT, AND
   MIN SUPPLY LEVEL AS INTEGER PERCENTS
     INPUT MIN,MAX SPEED LIMITS AS INTEGER PERCENT
   OF UNIT THEORETICAL BEST SPEED
■60 40 20 70
     INPUT LEFT BOUNDARY HEXES(AS FACE DIRECTION OF MOVEMENT)
     REAR TO FRONT,FOLLOWED BY ZERO(0)
     THEN RIGHT BOUNDARY HEXES-REAR TO FRONT
     TERMINATE LIST BY A NINE (9)
■777772133
■777772342
■777772241
■777772633
■777761577
■0
■777772515
■777772572
■777772476
■777776351
■777776255
■9
```

```
 DO YOU NEED INSTRUCTIONS FOR INPUT OF PHASELINES(YES/NO)
■YES
     YOU WILL BE ASKED TO INPUT AN OPERATION TYPE NUMBER
  FOR EACH PHASE. THE CODES REFER TO THE FOLLOWING:
   CODE      OFFENSIVE             DEFENSIVE
      1    MOVE TO CONTACT      HOLD POSITION
      2    BRKTHRU              DELAY
      3    HOLDING ATK          SCREEN,MOVE
      4    EXPLOIT              COUNTERATK
      5    RESERVE              RESERVE
           FOR THE PHASELINES,INPUT THE HEXES FROM LEFT TO RIGHT,MAKING
   SURE TO INCLUDE A HEX FROM THE LEFT AND RIGHT BOUNDARIES.
   TO TERMINATE HEXES,TYPE IN 9
   INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME
  OF PHASE AS INTEGER DHHMM
■3 10230
     INPUT HEX LIST AS INTEGERS
■777772633
■777772624
■777776337
■777776351
■9
   INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME
  OF PHASE AS INTEGER DHHMM
■3 10530
     INPUT HEX LIST AS INTEGERS
■777772241
■777772615
■777772655
■777772476
■9
   INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME
  OF PHASE AS INTEGER DHHMM
■3 10830
     INPUT HEX LIST AS INTEGERS
■777772342
■777772716
■777772757
■777772572
■9
   INPUT OPERATION CODE(0 TO TERMINATE),AS INTEGER, END TIME
  OF PHASE AS INTEGER DHHMM
■0 0
     END OF PHASE INPUT FOR THIS UNIT
```

```
     INPUT ORDERS FOR UNIT   219
     (   5,   3,   0,   0)


     OPERATION: DEF      START: 10100      STOP: 20000
     MIN SPEED: 20%      MAX SPEED: 70%
     MAX CASUALTIES: 60%      MIN SUPPLIES: 40%
     LEFT BOUNDARY:
                    777772133
                    777772342
                    777772241
                    777772633
                    777761577
     RIGHT BOUNDARY:
                    777772515
                    777772572
                    777772476
                    777776351
                    777776255
     PHASE NUMBER:  1
     TYPE PHASE:  3      END OF PHASE: 10230
     PHASELINE:
                    777772633
                    777772624
                    777776337
                    777776351
     PHASE NUMBER:  2
     TYPE PHASE:  3      END OF PHASE: 10530
     PHASELINE:
                    777772241
                    777772615
                    777772655
                    777772476
     PHASE NUMBER:  3
     TYPE PHASE:  3      END OF PHASE: 10830
     PHASELINE:
                    777772342
                    777772716
                    777772757
                    777772572
     DO YOU WANT TO USE THE LAST OPORD (YES/NO)
■YES
     WHICH SIDE (RED/BLUE/NONE)
■NONE
     ENTER SIDE FOR JAMMING SUPPORT
     (RED/BLUE/NONE)
■NONE
```

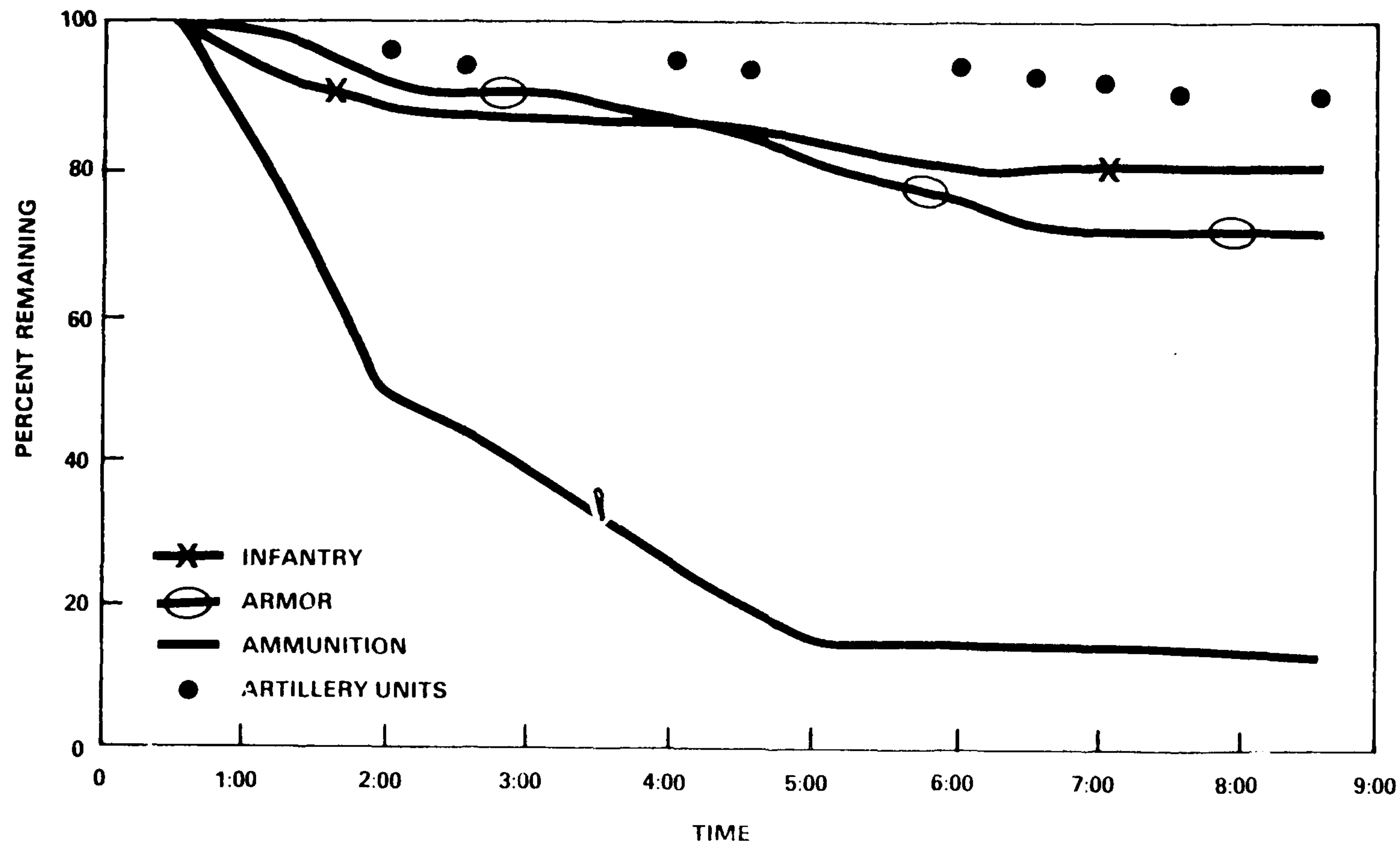
APPENDIX D

BLUE DIVISION RESOURCE DRAWDOWN

Expendable combat resources in the TRACE model are: armor units, infantry units, artillery units, and ammunition. The six charts in this appendix show the dynamic drawdown of those resources for the Blue player.

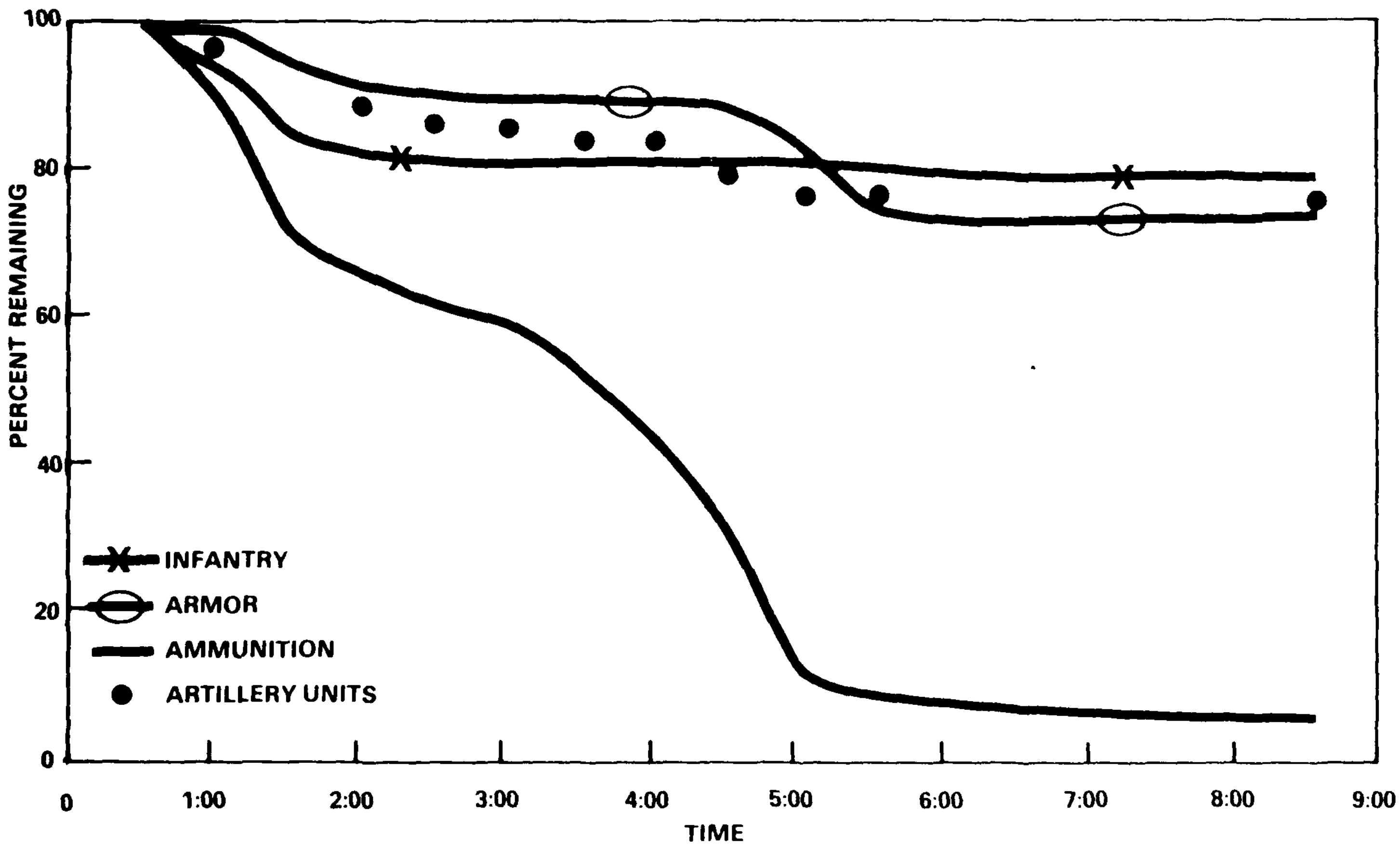
D-1

CASE I
BLUE DIVISION RESOURCES



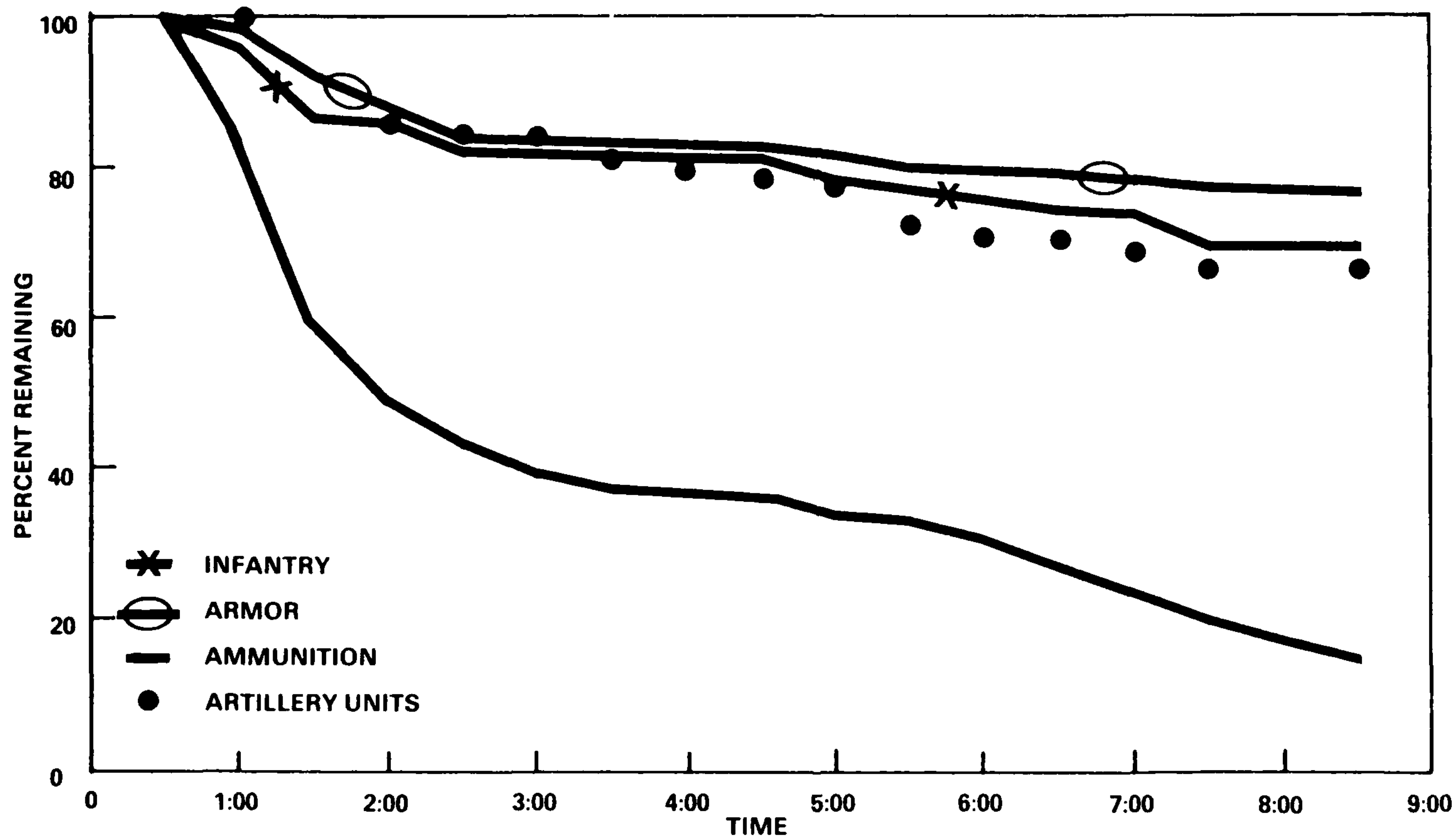
D-2

CASE II
BLUE DIVISION RESOURCES



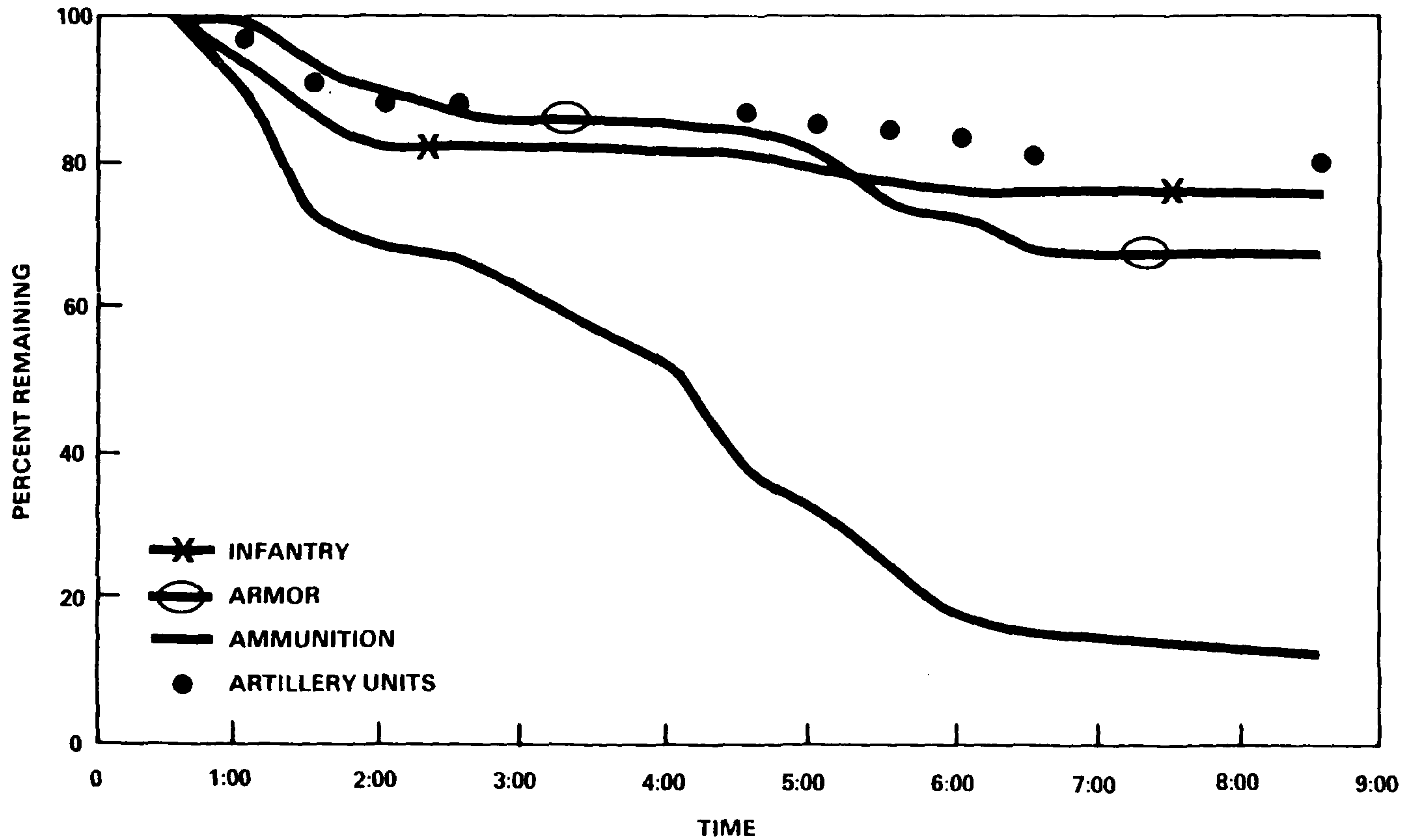
D-3

CASE III
BLUE DIVISION RESOURCES



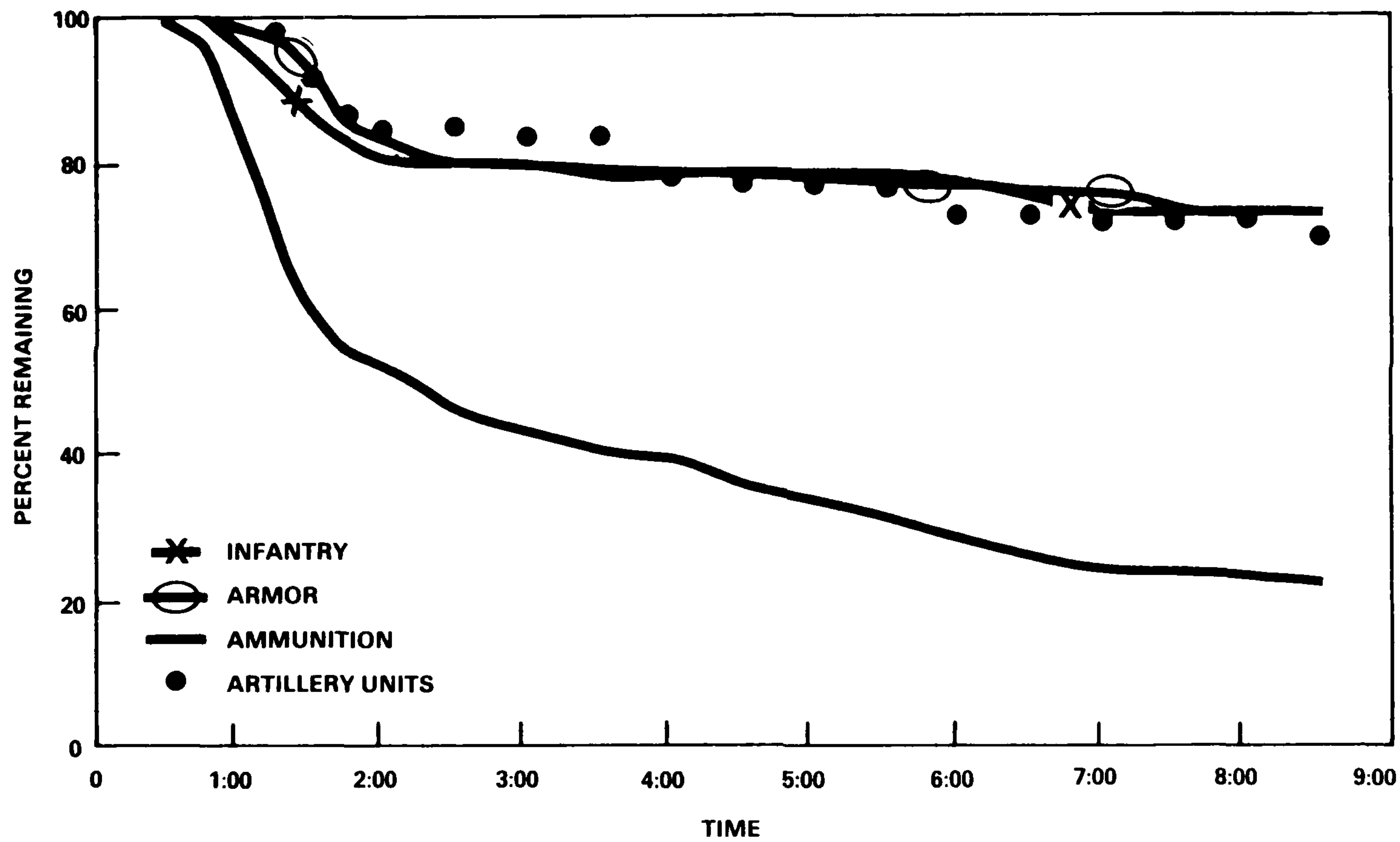
D-4

CASE IV
BLUE DIVISION RESOURCES

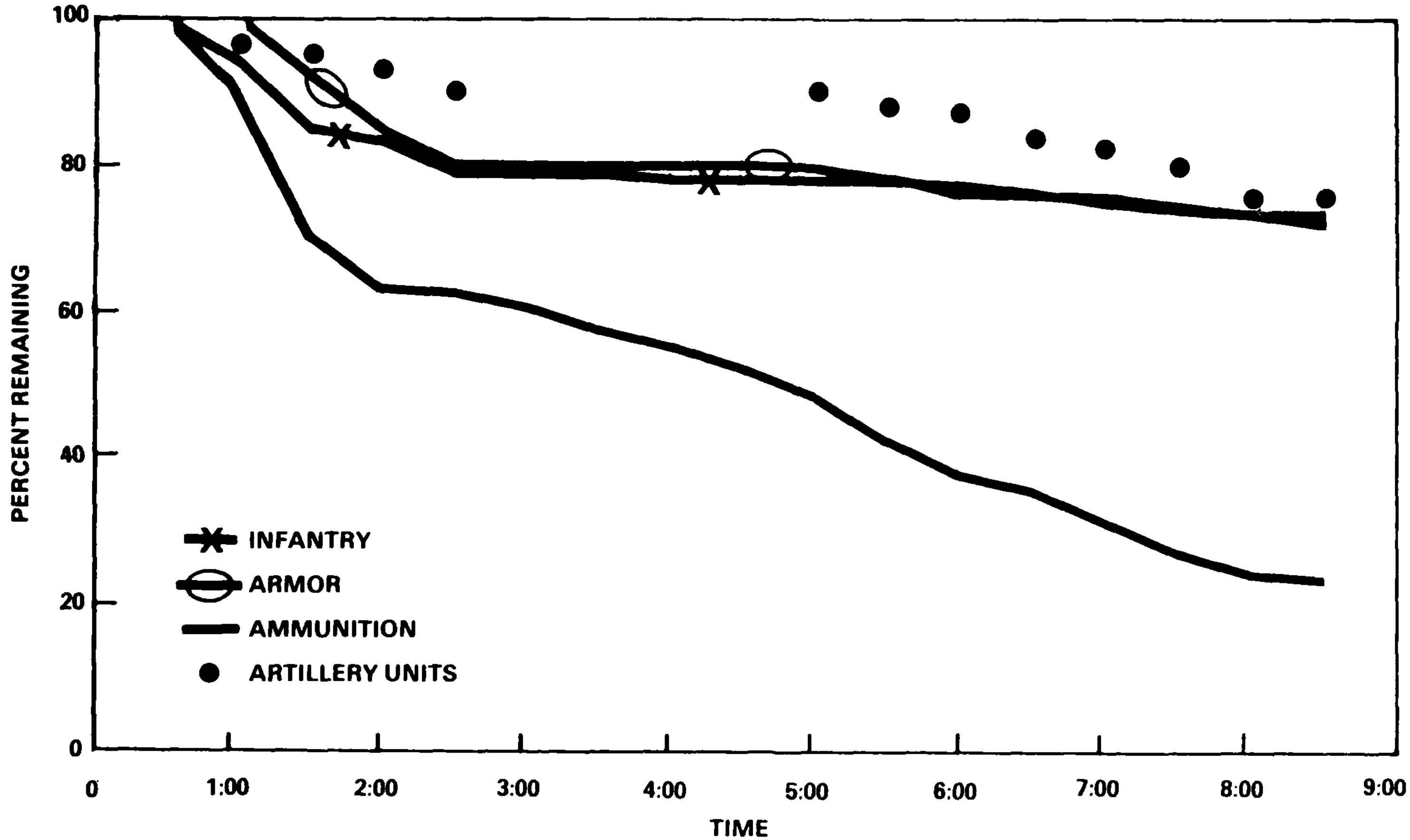


D-5

CASE III-FP
BLUE DIVISION RESOURCES



CASE IV-FP
BLUE DIVISION RESOURCES



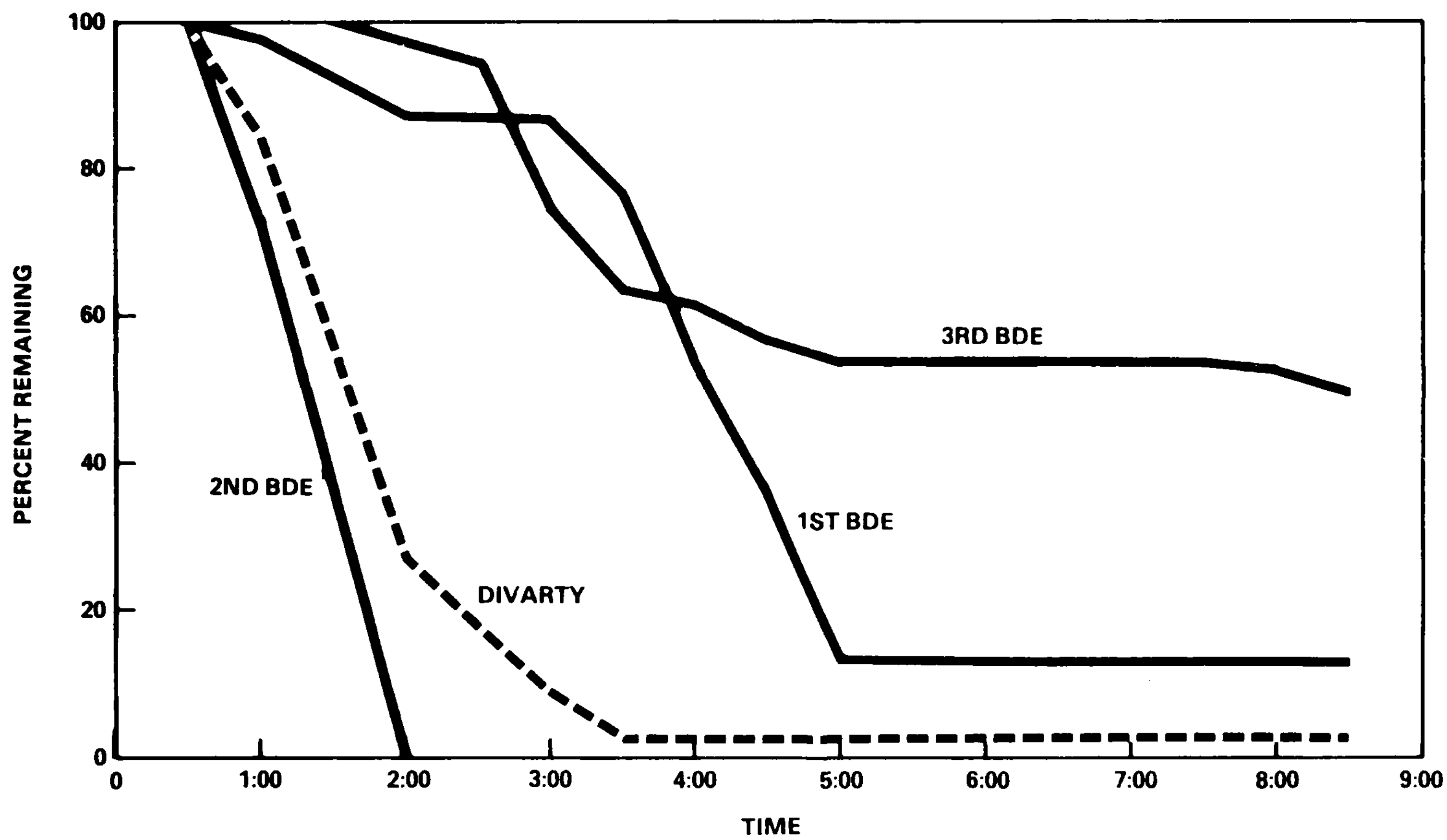
APPENDIX E

BLUE AMMUNITION DRAWDOWN BY BRIGADE

Due to the nature of the Red attack on a very narrow frontage, Blue units engaging in combat and the attendant ammunition expenditure is highly non-uniform over Blue Division assets. The six graphs in this appendix show that effect clearly as well as the expenditure of Blue Division artillery rounds.

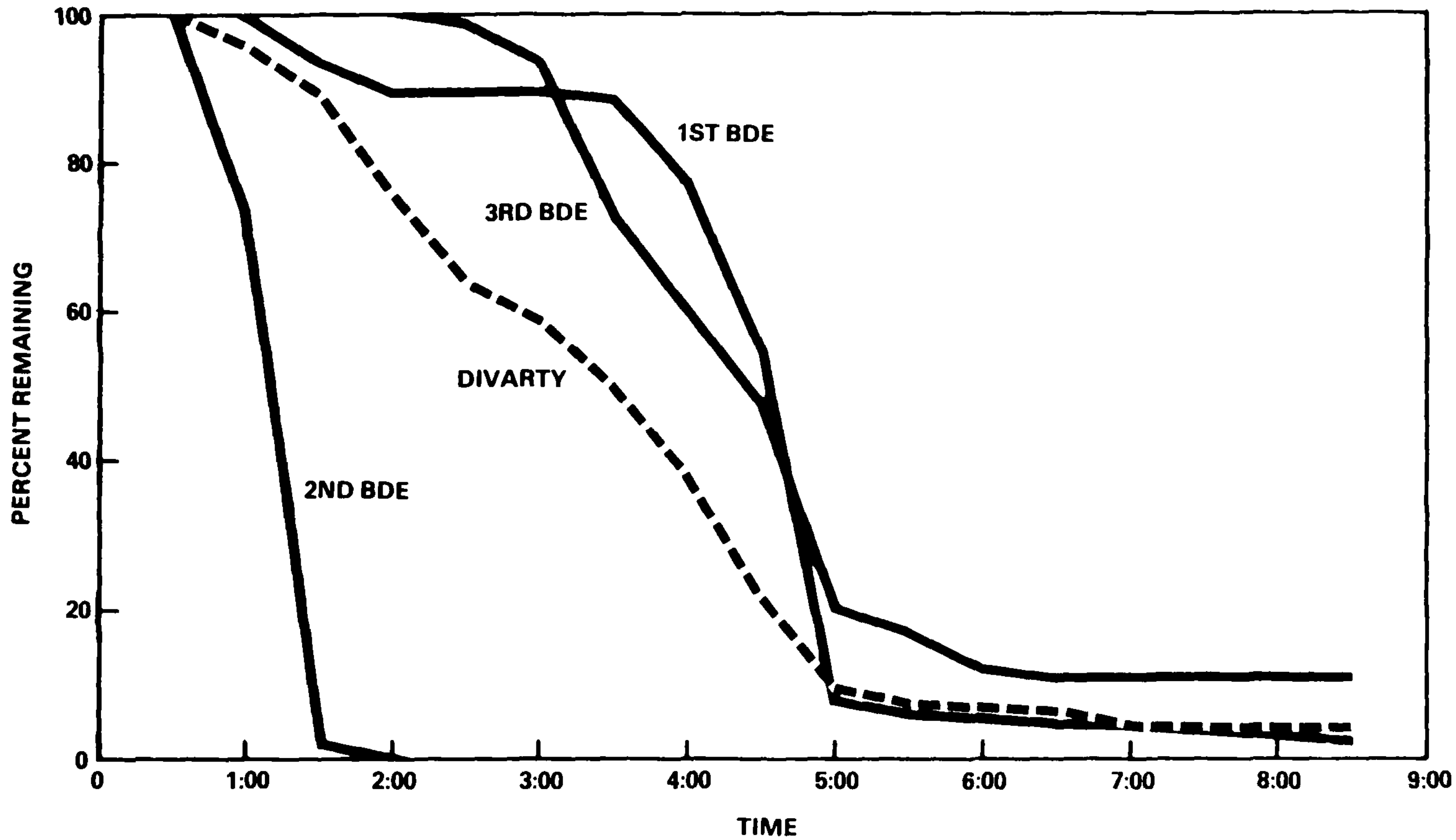
E-1

CASE I
BLUE AMMUNITION

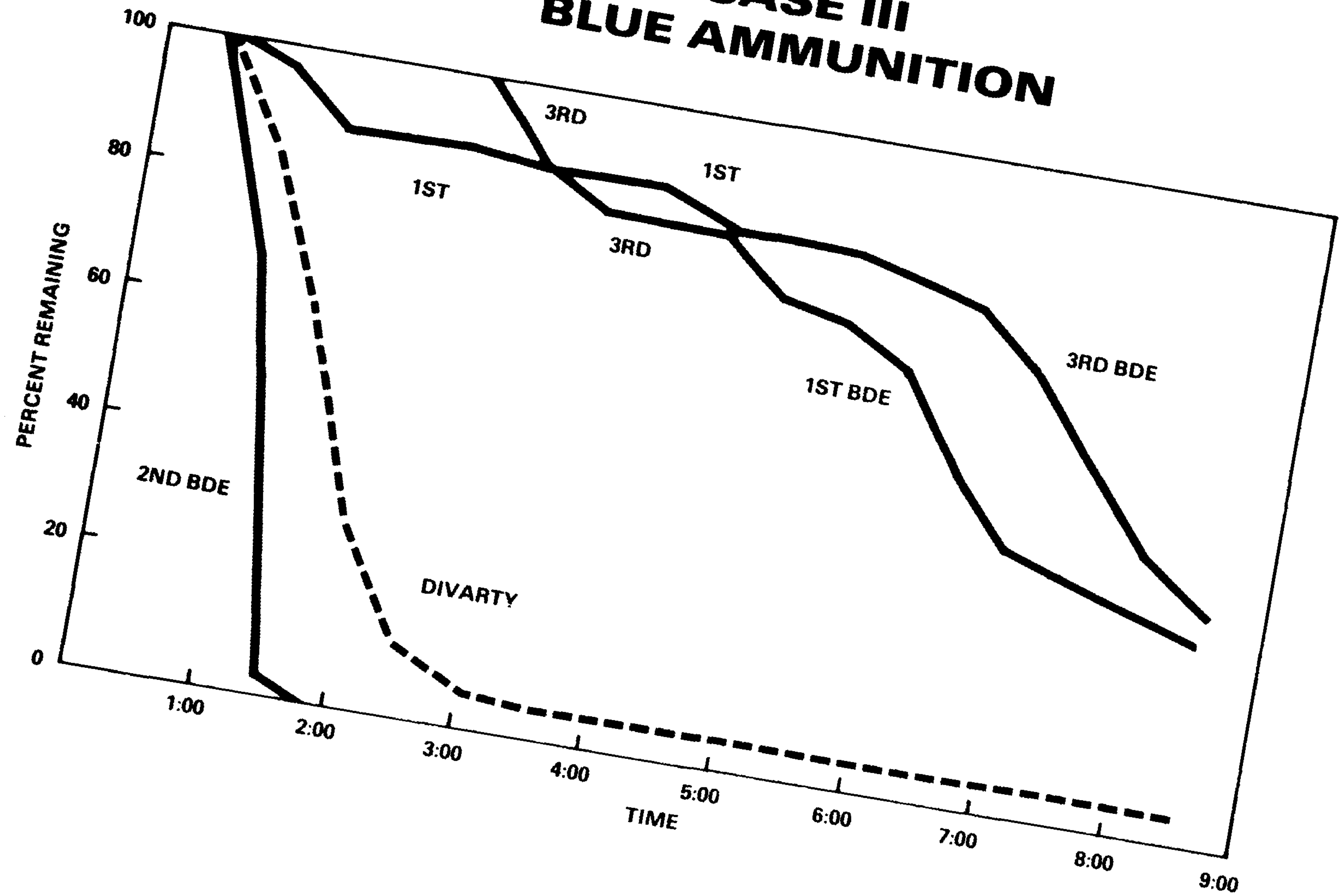


E-2

CASE II
BLUE AMMUNITION

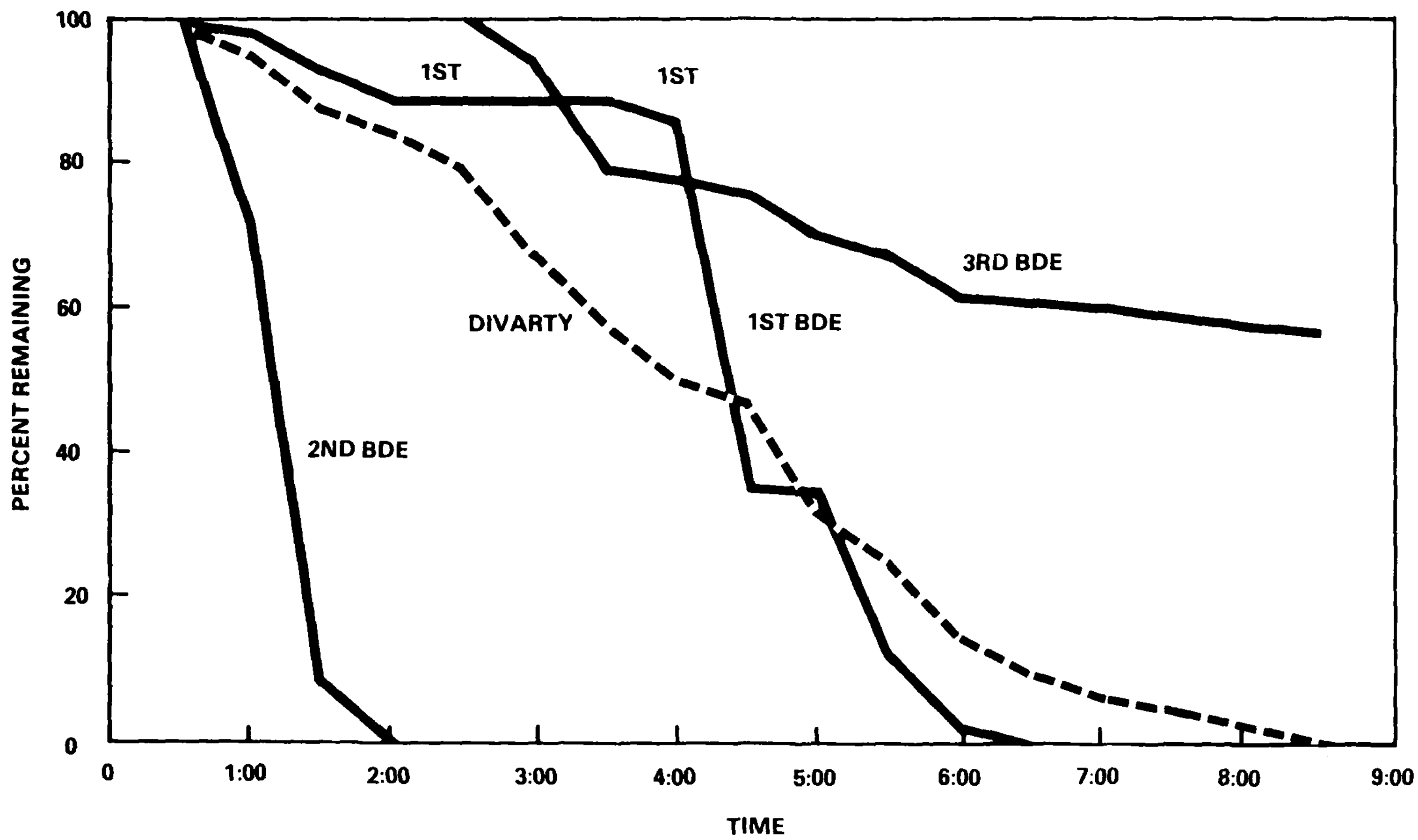


CASE III
BLUE AMMUNITION



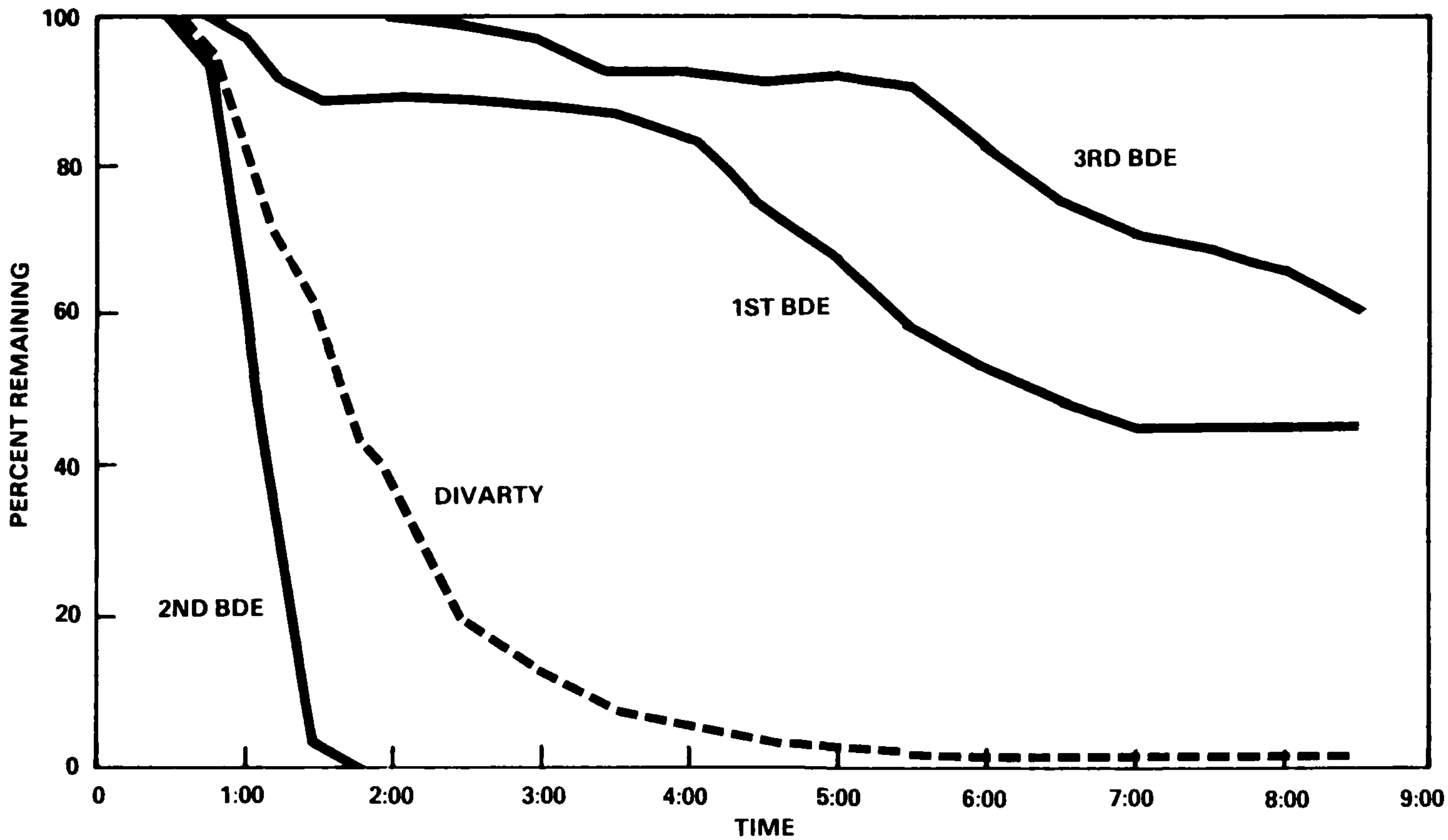
E-4

CASE IV
BLUE AMMUNITION



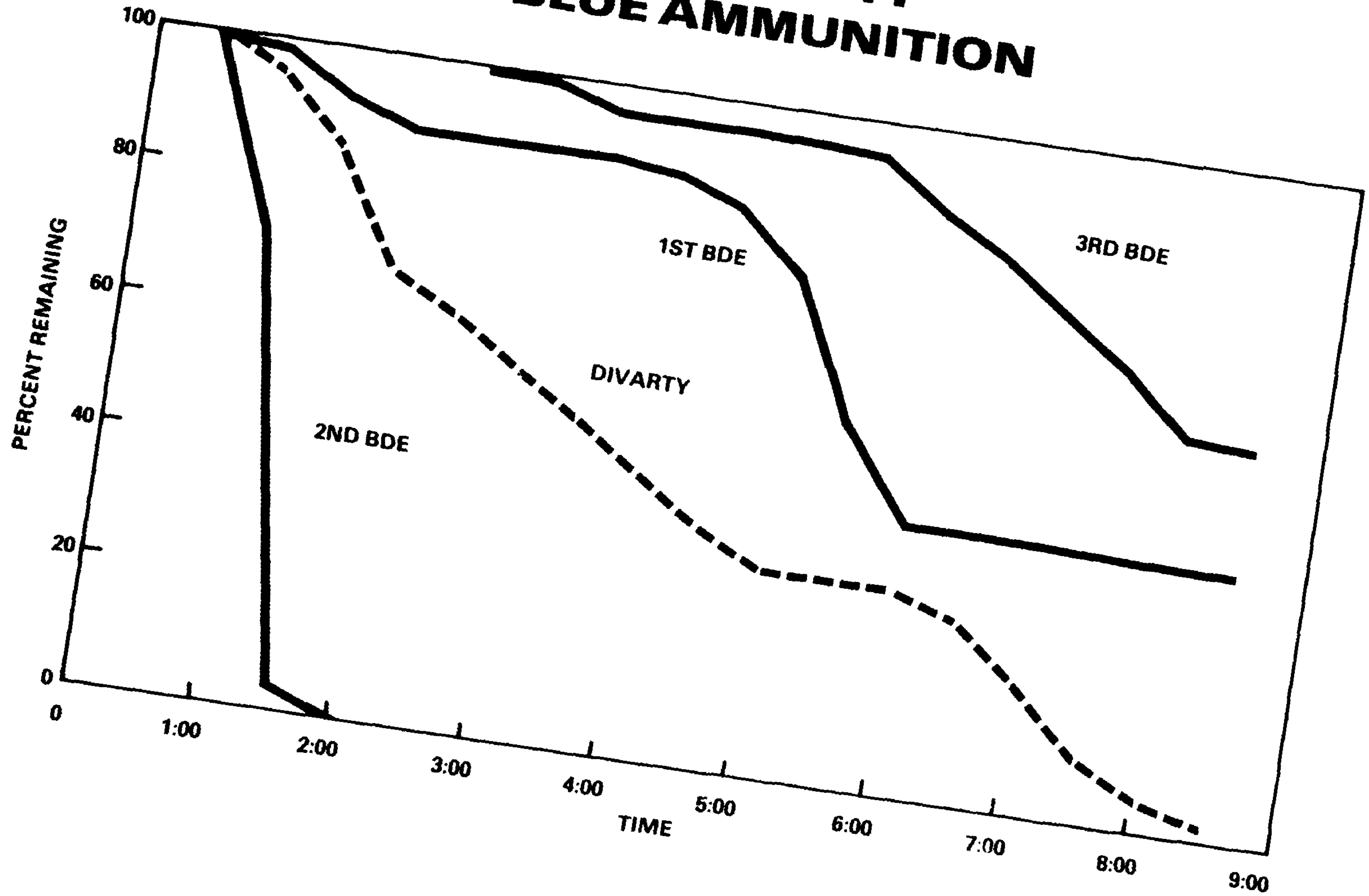
E-5

CASE III-FP
BLUE AMMUNITION



E-6

CASE IV-FP
BLUE AMMUNITION



APPENDIX F

CASE I TACTICAL POSITION MAPS

One of the game history post-processing capabilities developed for the TRACE model was the automatic generation of unit position maps on standard computer printer paper. This feature was used to generate tactical unit position maps at one-half hour intervals for each of the six cases examined. The 18 maps for Case I are presented in this appendix while those for Cases II through IV-FP appear in Appendices G through K respectively. Explanatory information regarding these maps is given in the subsequent paragraphs of this appendix and is applicable to all six Appendices F through K.

The TCOR based family of models employs a hexagonal grid coordinate system. Locations in a hexagonally-tiled plane are specified by the numerical identifier of the hexagon within which the point of interest lies. In the six TRACE cases, the plane (battlefield) is perfectly tiled with 1.35 km diameter hexagons (center-to-center distance between adjacent hexagons is also 1.35 km). The greatest unit location accuracy obtainable, therefore, is to specify that it is within one of these hexagons. TRACE is capable, however, of tiling the plane with 73 meter diameter hexagons at the finest grain and these are referred to as level zero hexes. Any given hexagon is surrounded by six others like itself and these seven taken together constitute a level-of-aggregation. The model allows up to twelve levels of aggregation and we are using the third level as our basic hexagonal tiling of the plane. A level three hex contains roughly the area that would normally be occupied by a Company size unit while level four a battalion and level five a brigade.

The post-processor will plot unit positions using any hex level and hexagonal grids at any other level as long as the lowest level used in the game is not exceeded (not less or smaller than the game level). The unit position maps that we will see in these appendices were plotted at level three accuracy (the greatest available) and have a level five hexagonal grid superimposed on them. The level five hexagonal grid system is shown in Figure F-1 along with a legend tht identifies the actual hexagonal address of each brigade size hexagon. Figure F-2 presents a table that allows one to determine the latitude and longitude coordinates of the center of each hexagon in the grid.

Letters of the alphabet for the Blue side and numerals for Red are used to identify unit locations on the position maps. The particular letter or numeral used is related to the type of unit being located as shown in Figure F-3. Note also in Figure F-3 that level three units are being plotted and hence each letter/numeral represents a company/battery size unit.

If several units are clustered in a small geographic area, the plot scale selected may not allow a symbol to be plotted for all of the units at that location. The units that are plotted is based simply on "first-encountered first-plotted" as they occur on the game history file. Dead units are not plotted at all but neutralized units are. The information given in Figure F-1, F-2, and F-3 are always the first three pages of output for any post-game plotting request.

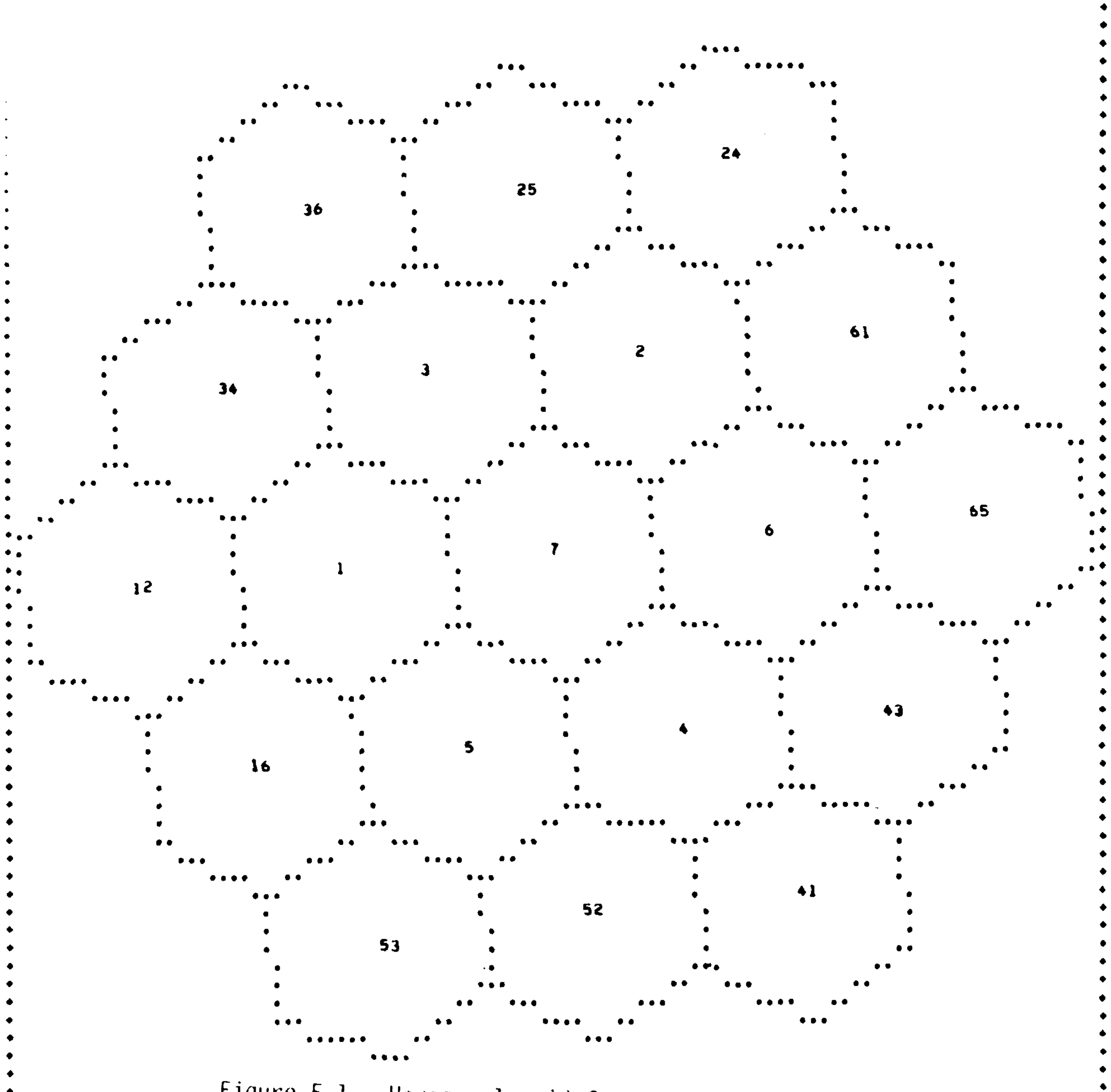


Figure F-1. Hexagonal grid for tactical position maps

TABLE RELATING THE LATITUDE AND LONGITUDE FOR
A GIVEN HEX ADDRESS FOR BRIGADE SIZE HEXES

LEGEND NUMBER	HEX ADDRESS	(DEG) LATITUDE	(DEG) LONGITUDE	LEVEL
2	7777611	50.810	9.723	5
3	7777722	50.802	9.589	5
4	7777763	50.663	9.744	5
5	7777724	50.655	9.611	5
6	7777615	50.741	9.800	5
7	7777726	50.733	9.667	5
12	7777721	50.716	9.400	5
16	7777725	50.647	9.478	5
24	7777613	50.888	9.779	5
25	7777244	50.880	9.645	5
34	7777723	50.794	9.455	5
36	7777245	50.872	9.511	5
41	7777767	50.594	9.822	5
43	7777762	50.671	9.878	5
52	7777761	50.586	9.689	5
53	7777772	50.577	9.555	5
61	7777617	50.819	9.857	5
65	7777614	50.749	9.934	5

Figure F-2. Coordinate conversion table for hex maps

```
THE FOLLOWING ARE SNAPSHOTS FROM          0 TO     36000.
OF EVERY  1 TIME POINTS


 3 LEVEL UNITS ARE DISPLAYED
                   SYMBOLS
                 BLUE   UNIT   RED
                   A     HQ     1
                   B     INF    2
                   C     ART    3
                   D     TNK    4
                   E     REC    5
                   F    MISC    6
```

Figure F-3. Position map ploting symbology

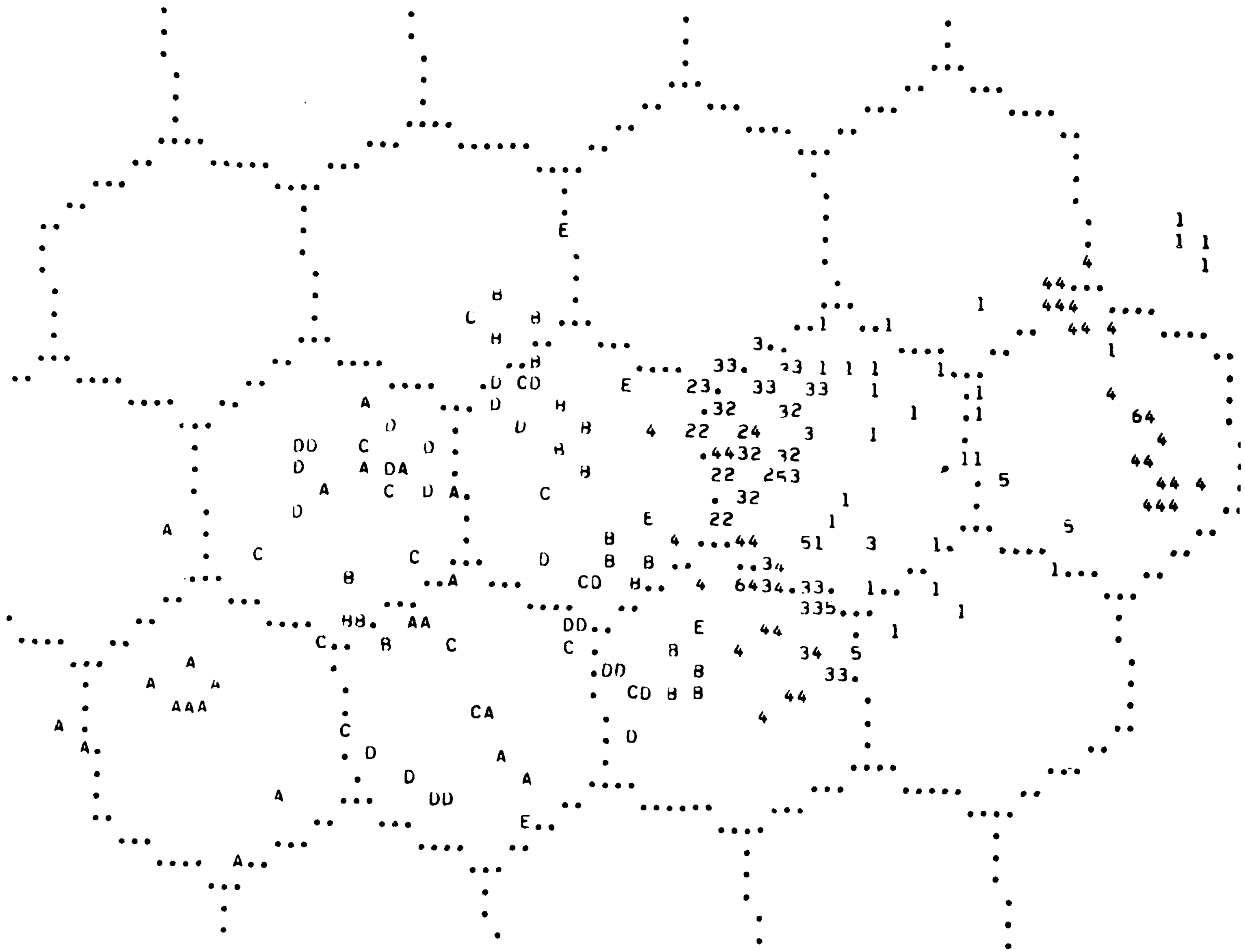


Figure F-4. Case I unit positions at 00:00 hours.

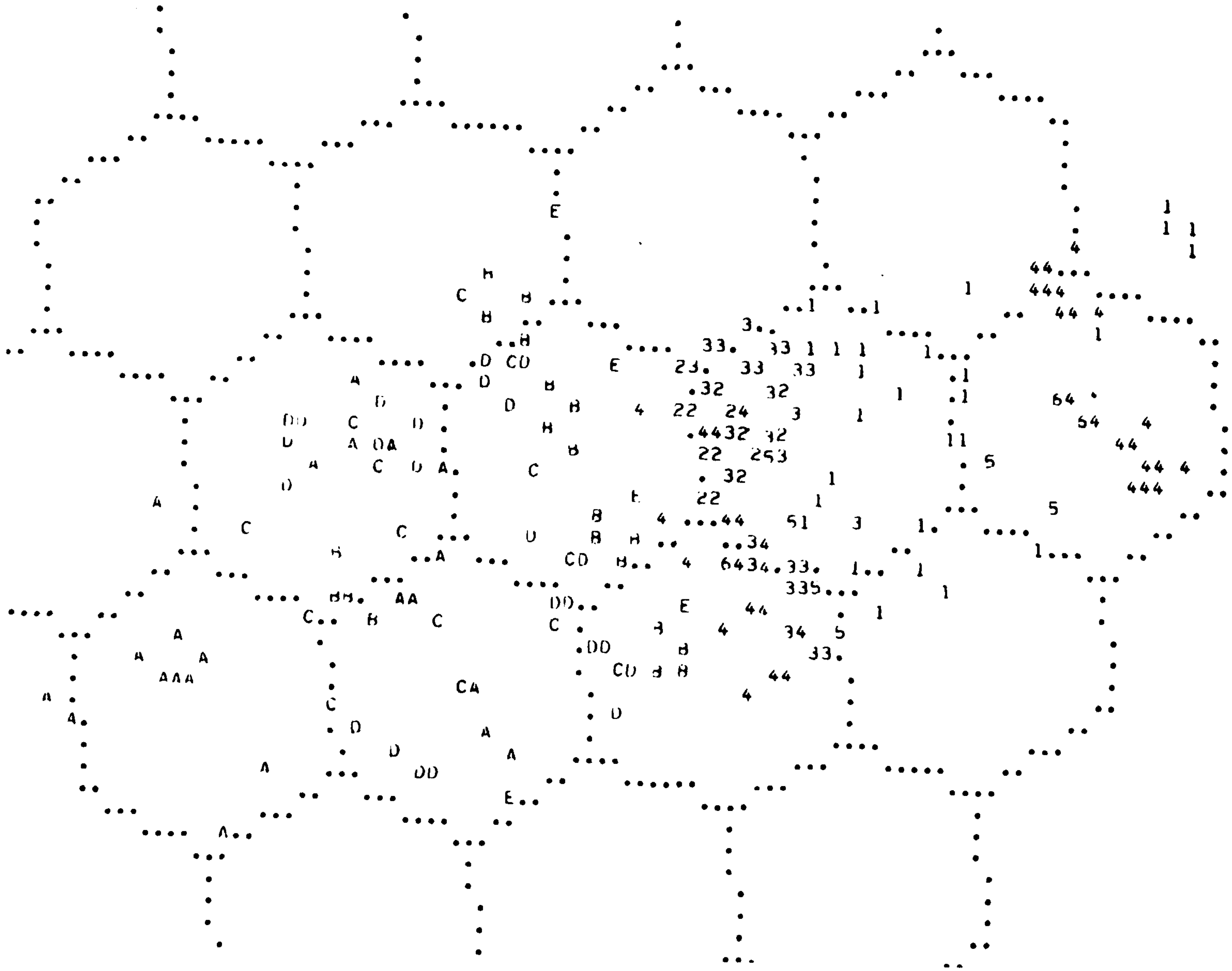


Figure F-5. Case I unit positions at 00:30 hours.

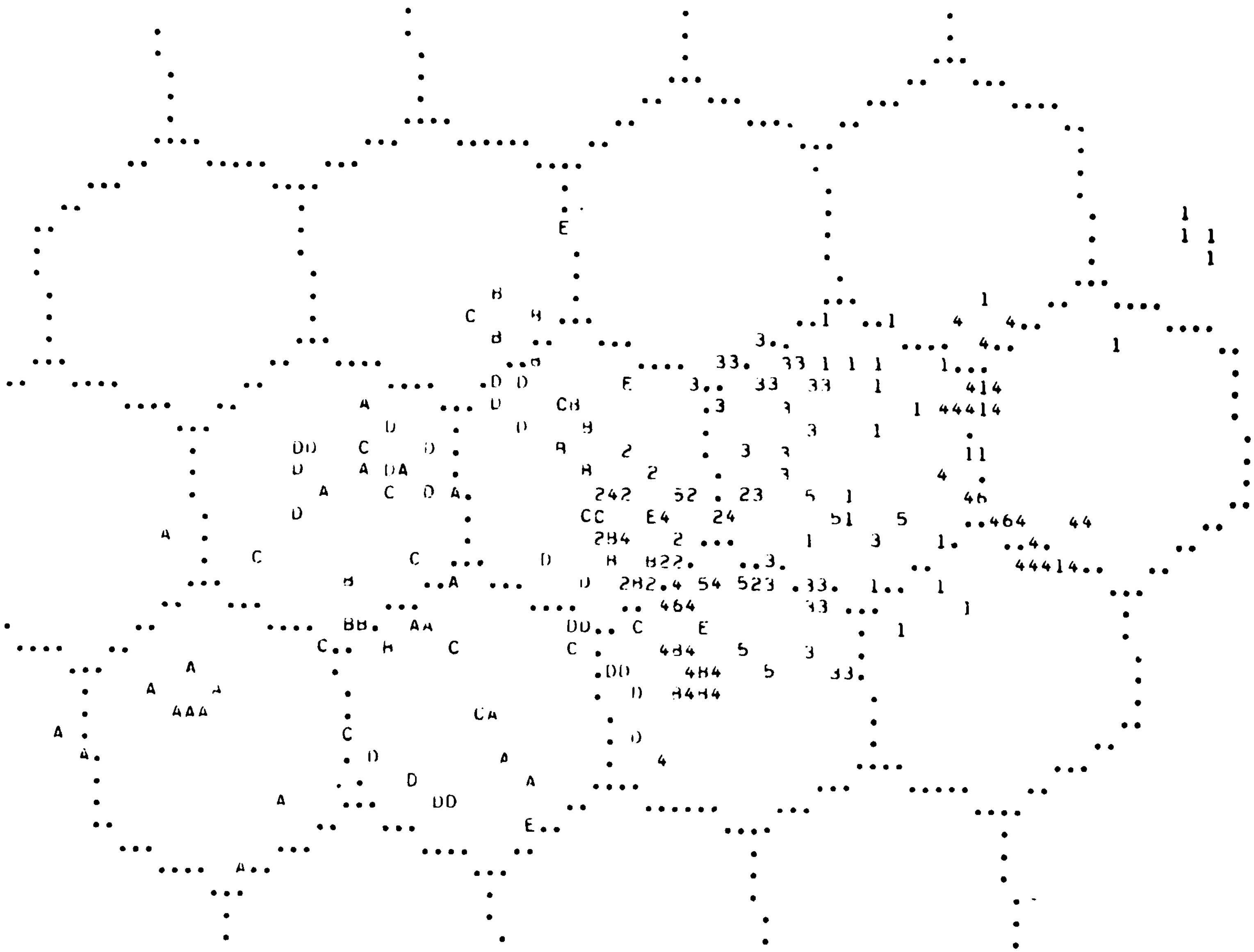


Figure F-6. Case I unit positions at 01:00 hours.

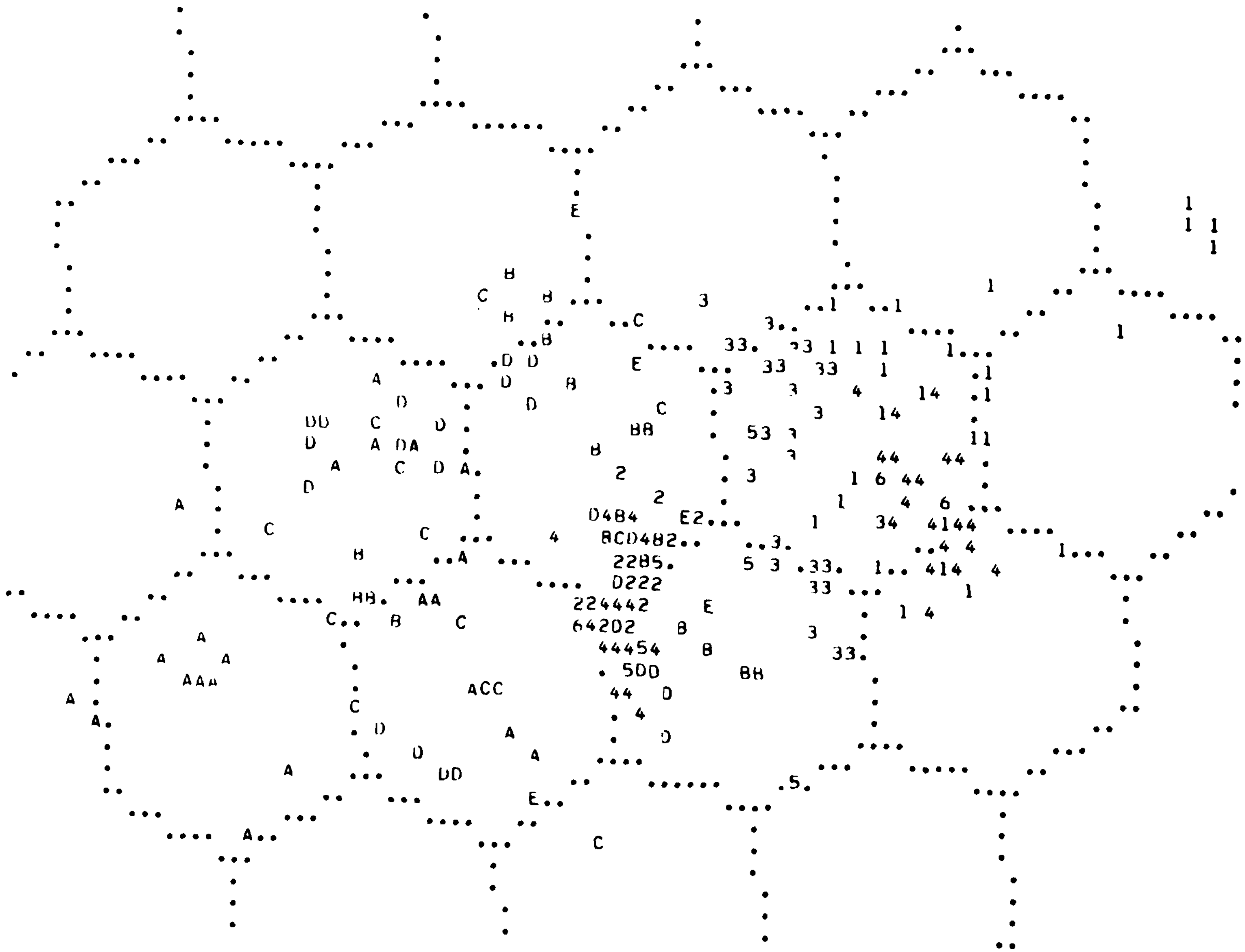


Figure F-7. Case I unit positions at 01:30 hours.

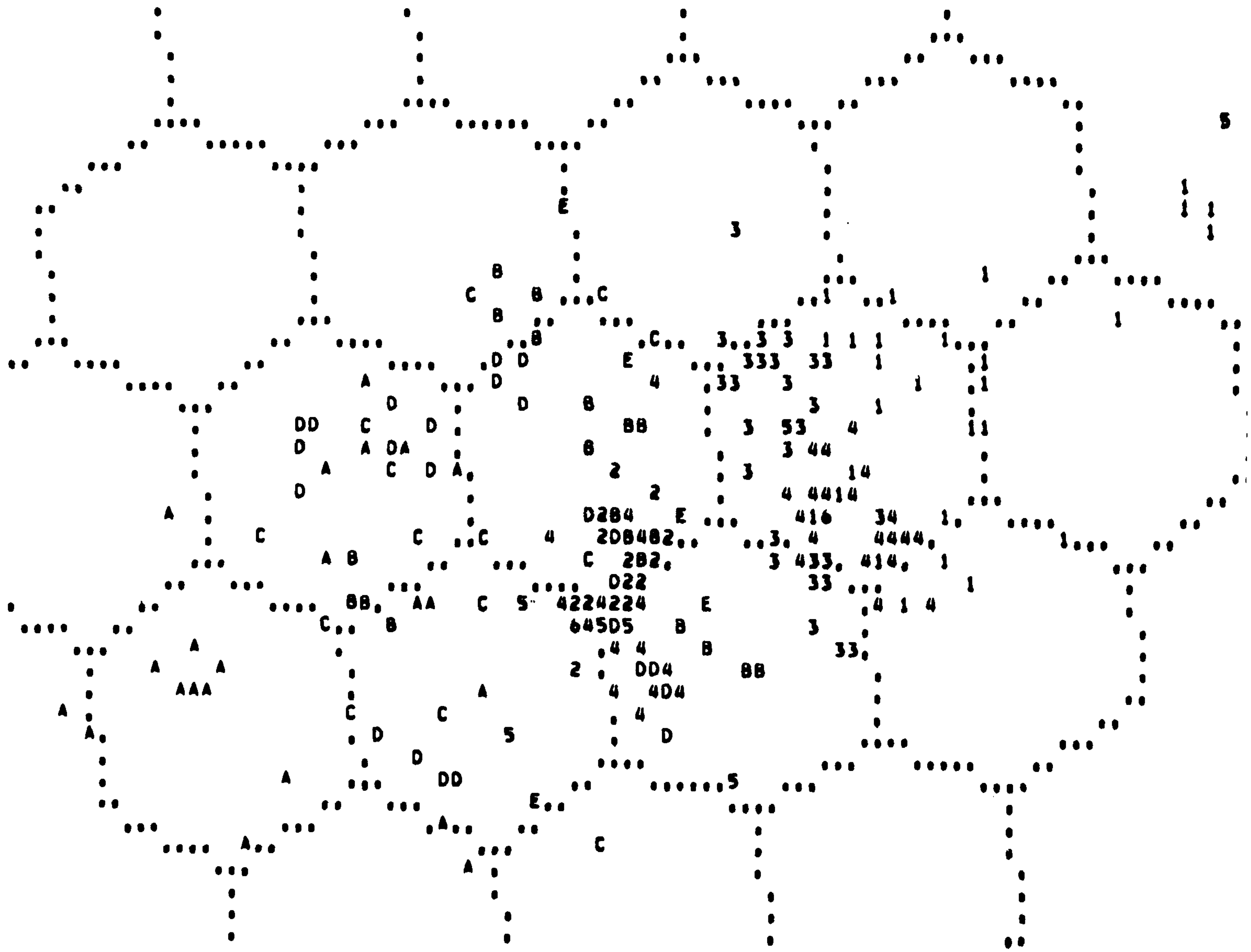


Figure F-8. Case I unit positions at 02:00 hours.

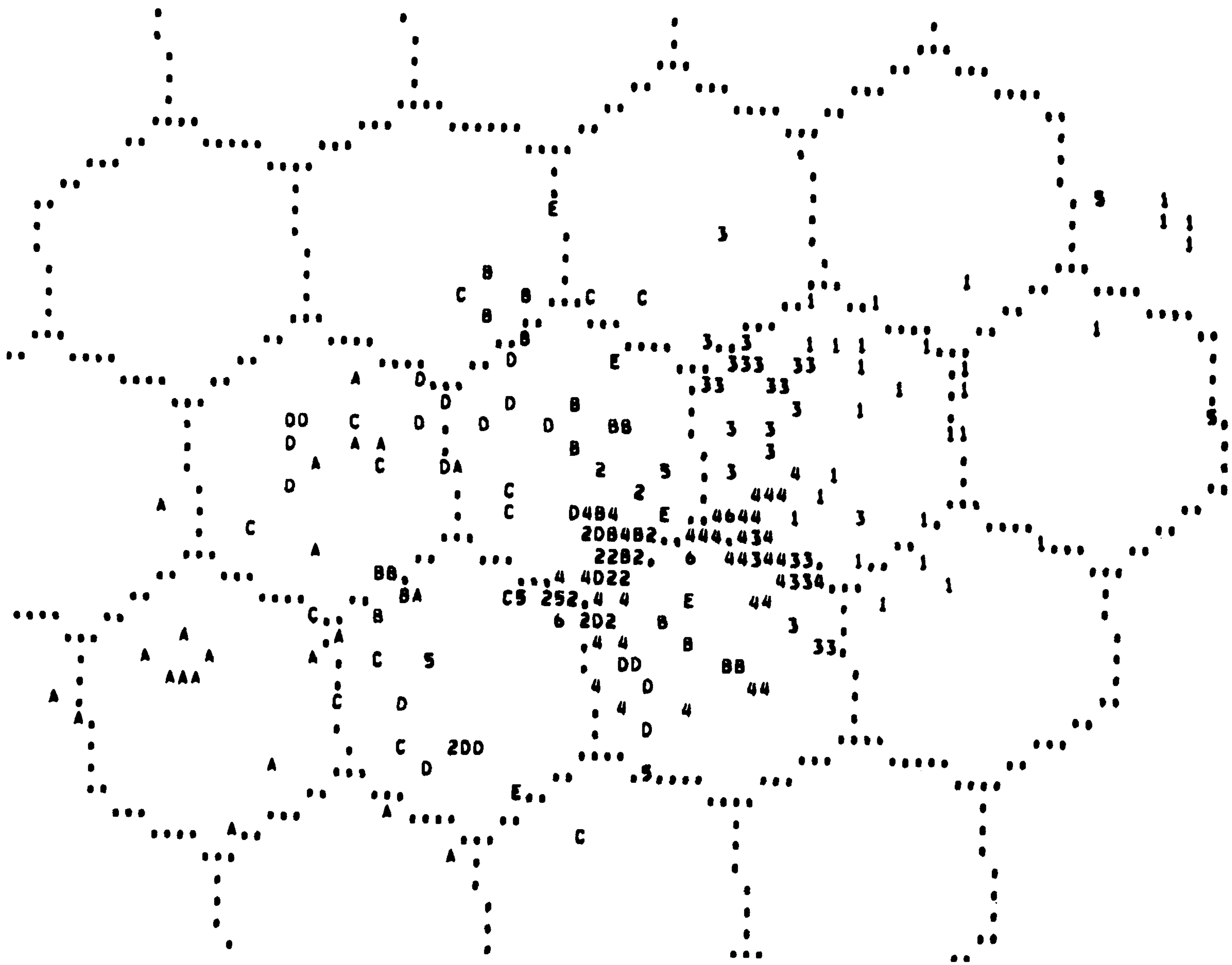


Figure F-9. Case I unit positions at 02:30 hours.

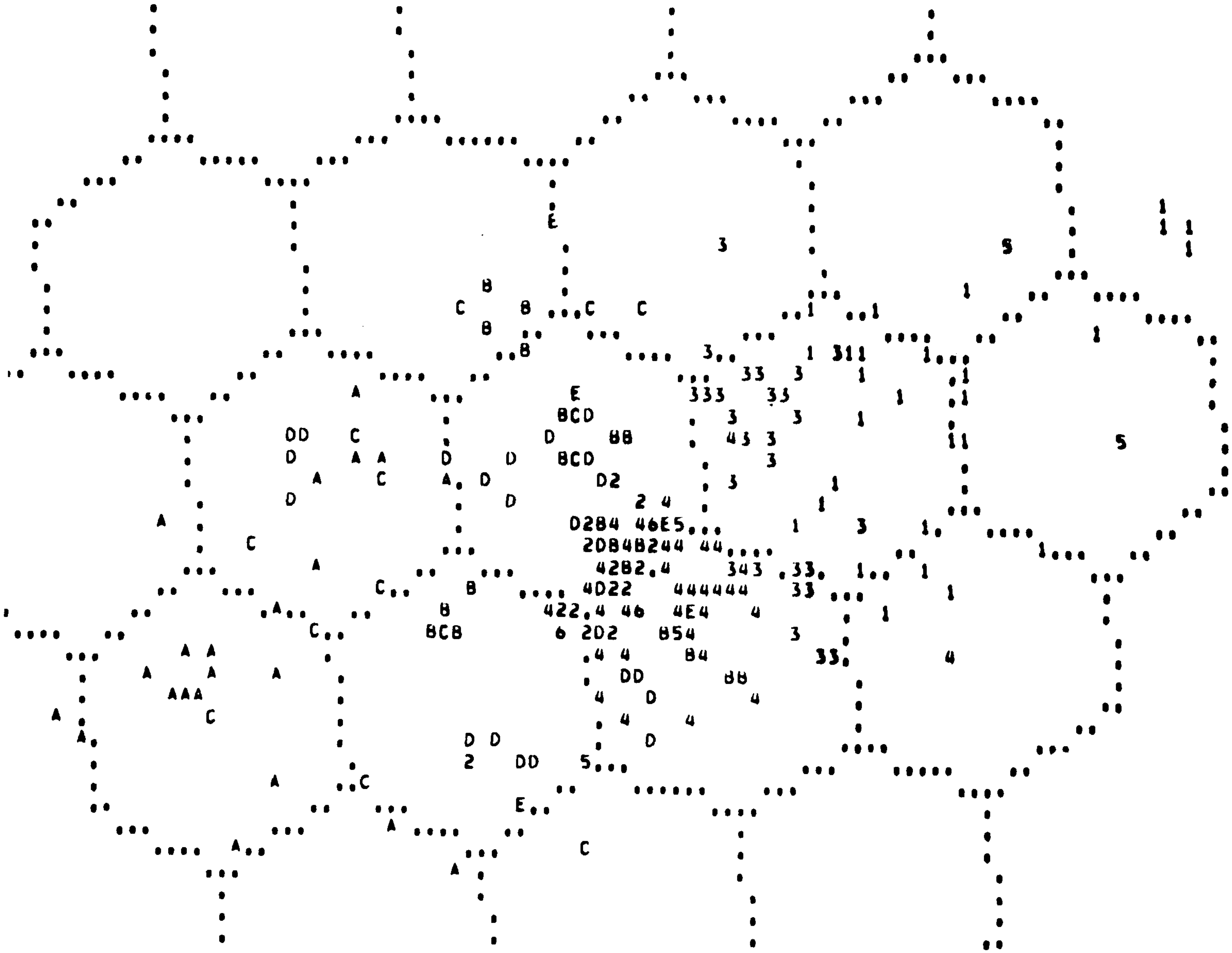


Figure F-10. Case I unit positions at 03:00 hours.

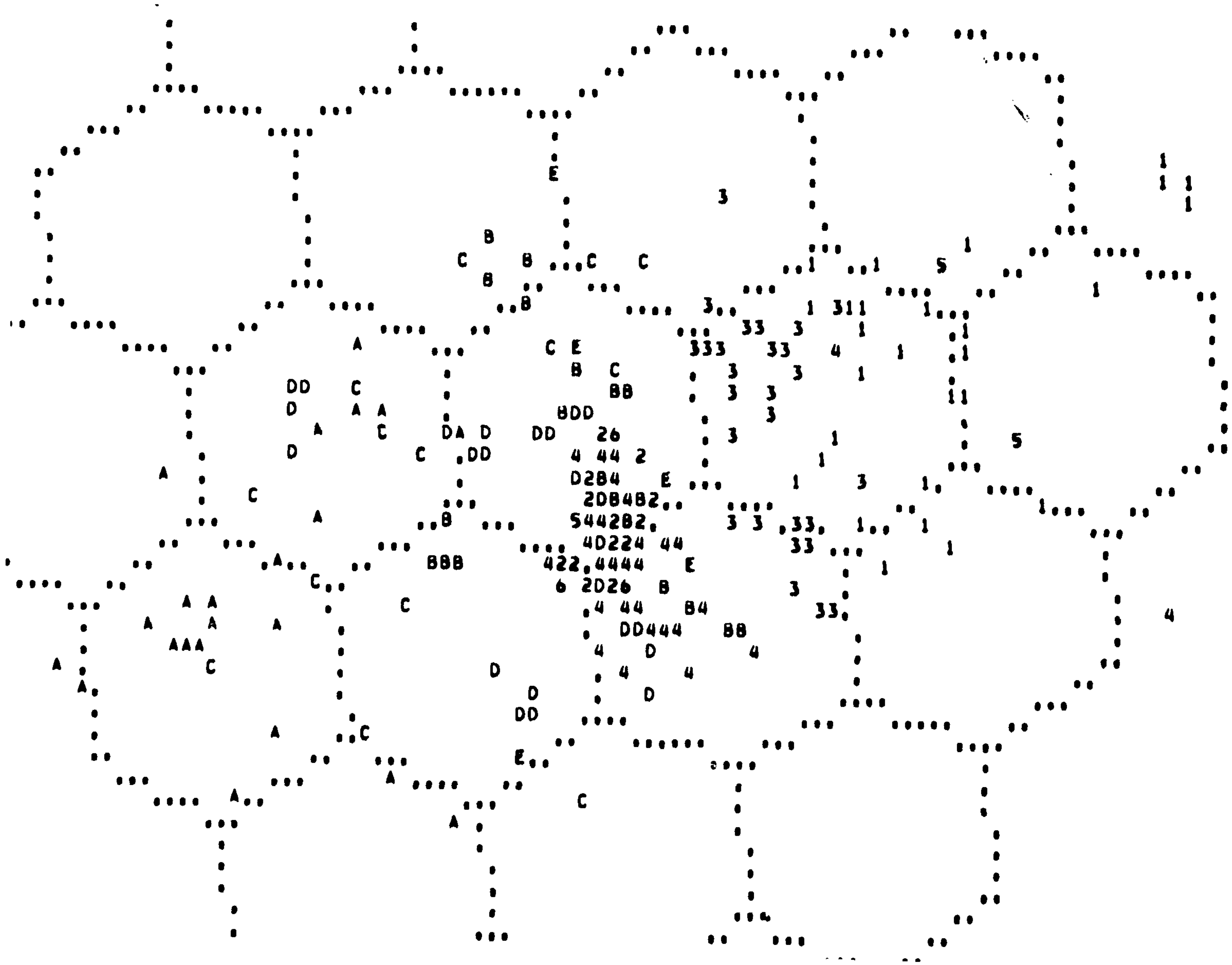


Figure F-11. Case I unit positions at 03:30 hours.

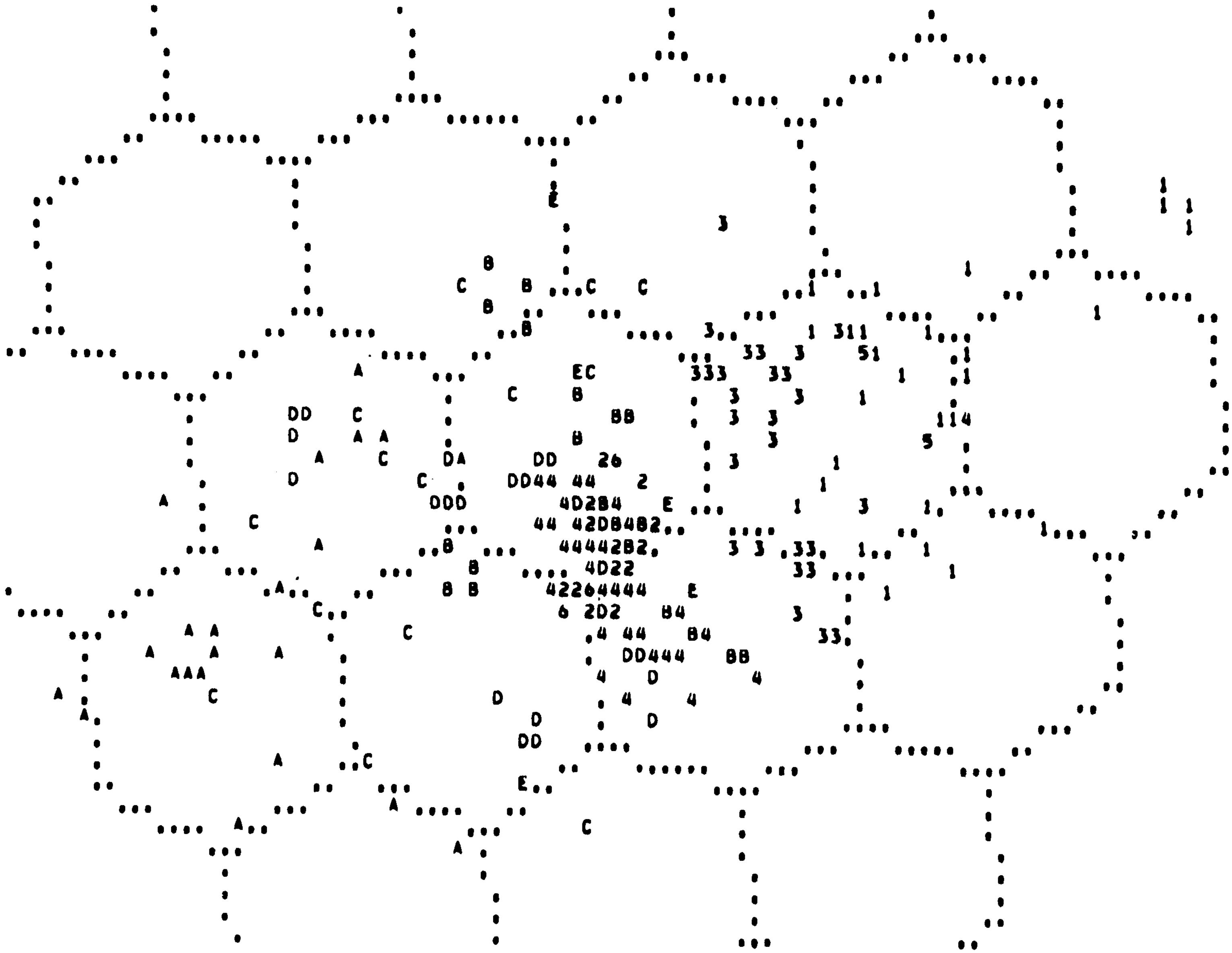


Figure F-12. Case I unit positions at 04:00 hours.

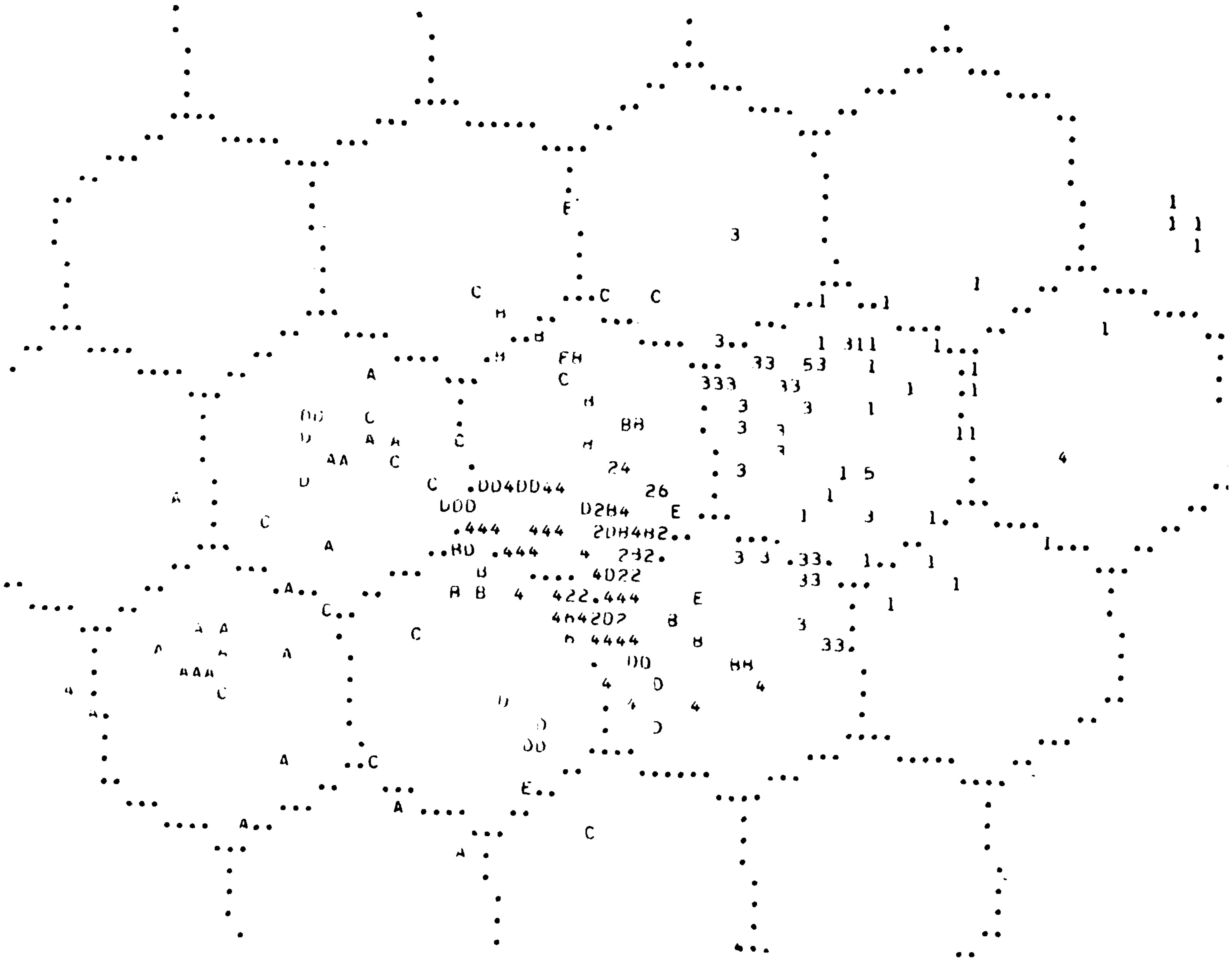


Figure F-13. Case I unit positions at 04:30 hours.

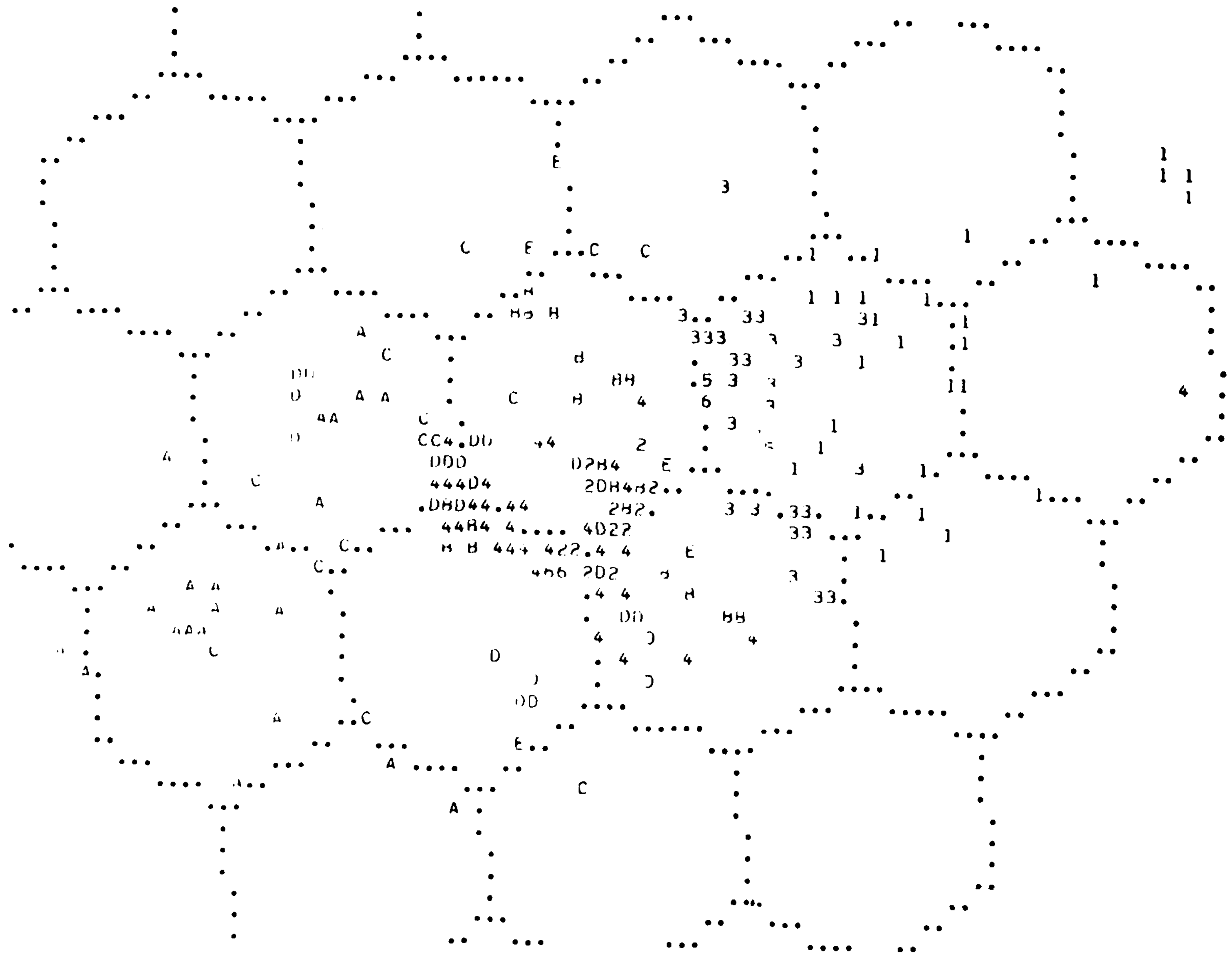
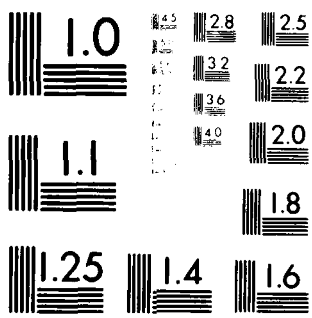


Figure F-14. Case I unit positions at 05:00 hours.

AD-A089 723 BDM CORP MCLEAN VA F/G 17/2
DEVELOPMENT AND IMPLEMENTATION OF TCOR COMMO.(U)
FEB 80 D L PORTER, R L ROTHROCK, R H SCHMIDT DNA001-78-C-0175
UNCLASSIFIED BDM/W-80-055-TR DNA-5238F NL

3 of 4
AD
A089 723



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963-A

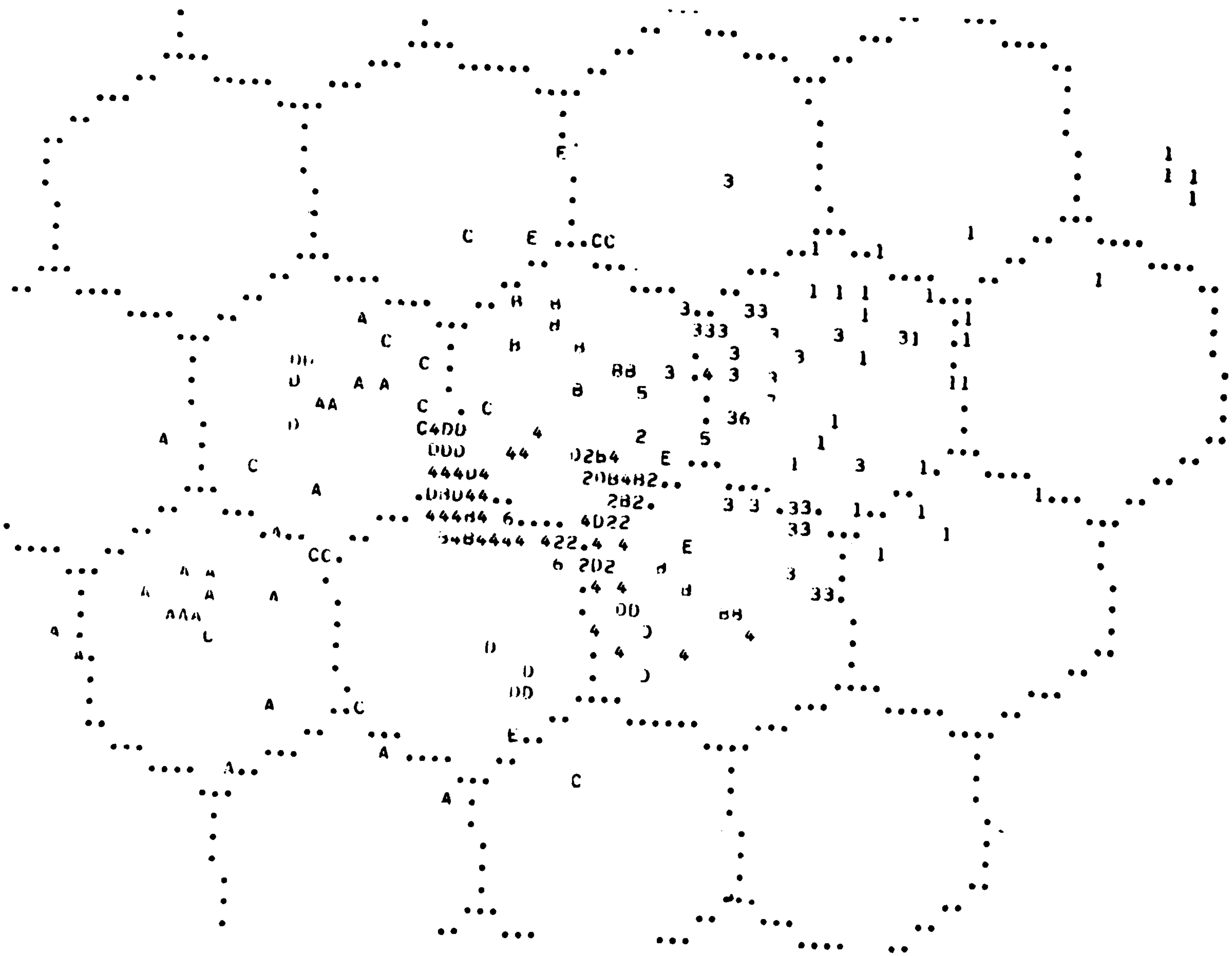


Figure F-15. Case I unit positions at 05:30 hours.

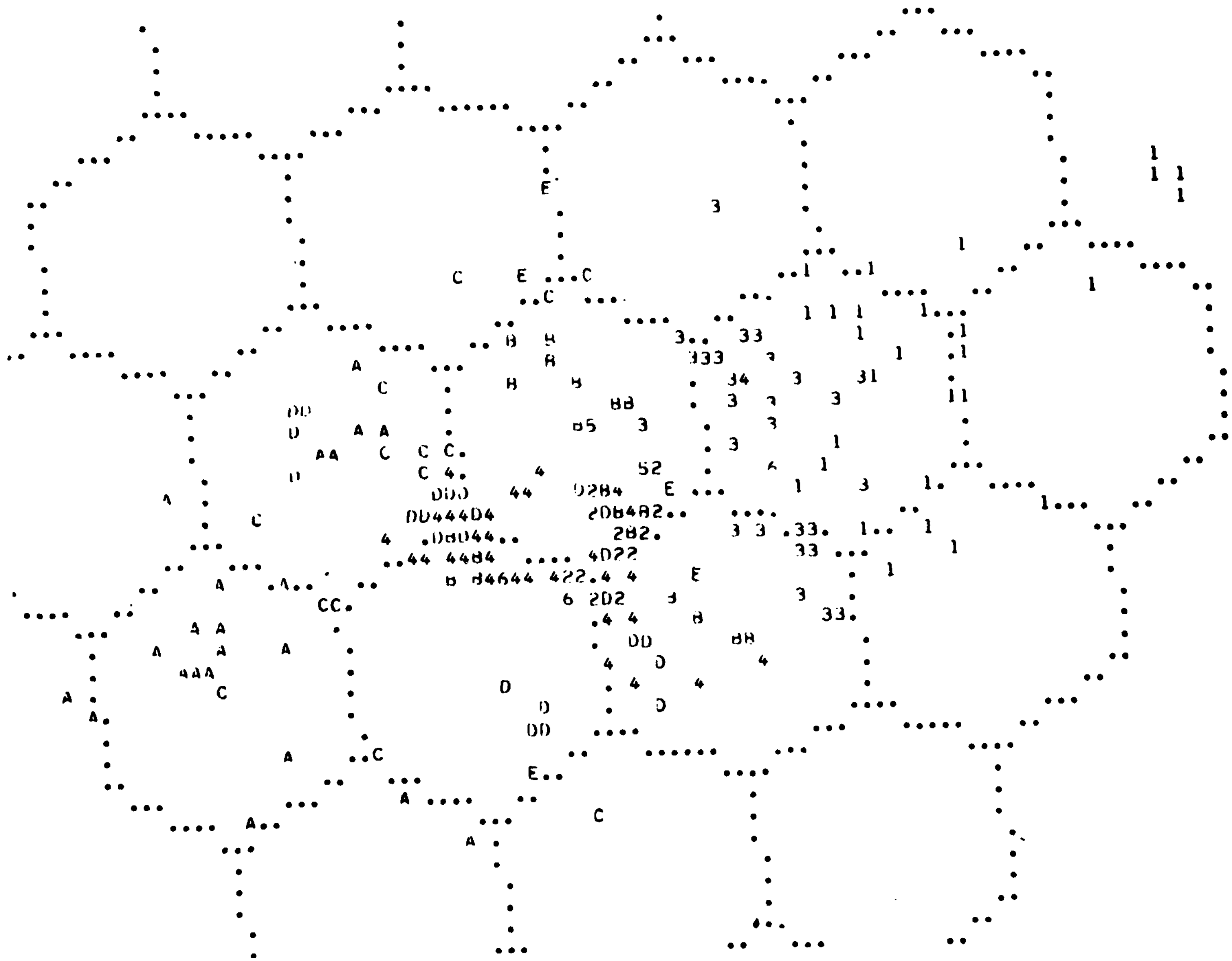


Figure F-16. Case I unit positions at 06:00 hours.

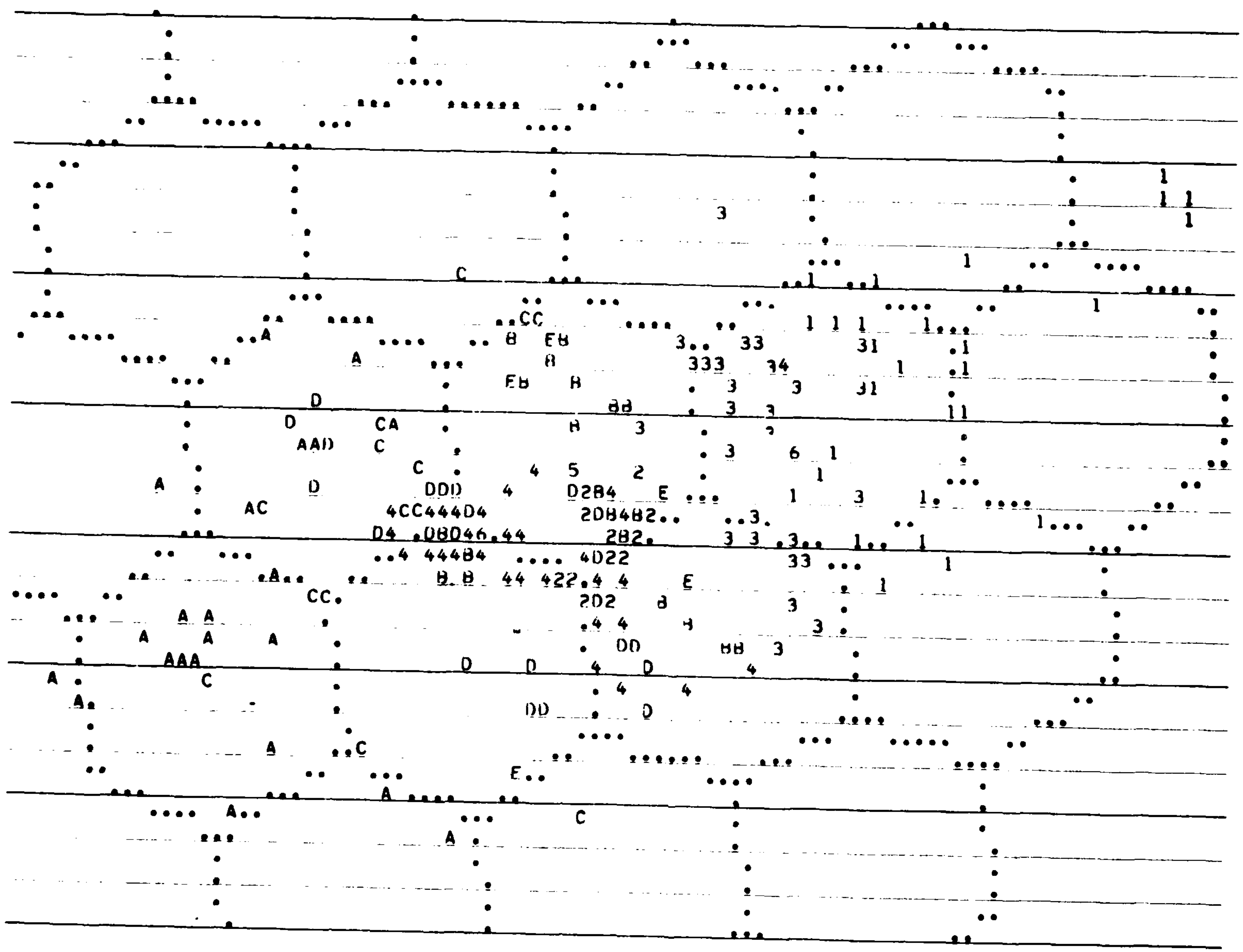


Figure F-17. Case I unit positions at 06:30 hours.

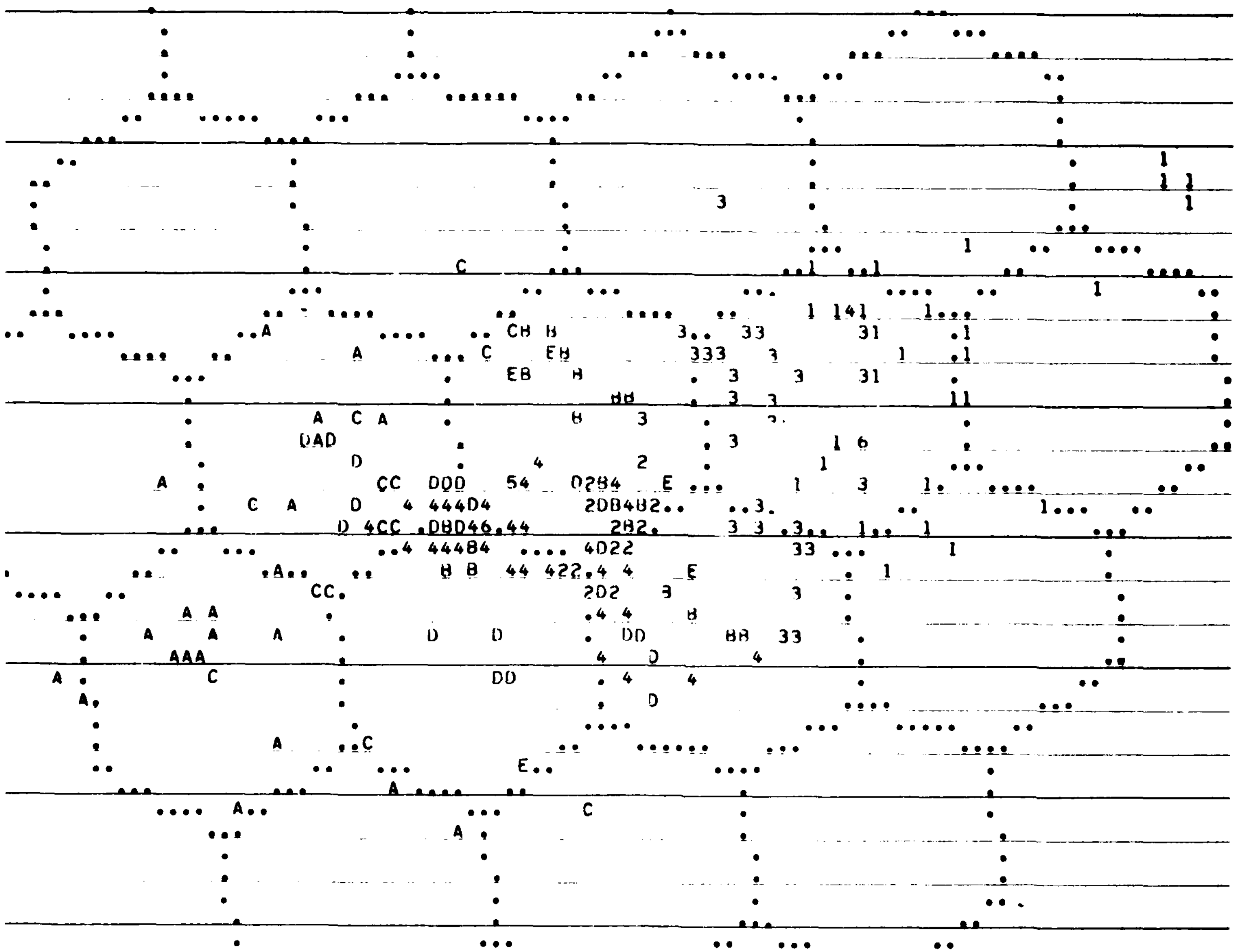


Figure F-18. Case I unit positions at 07:00 hours.

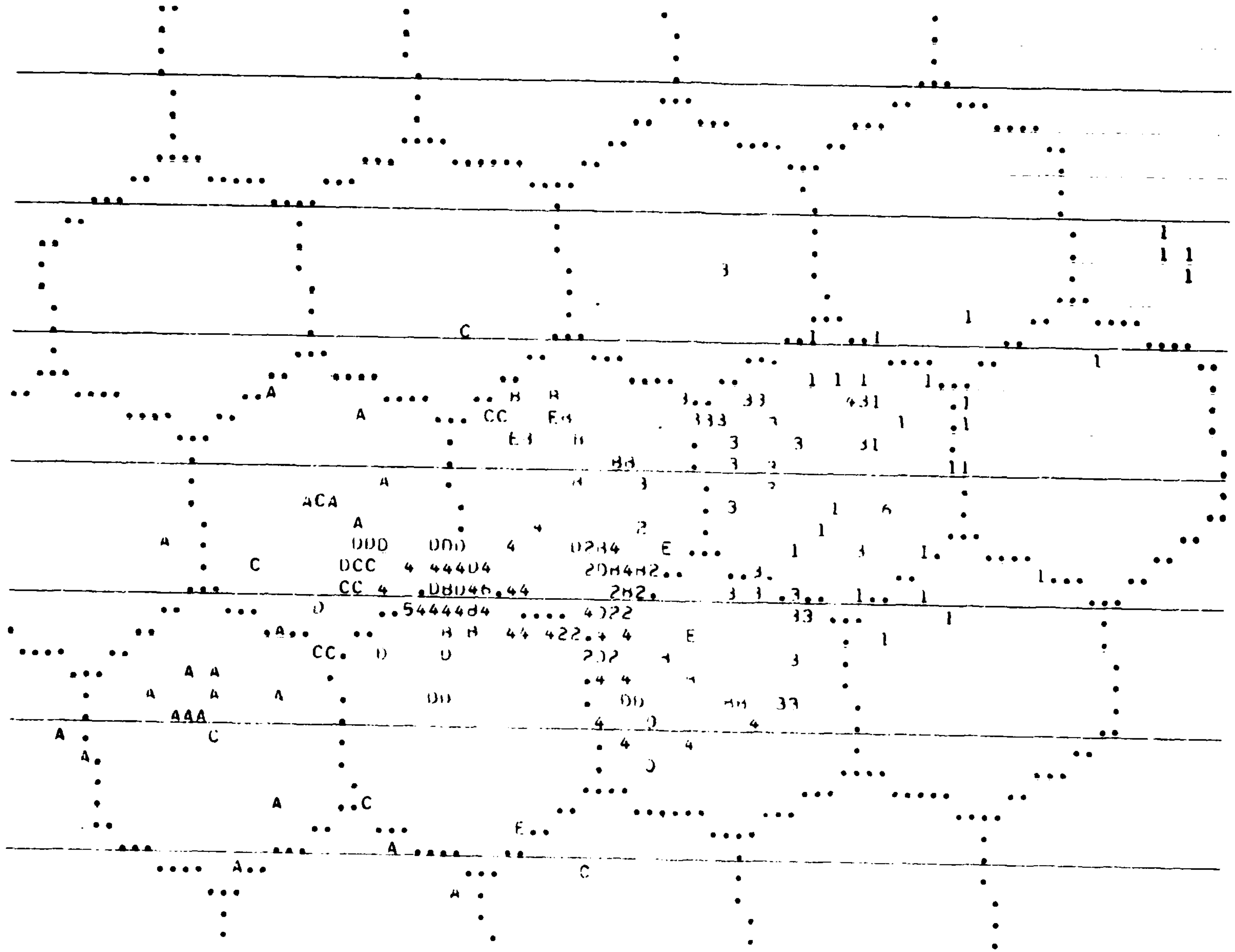


Figure F-19. Case I unit positions at 07:30 hours.

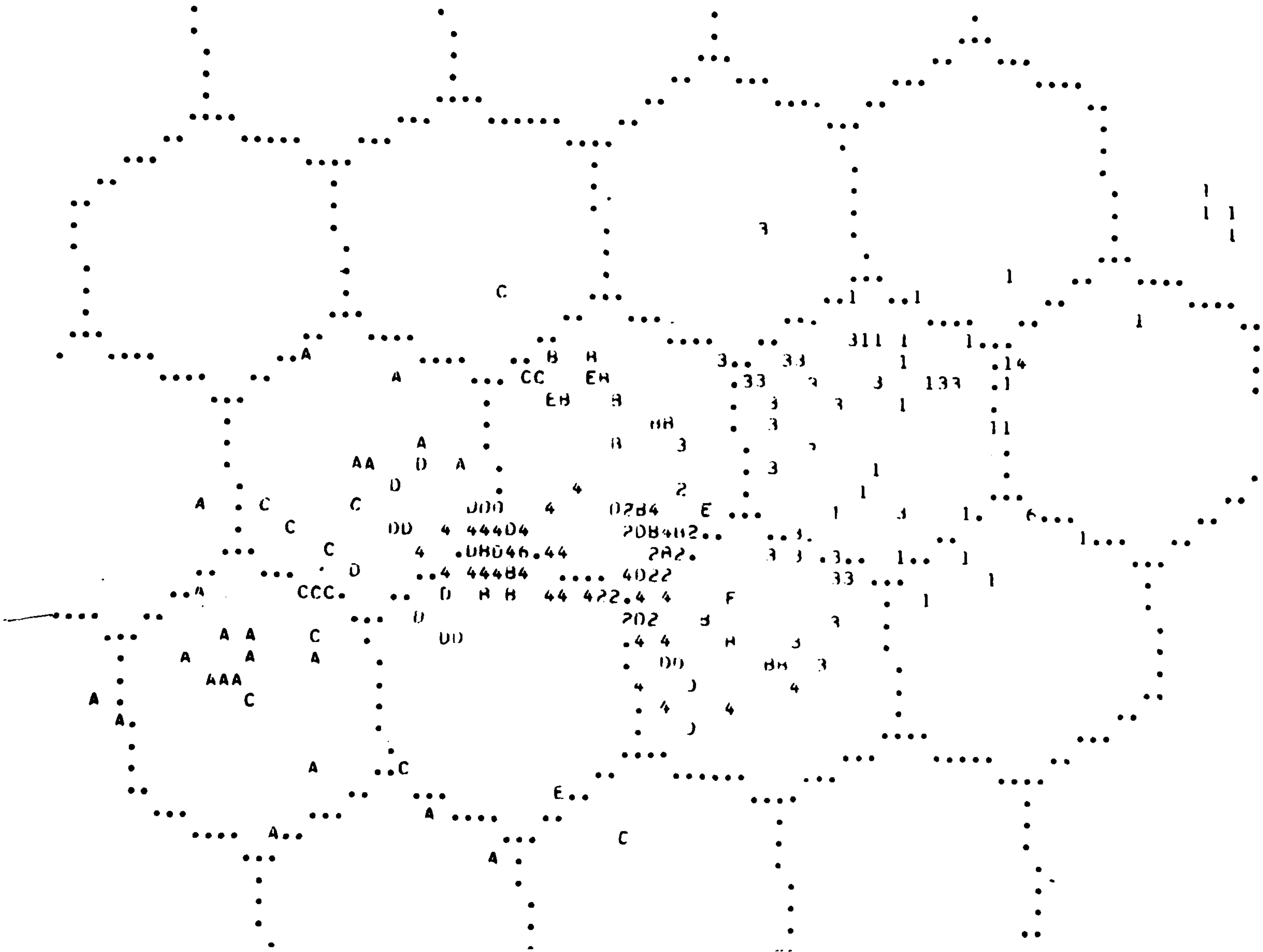


Figure F-20. Case I unit positions at 08:00 hours.

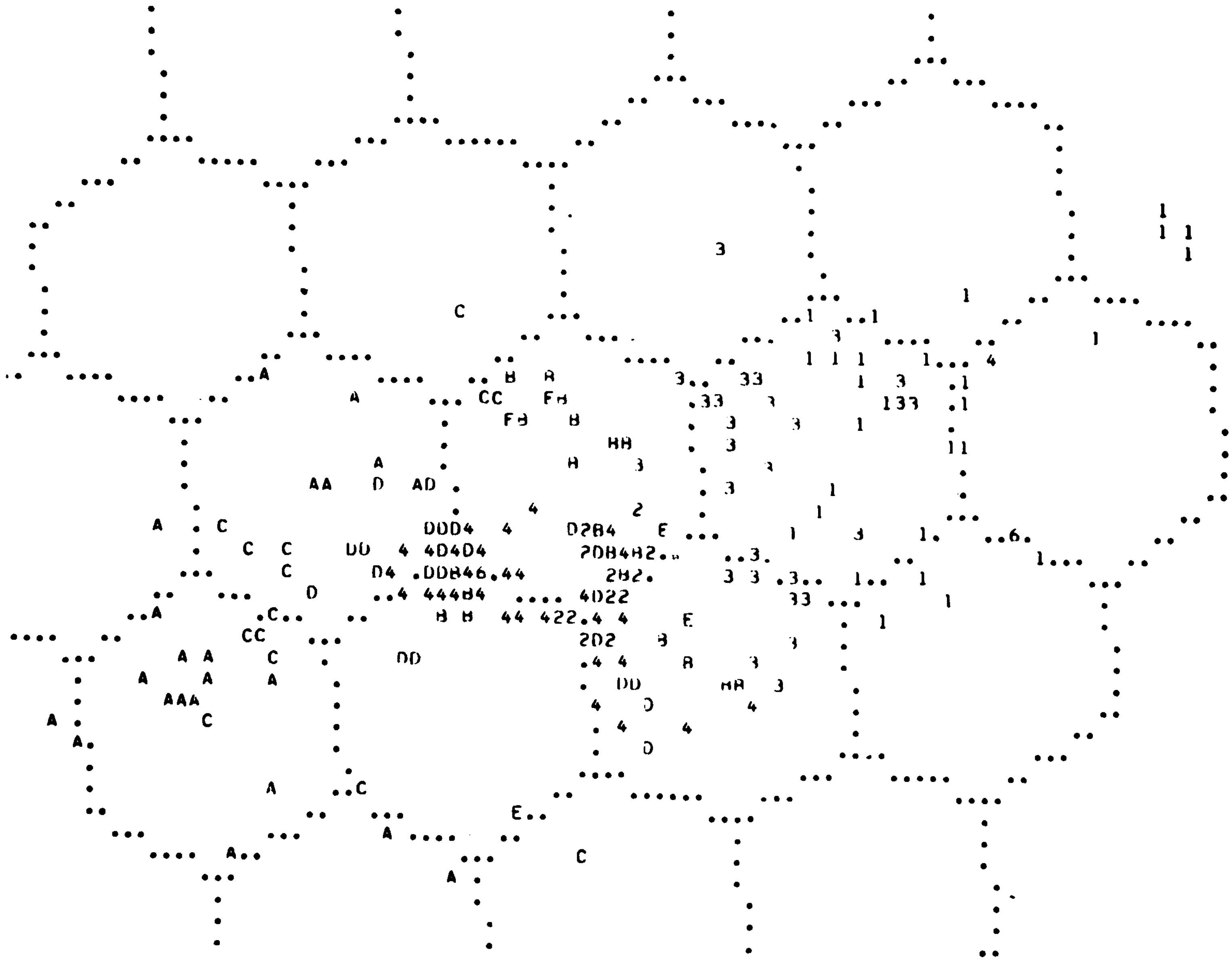


Figure F-21. Case I unit positions at 08:30 hours.

APPENDIX G

CASE II TACTICAL POSITION MAPS

The 18 maps presented in this appendix show the dynamic combat positions of both combatants at the company/battery level from zero to 0830 hours in one-half hour increments. Legend and other pertinent information concerning these maps is the same as for Case I, Appendix F.

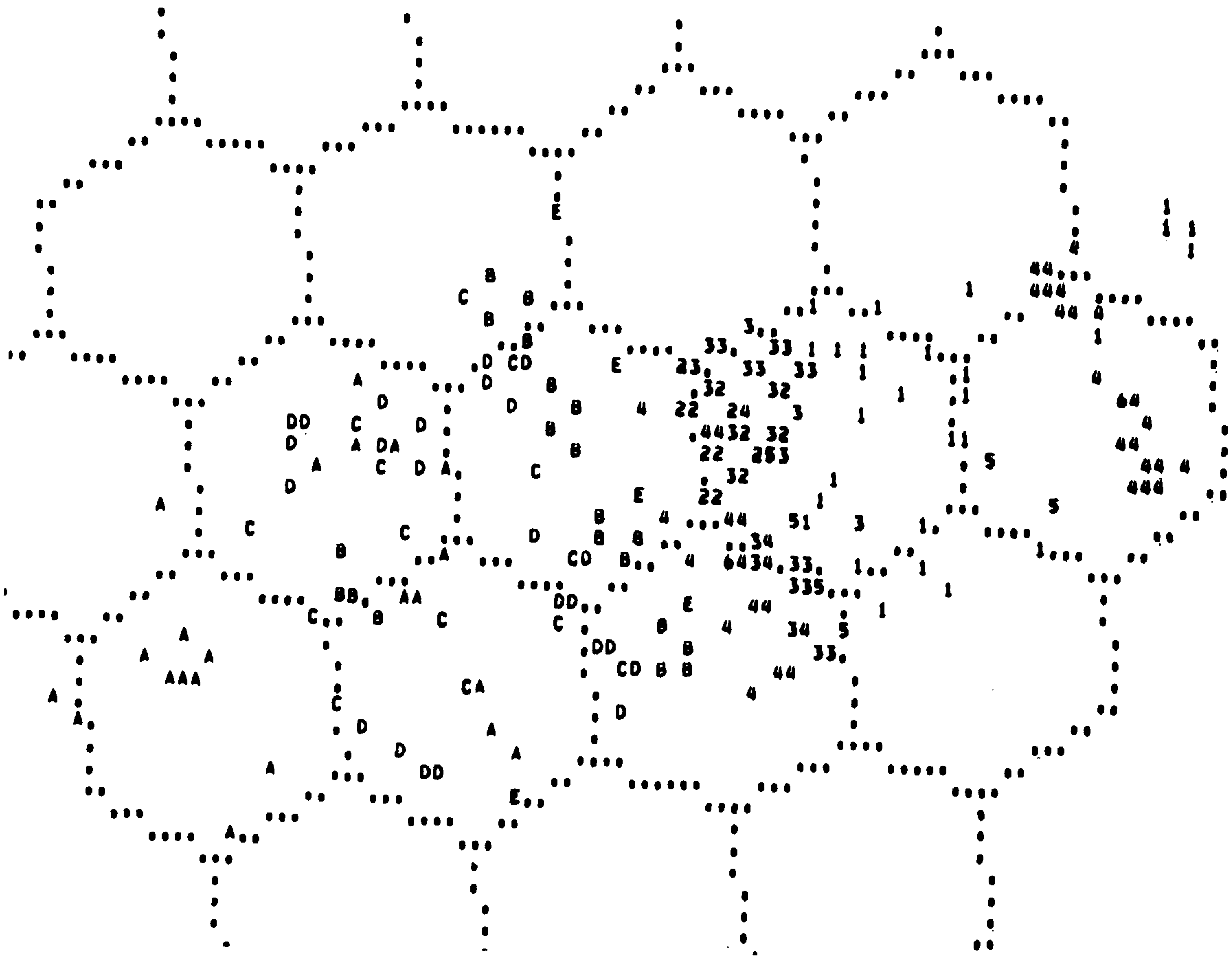


Figure G-1. Case II unit positions at 00:00 hours.

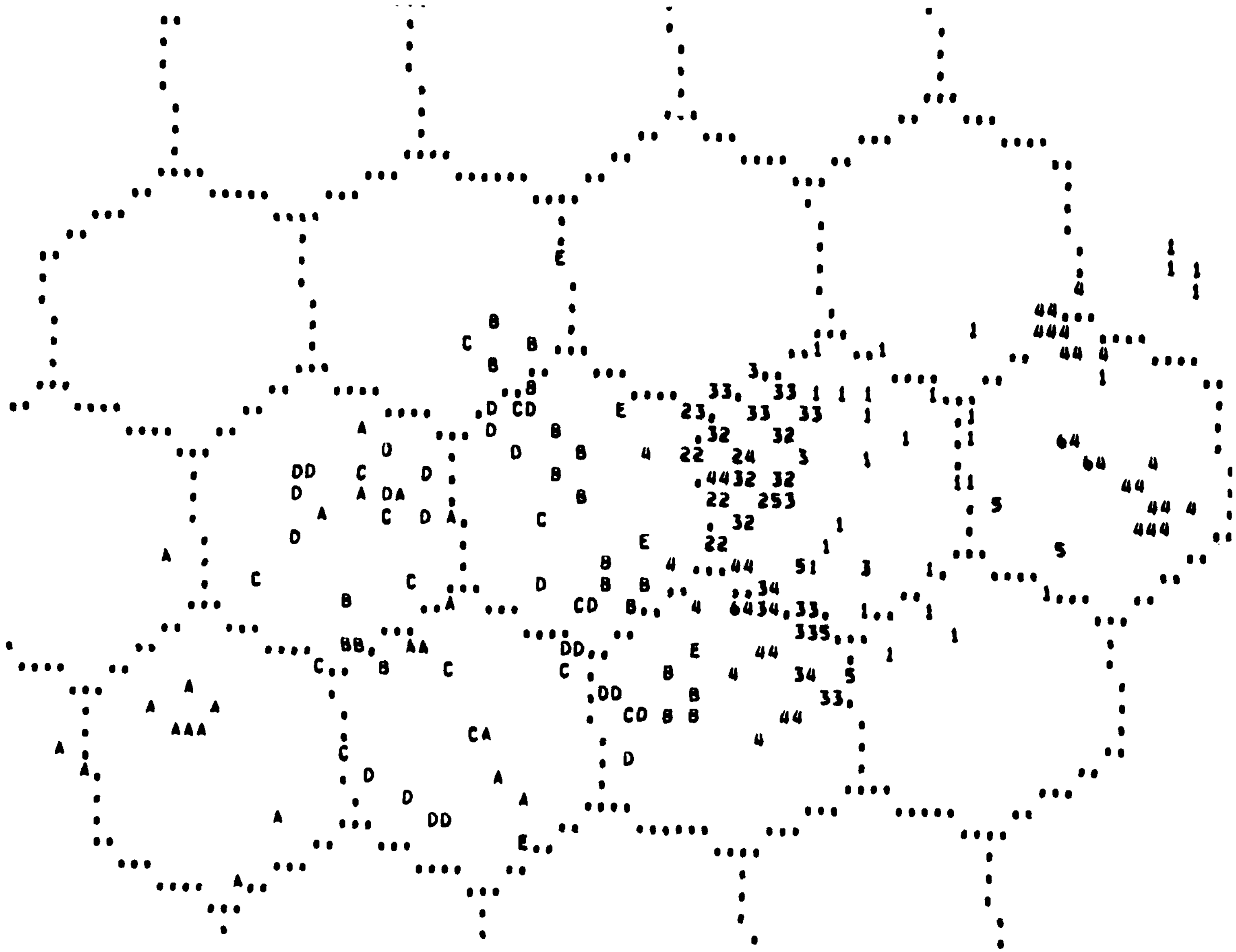


Figure G-2. Case II unit positions at 00:30 hours.

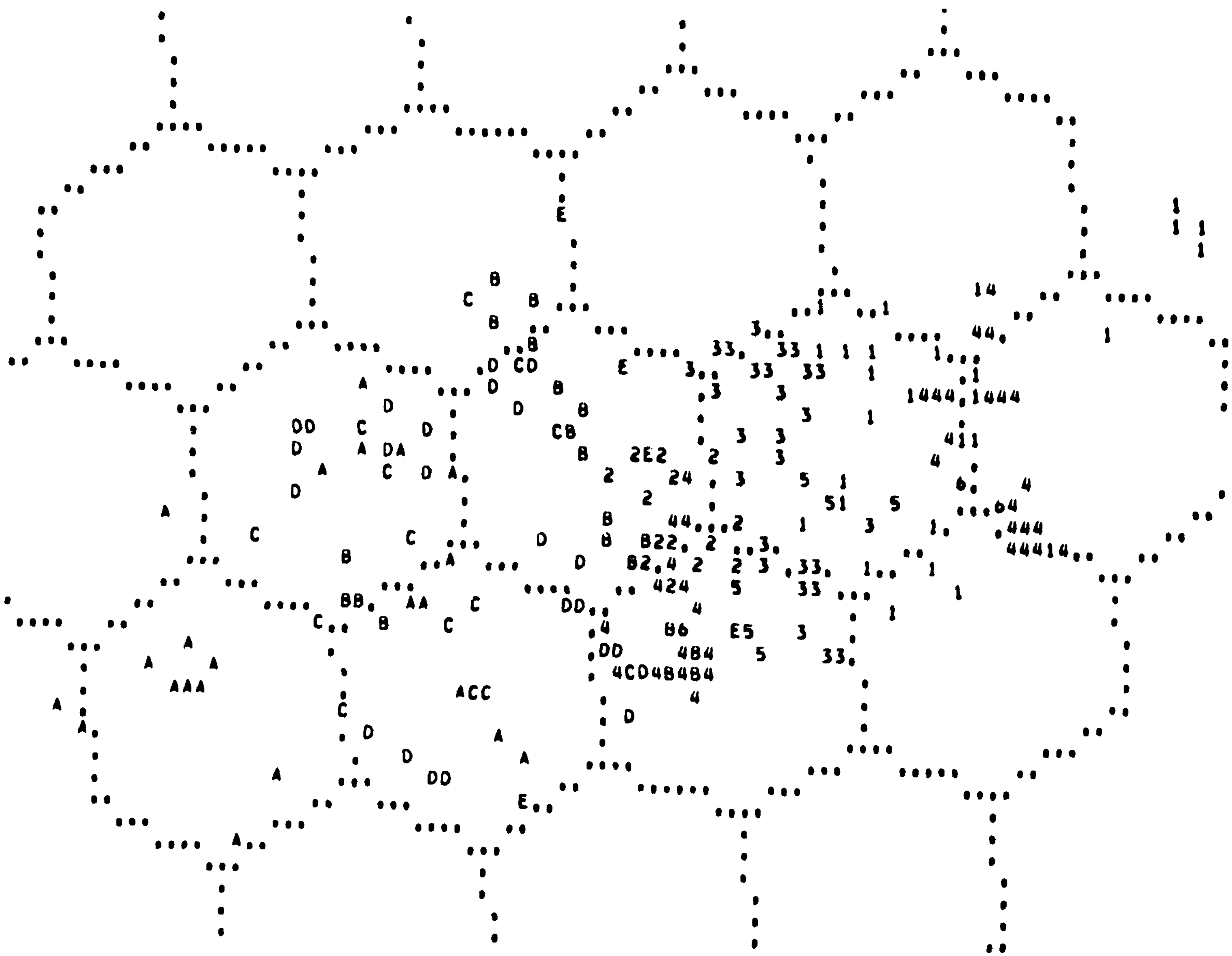


Figure G-3. Case II unit positions at 01:00 hours.

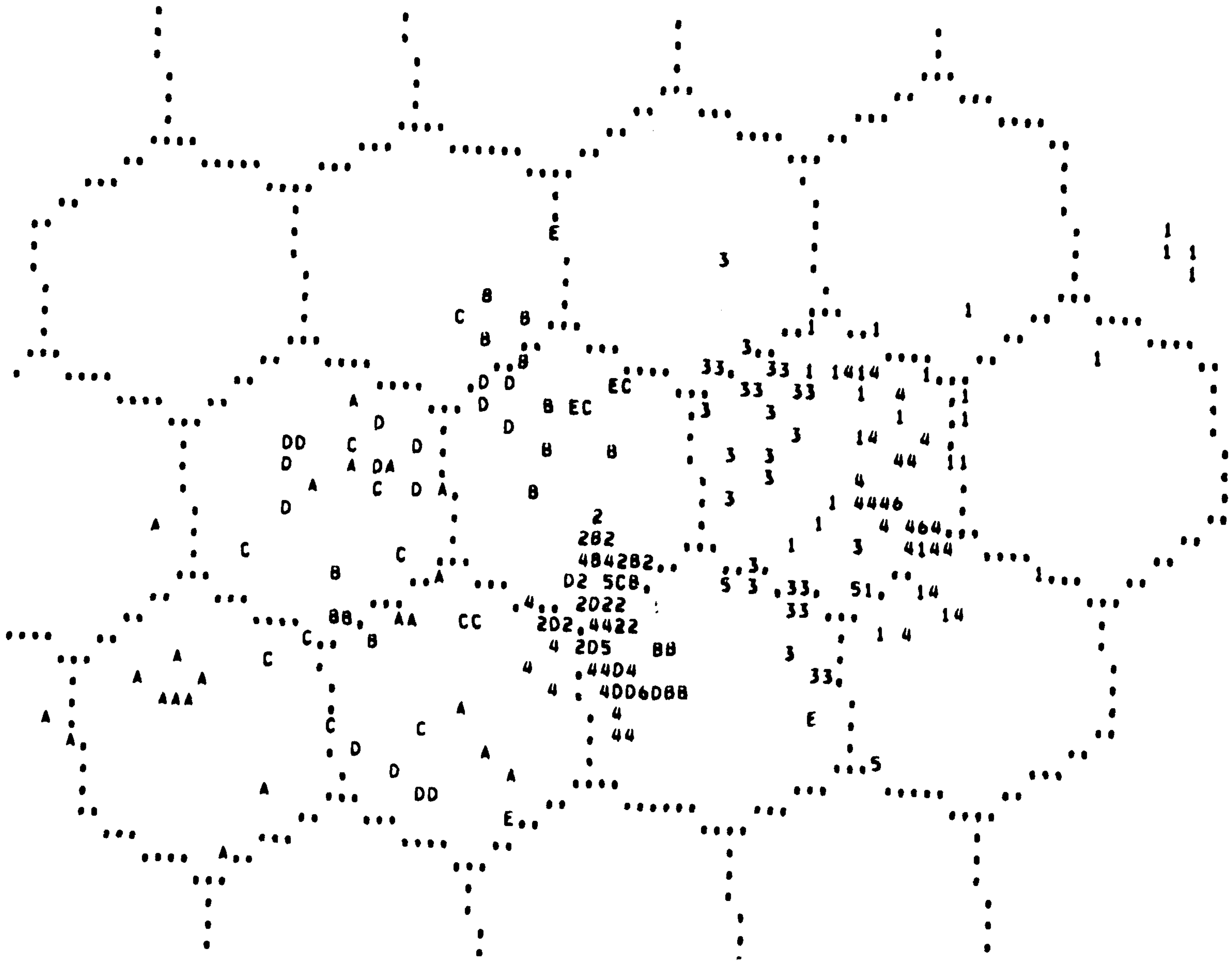


Figure G-4. Case II unit positions at 01:30 hours.

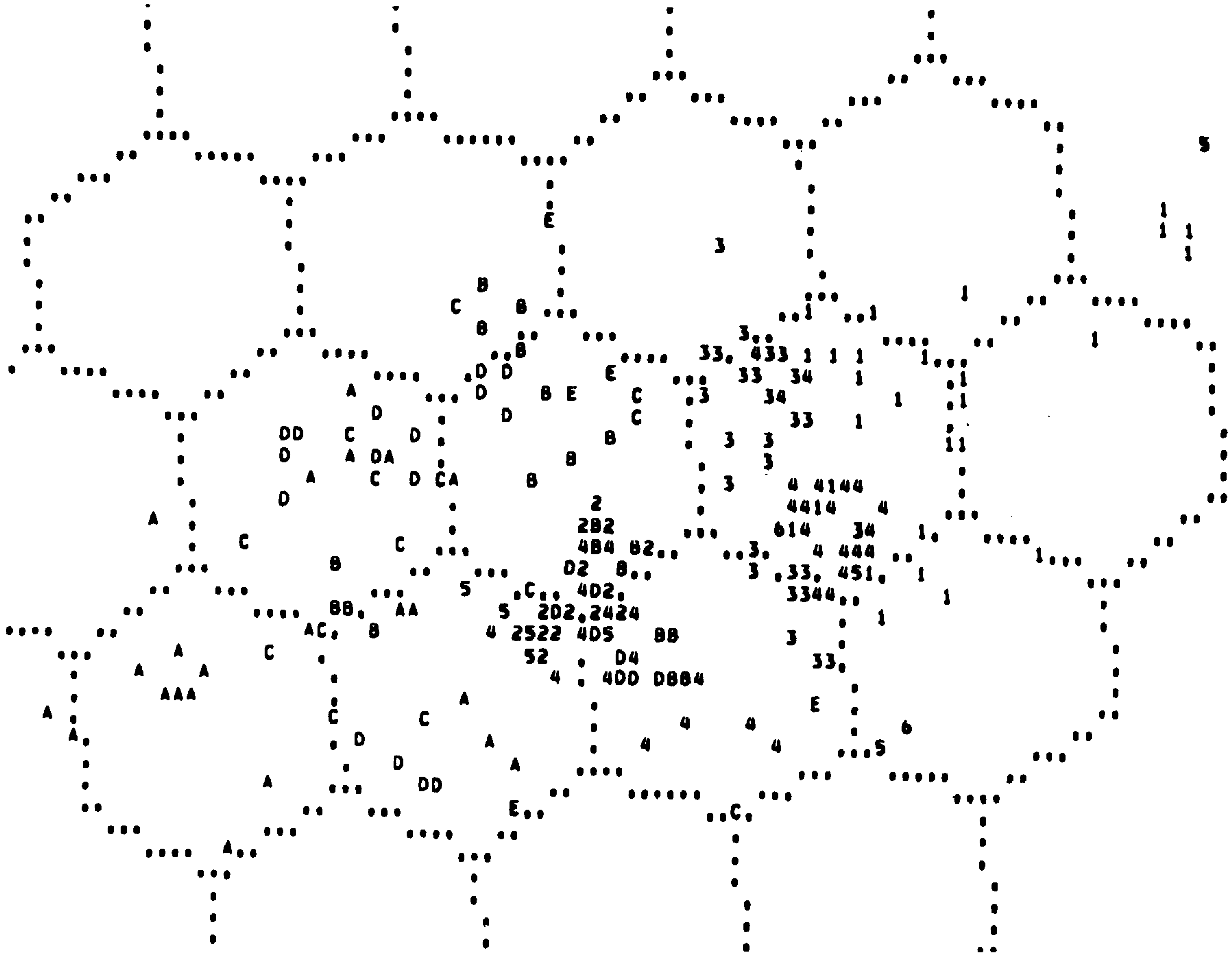


Figure G-5. Case II unit positions at 02:00 hours.

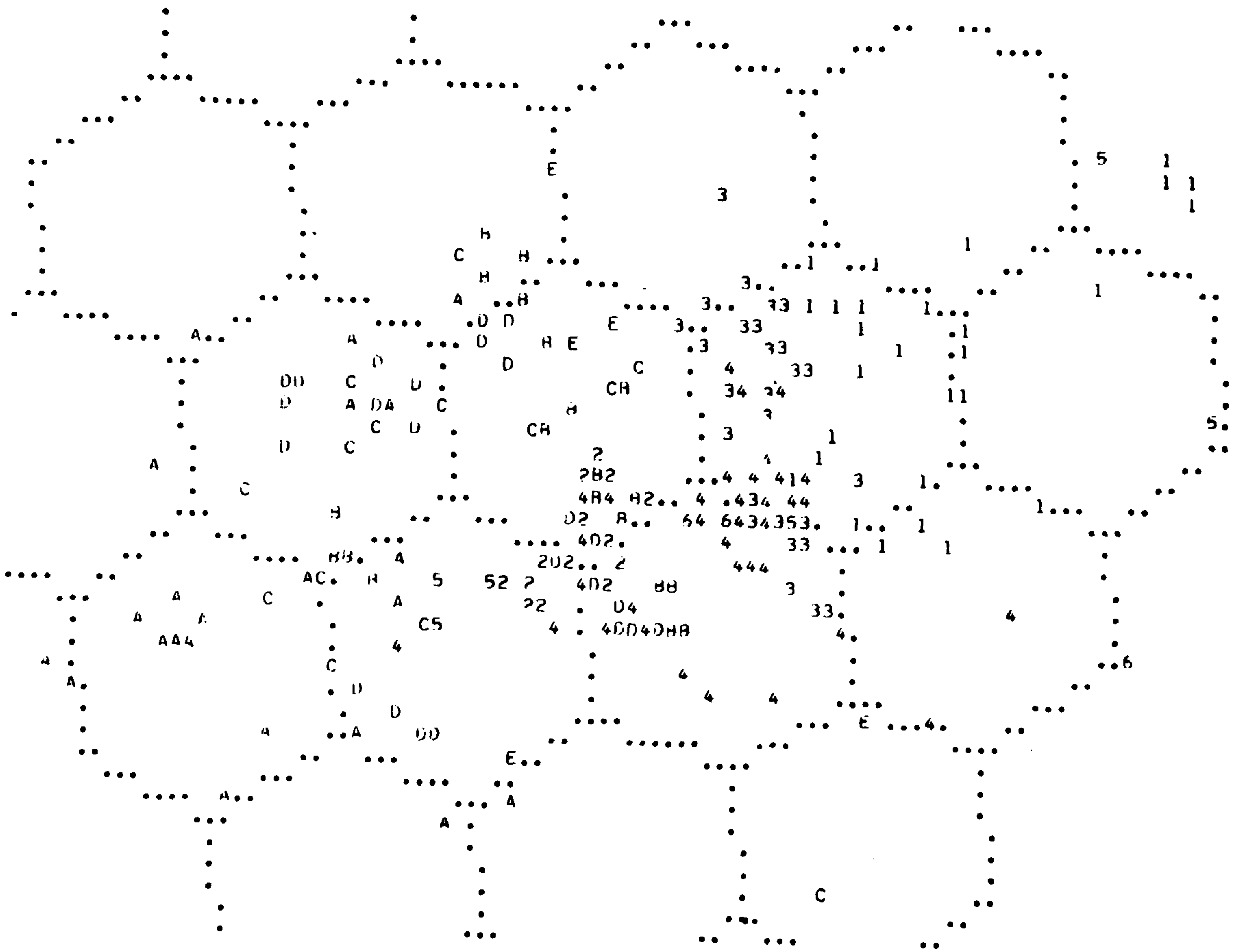


Figure G-6. Case II unit positions at 02:30 hours.

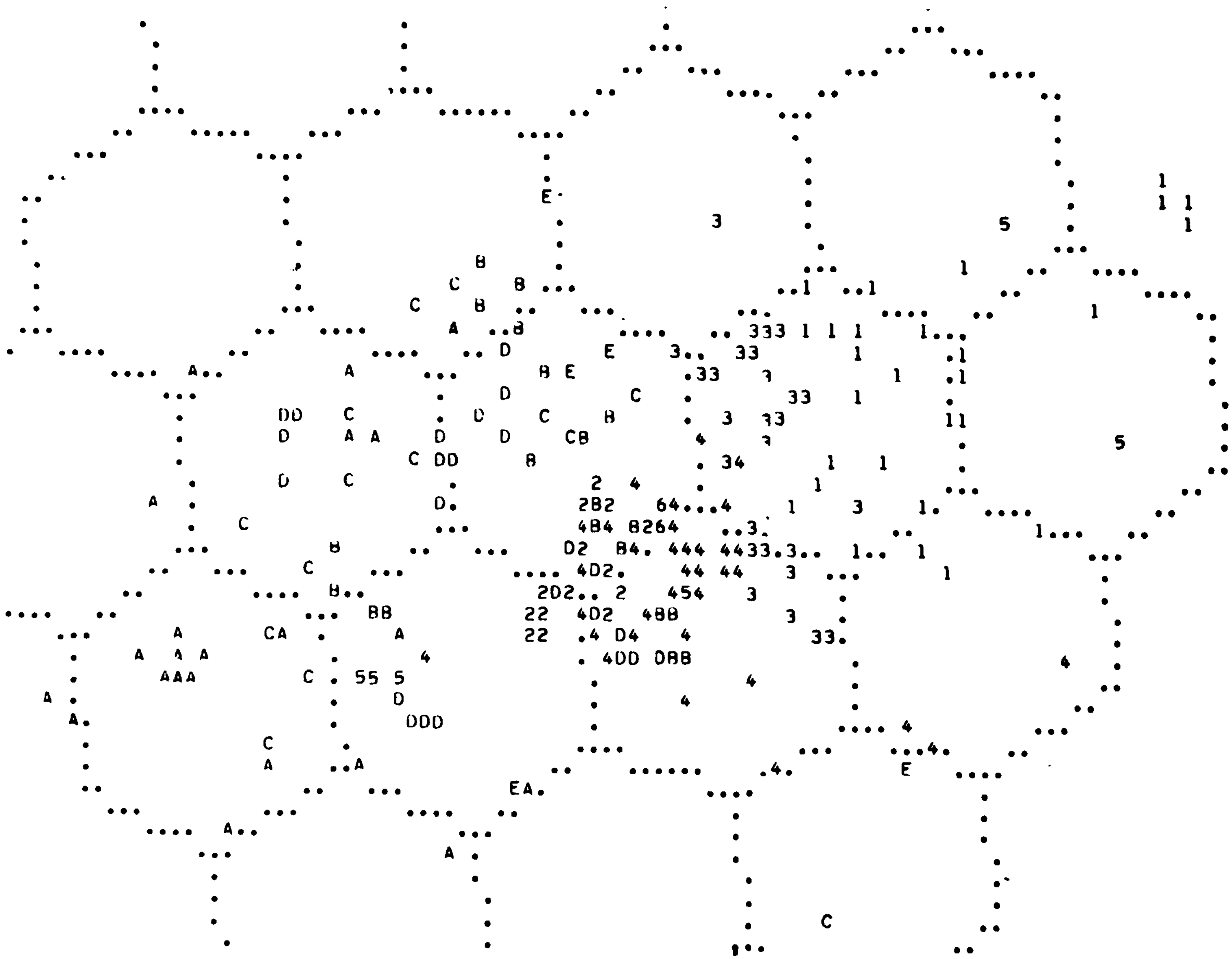


Figure G-7. Case II unit positions at 03:00 hours.

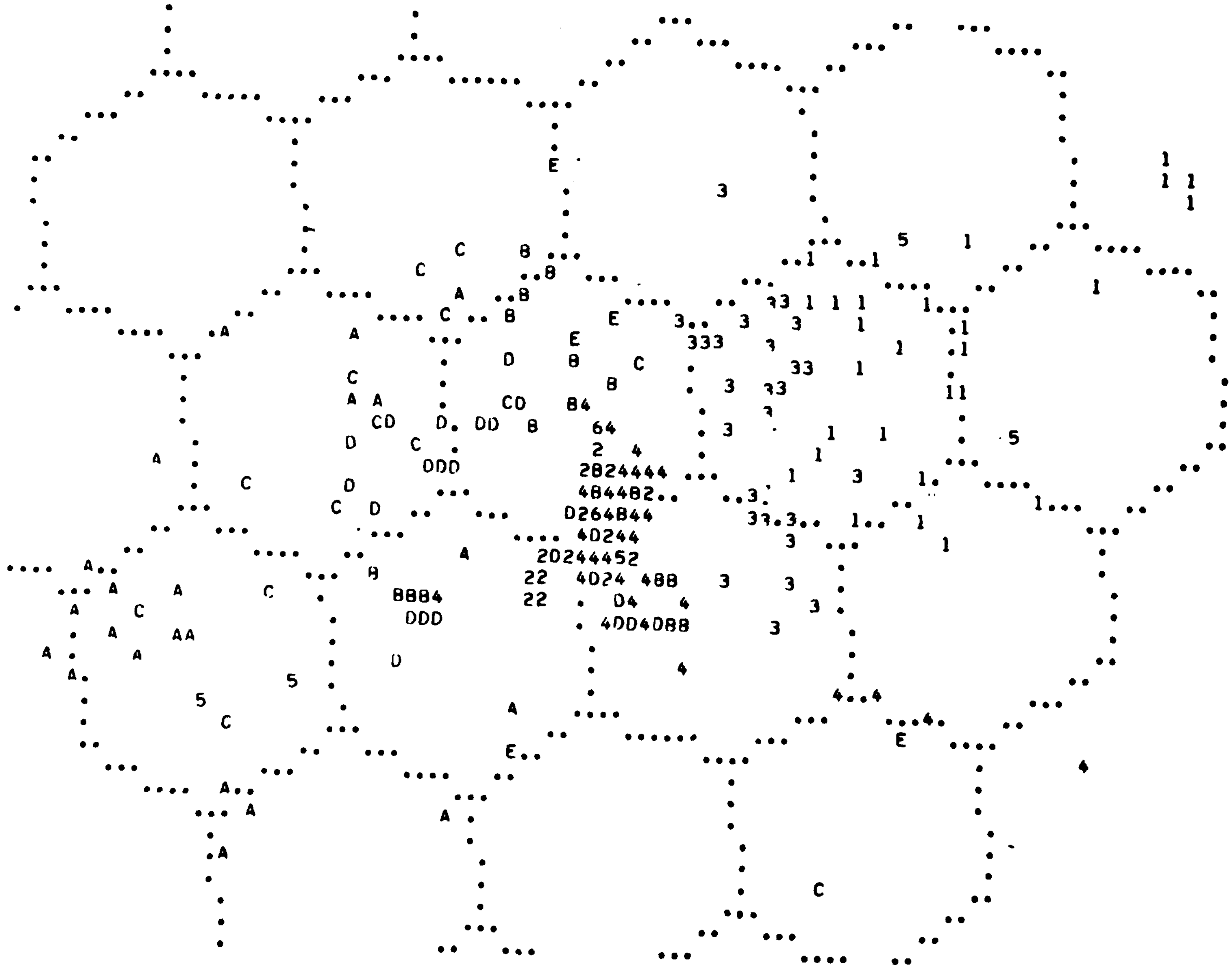


Figure G-8. Case II unit positions at 03:30 hours.

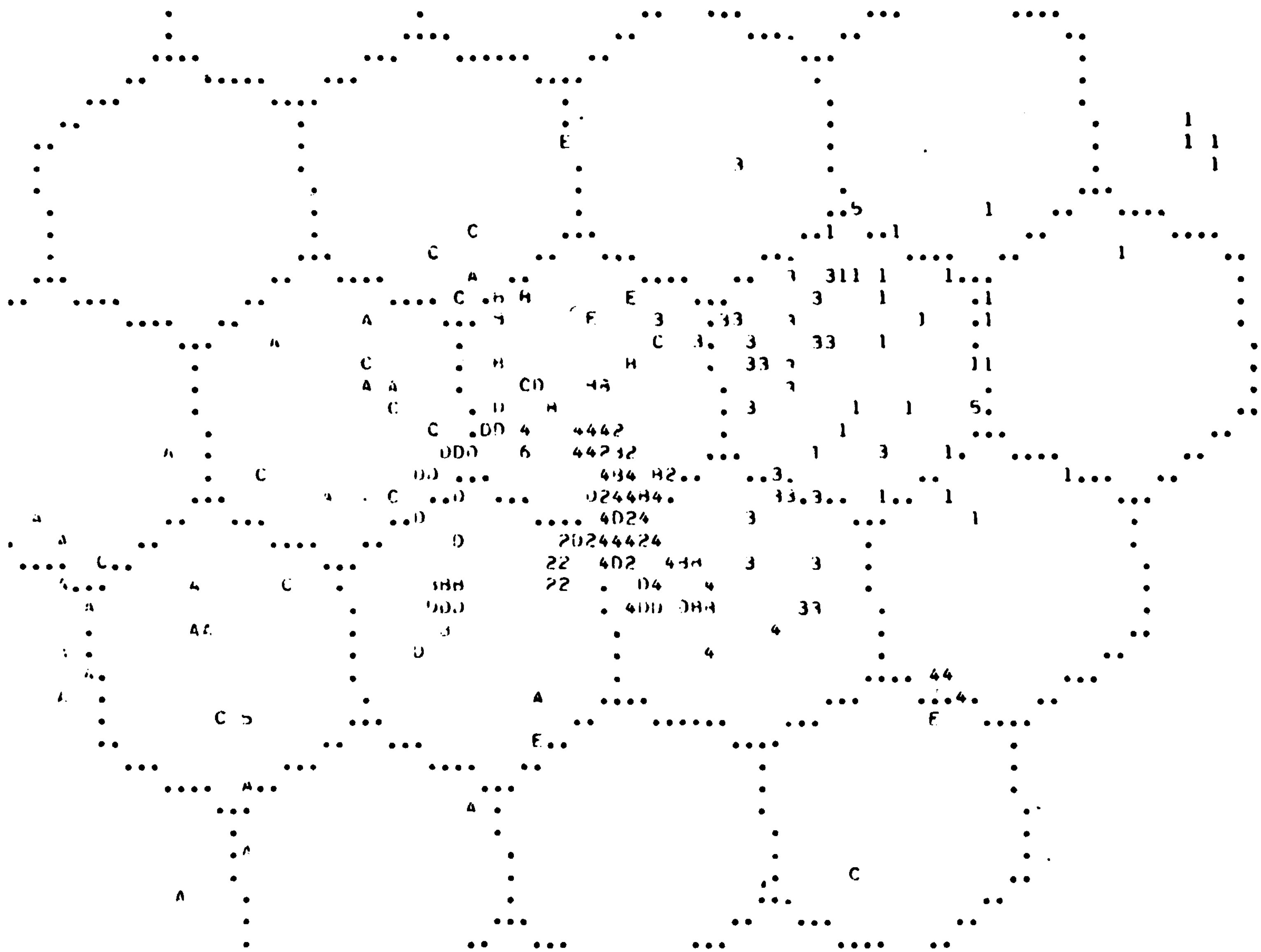


Figure G-9. Case II unit positions at 04:00 hours.

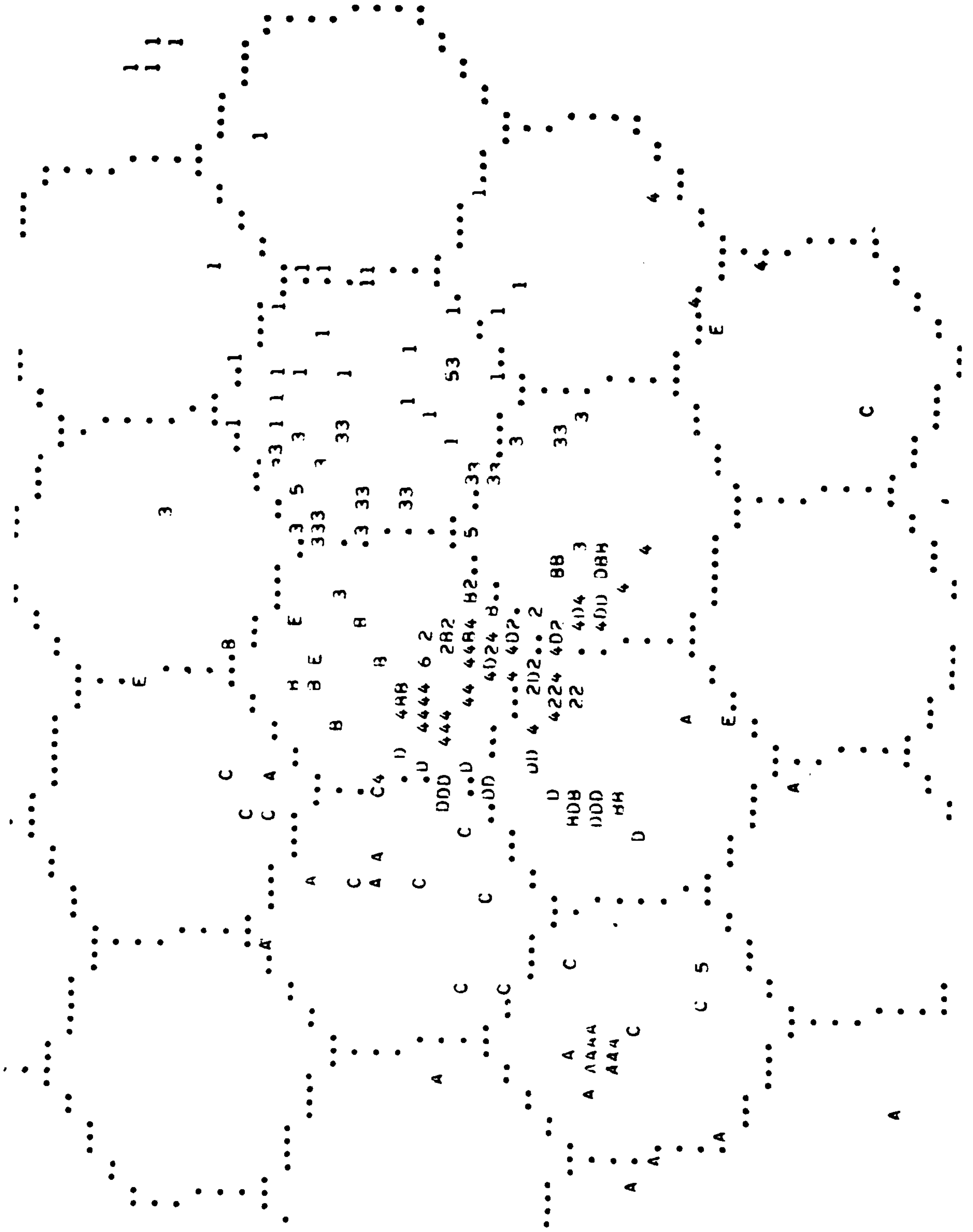


Figure G-10. Case II unit positions at 04:30 hours.

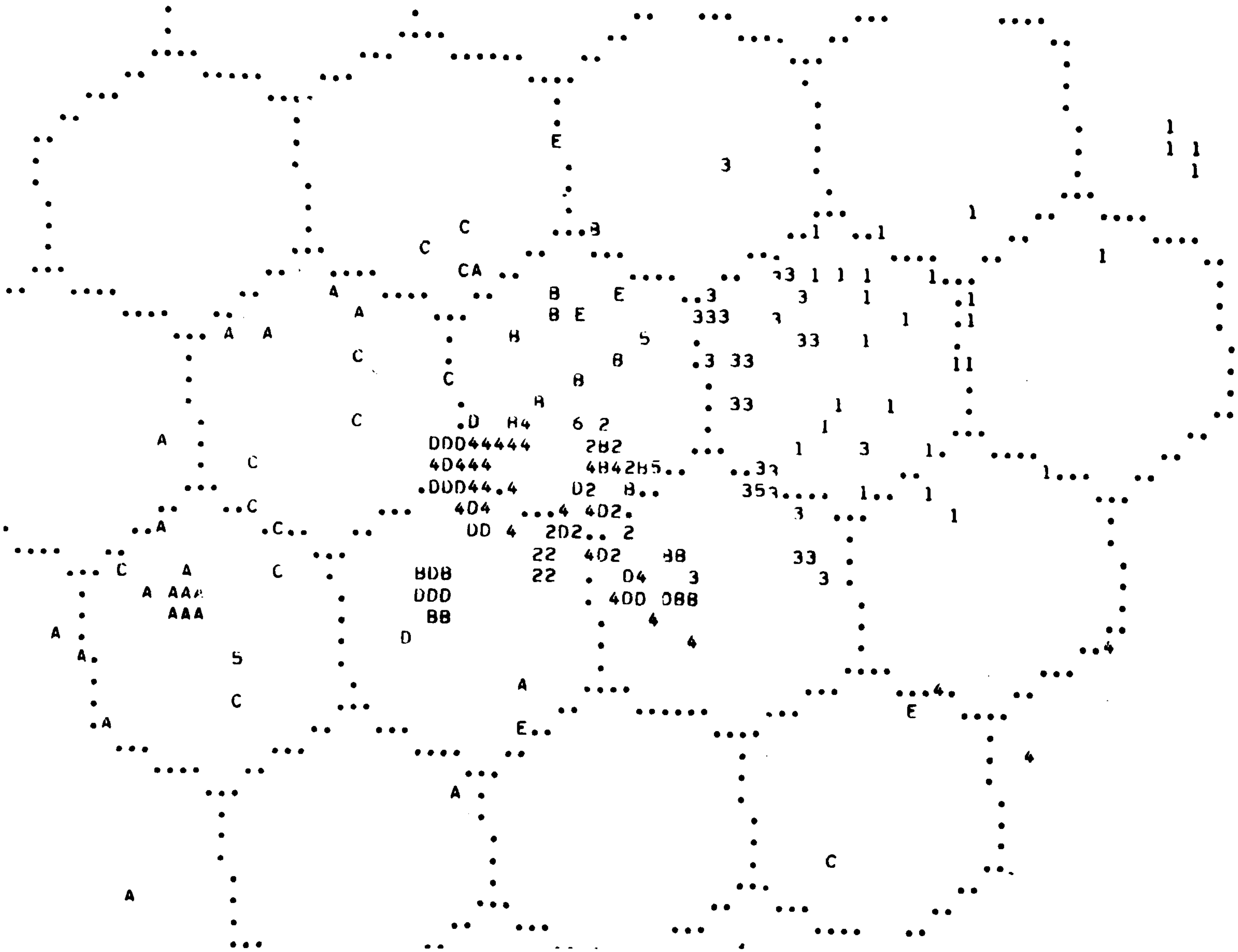


Figure G-11. Case II unit positions at 05:00 hours.

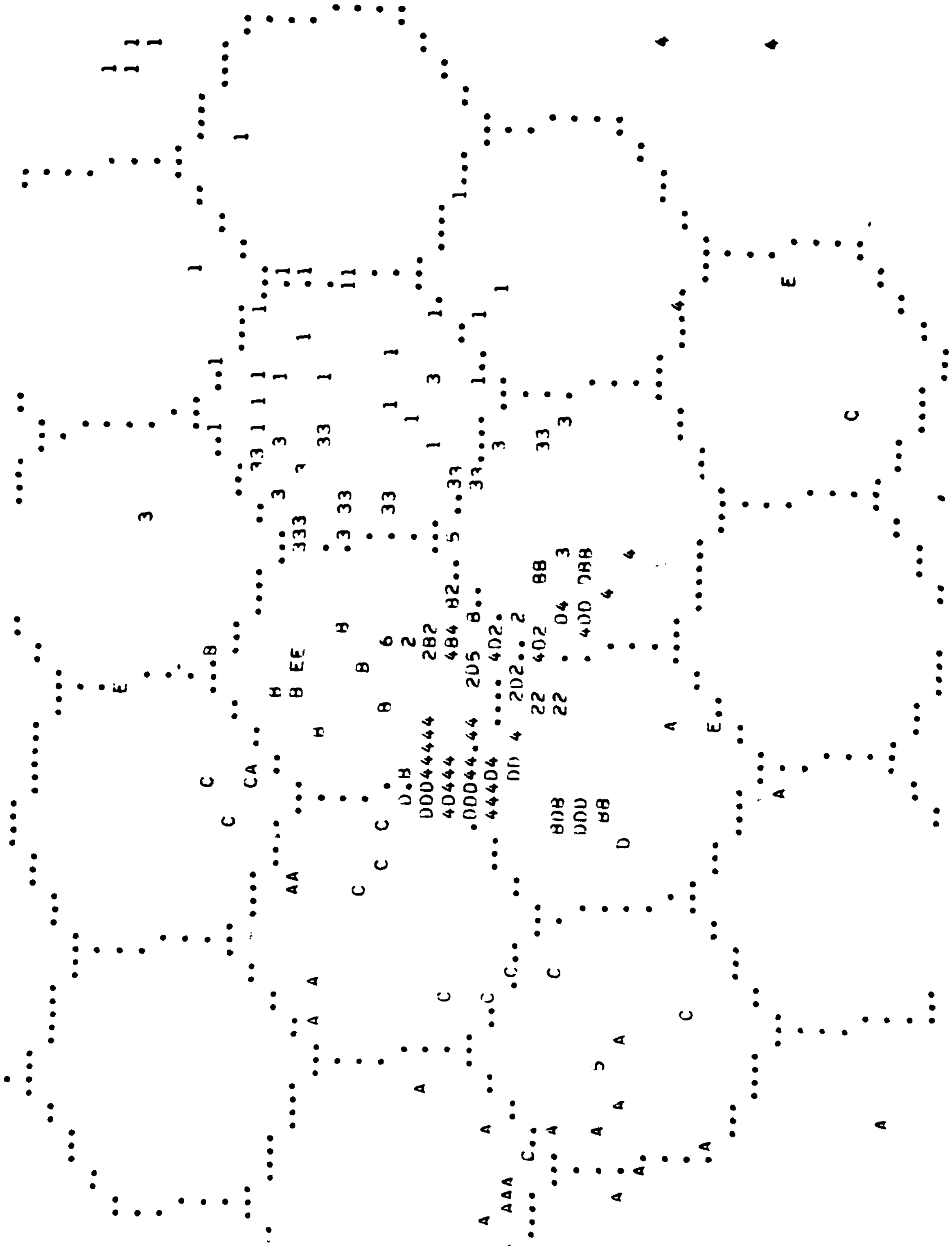


Figure G-12. Case II unit positions at 05:30 hours.

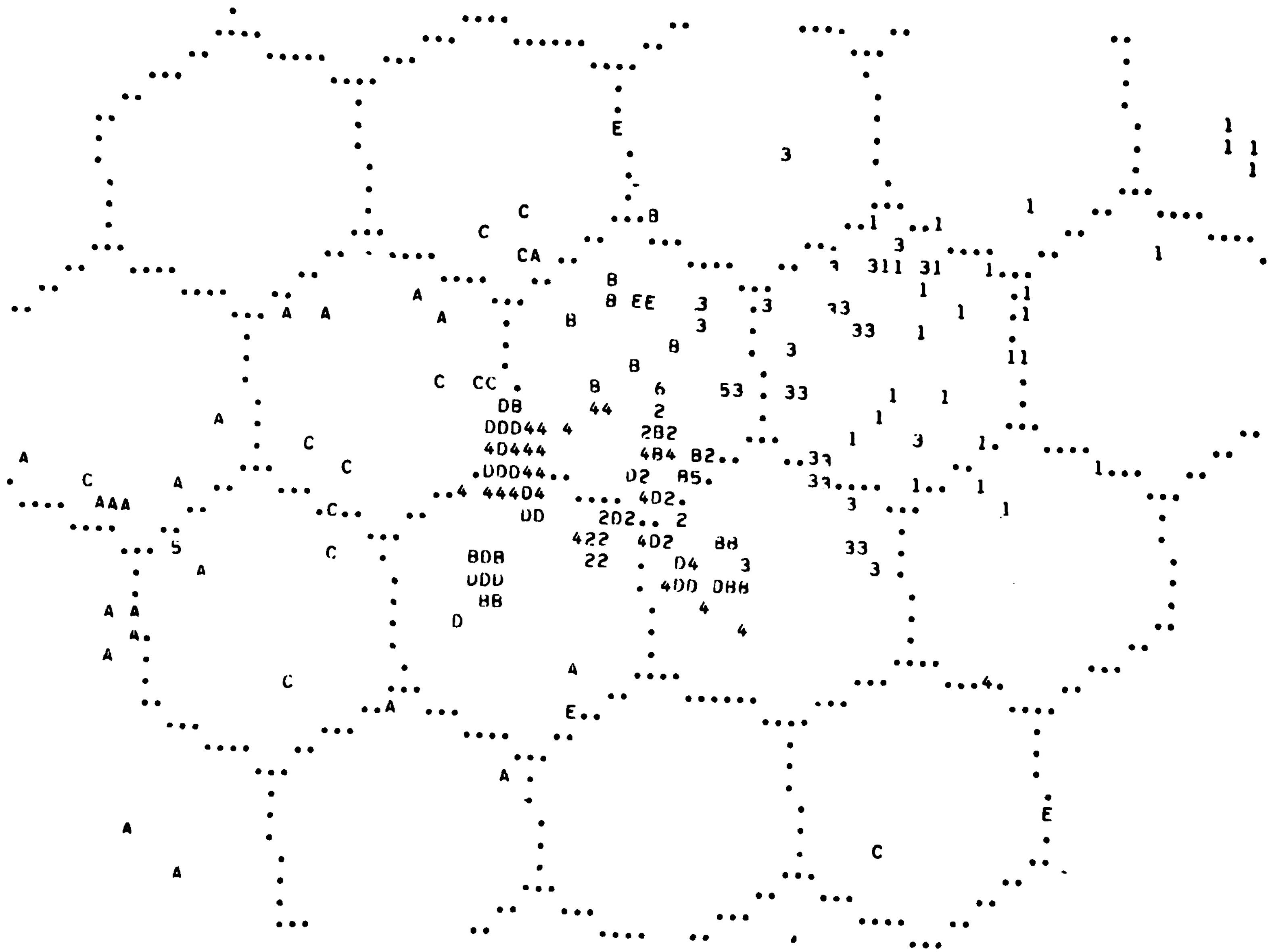


Figure G-13. Case II unit positions at 06:00 hours.

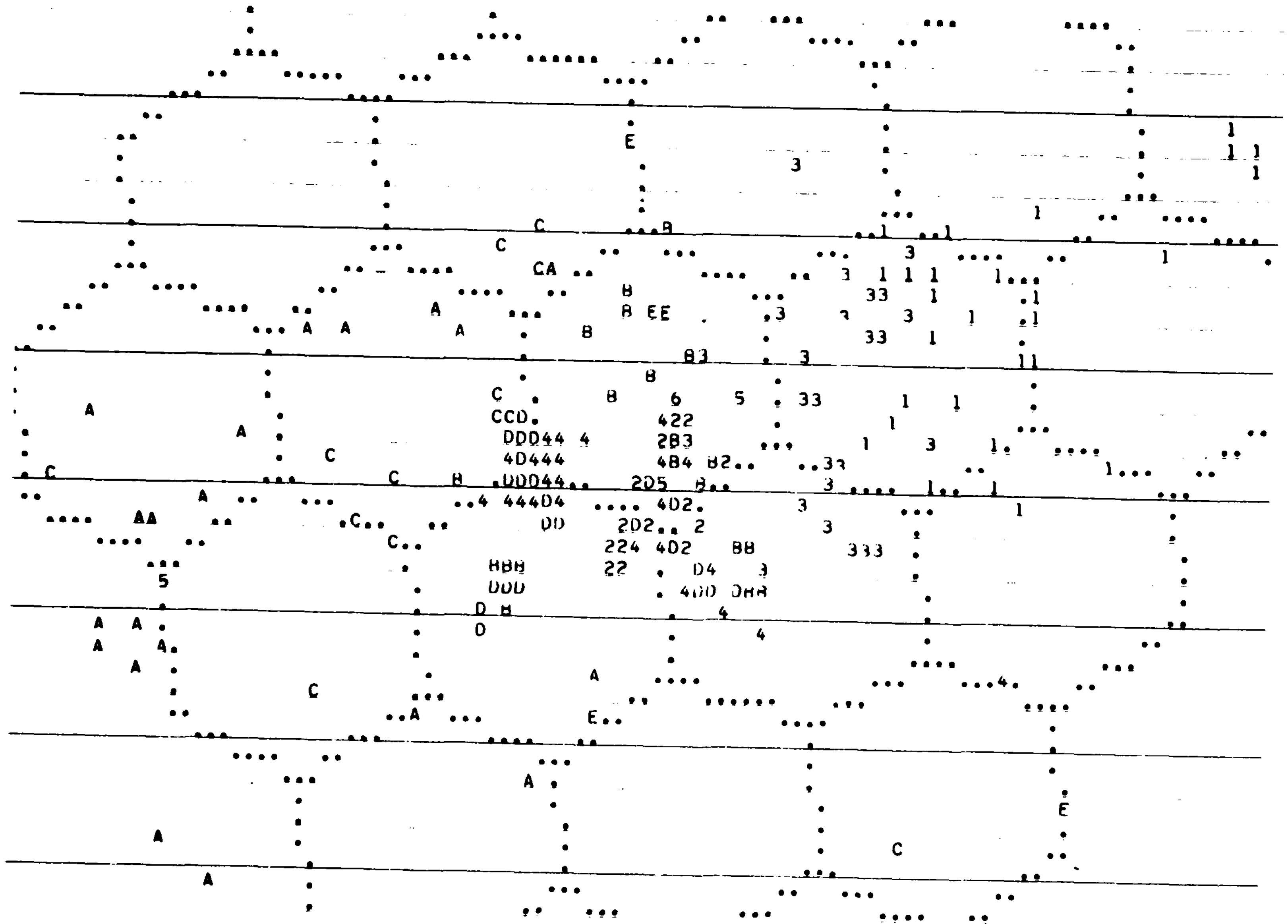


Figure G-14. Case II unit positions at 06:30 hours.

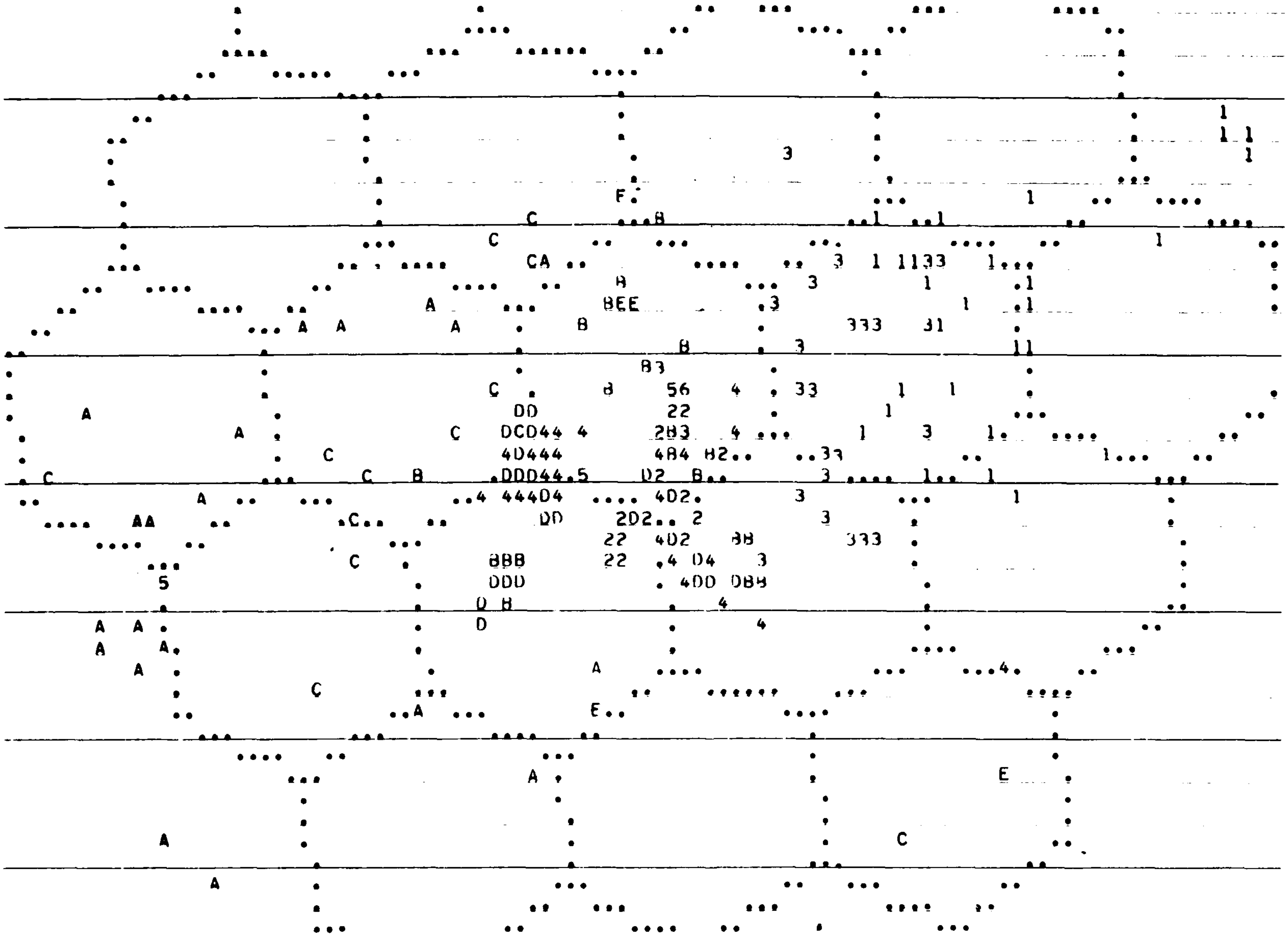


Figure G-15. Case II unit positions at 07:00 hours.

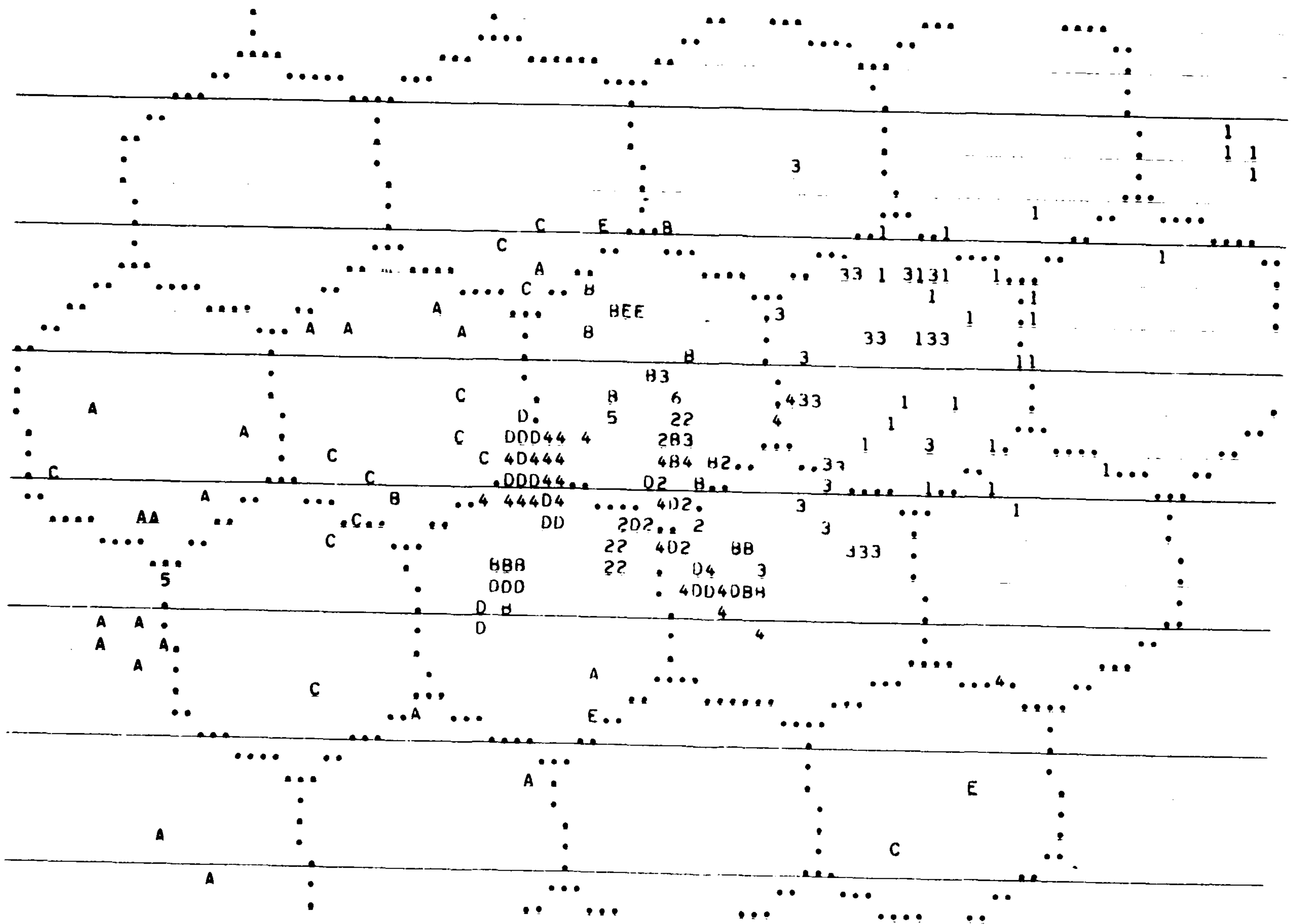


Figure G-16. Case II unit positions at 07:30 hours.

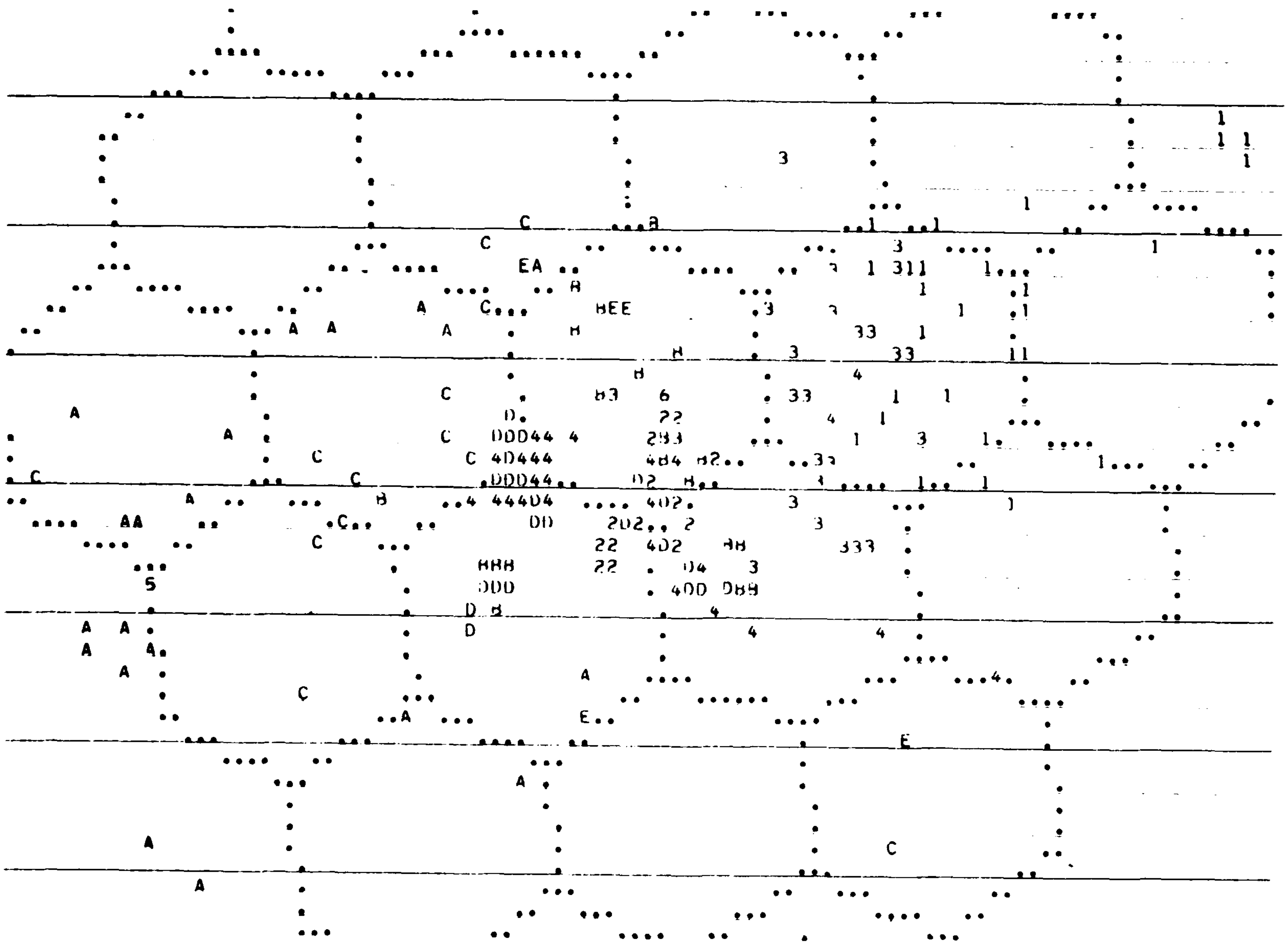


Figure G-17. Case II unit positions at 08:00 hours.

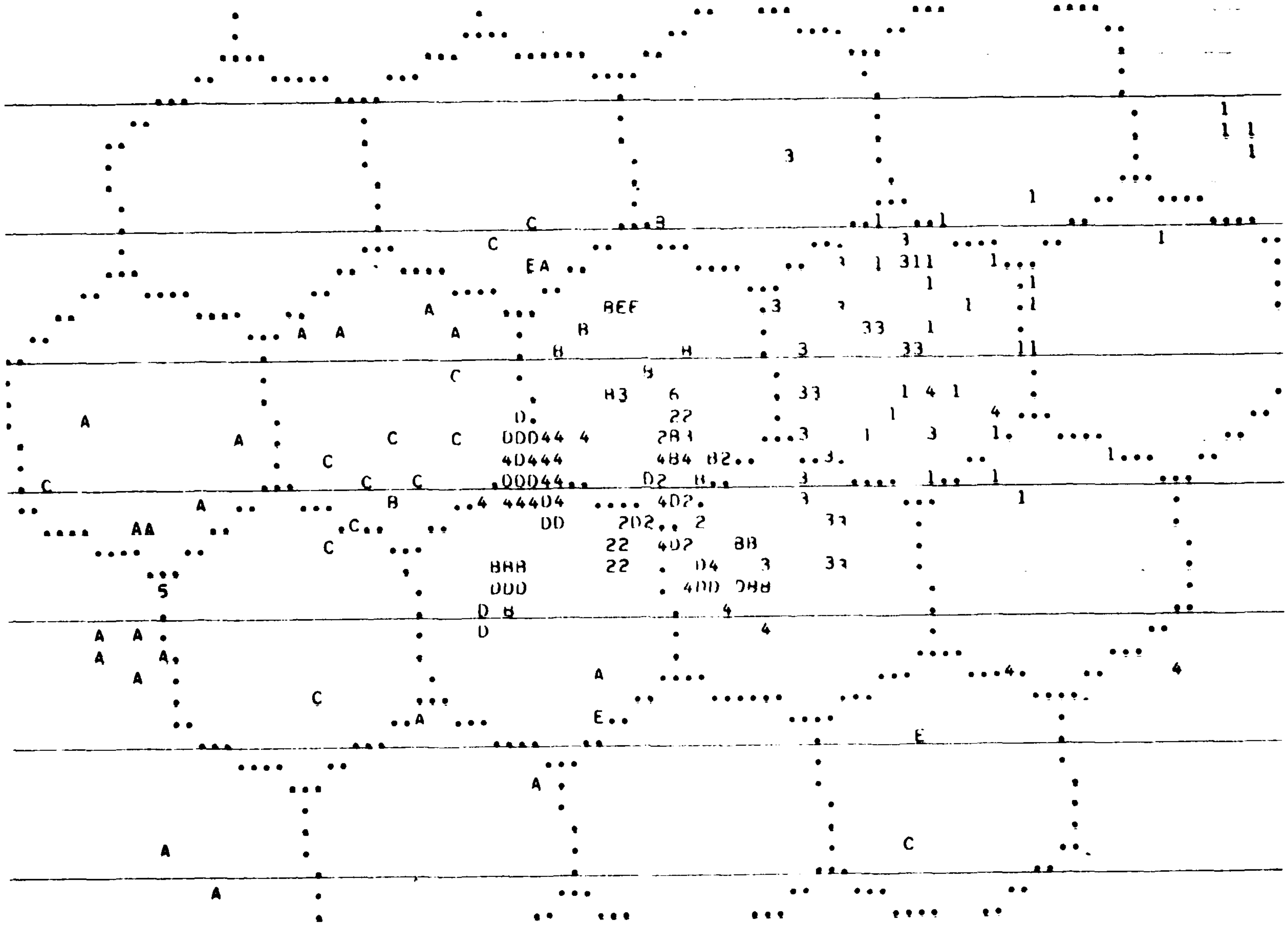


Figure G-18. Case II unit positions at 08:30 hours.

APPENDIX H
CASE III TACTICAL POSITION MAPS

The 18 maps presented in this appendix show the dynamic combat positions of both combatants at the company/battery level from zero to 0830 hours in one-half hour increments. Legend and other pertinent information concerning these maps is the same as for Case I, Appendix F.

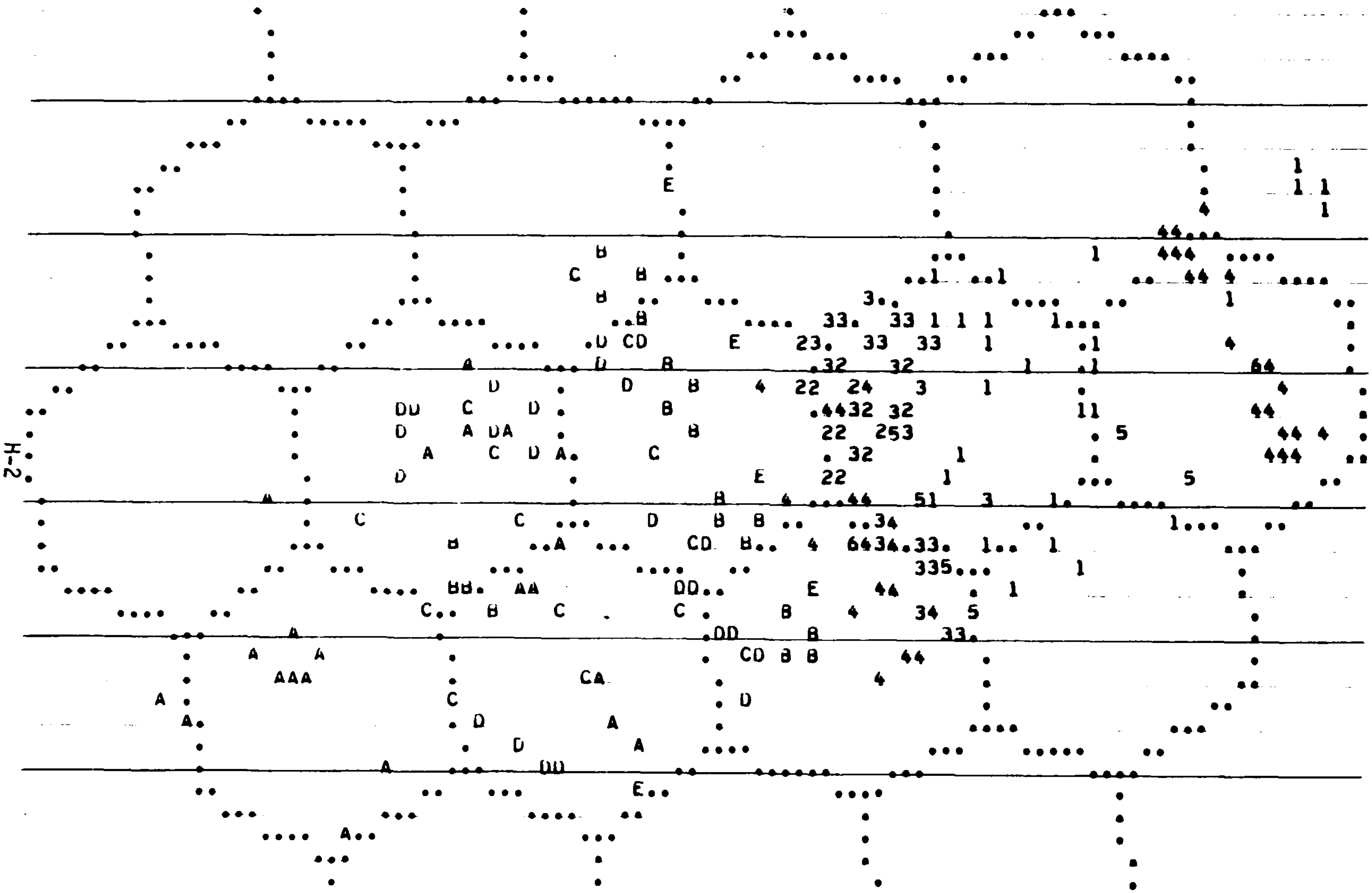


Figure H-1. Case III unit positions at 00:00 hours.

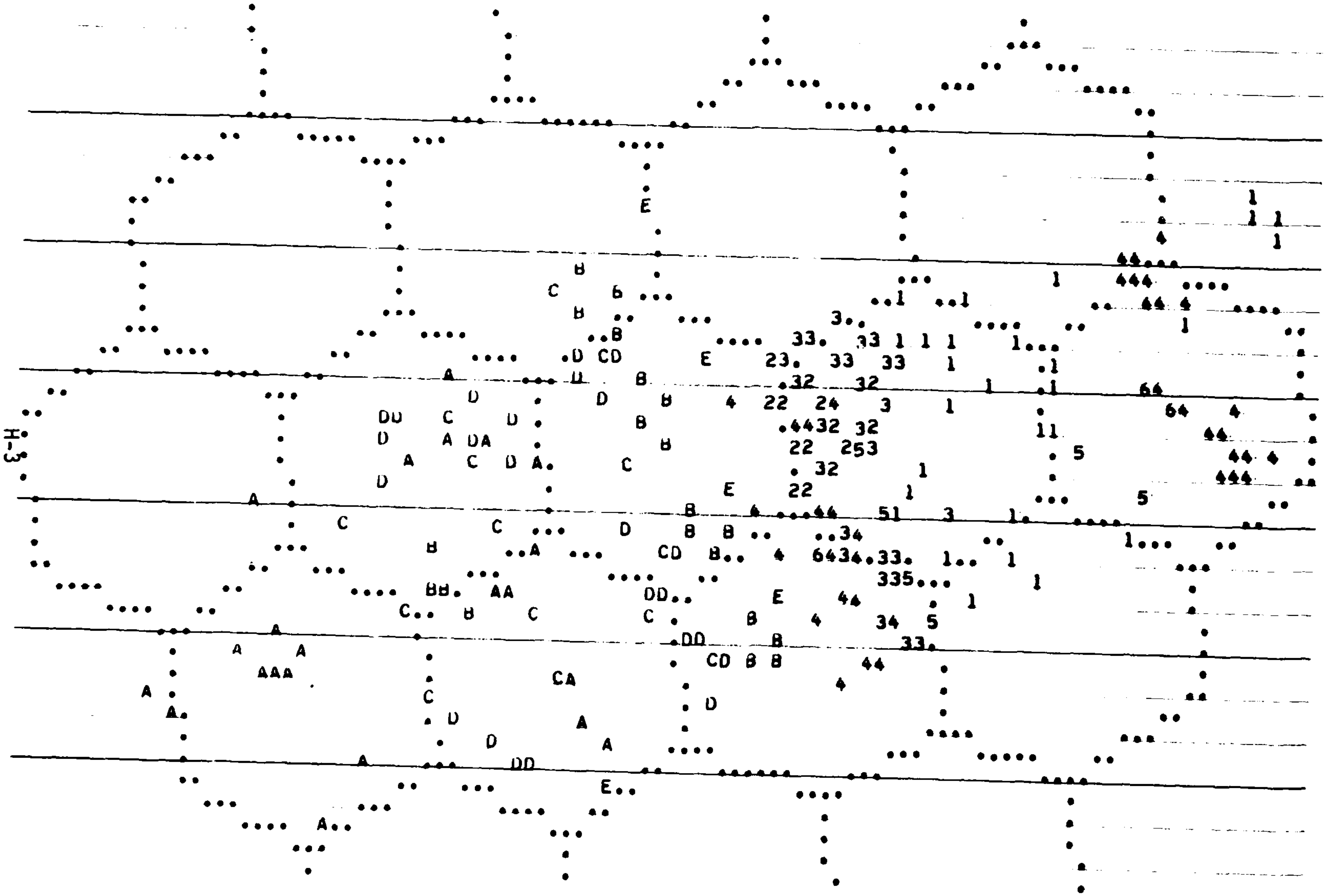


Figure H-2. Case III unit positions at 00:30 hours.

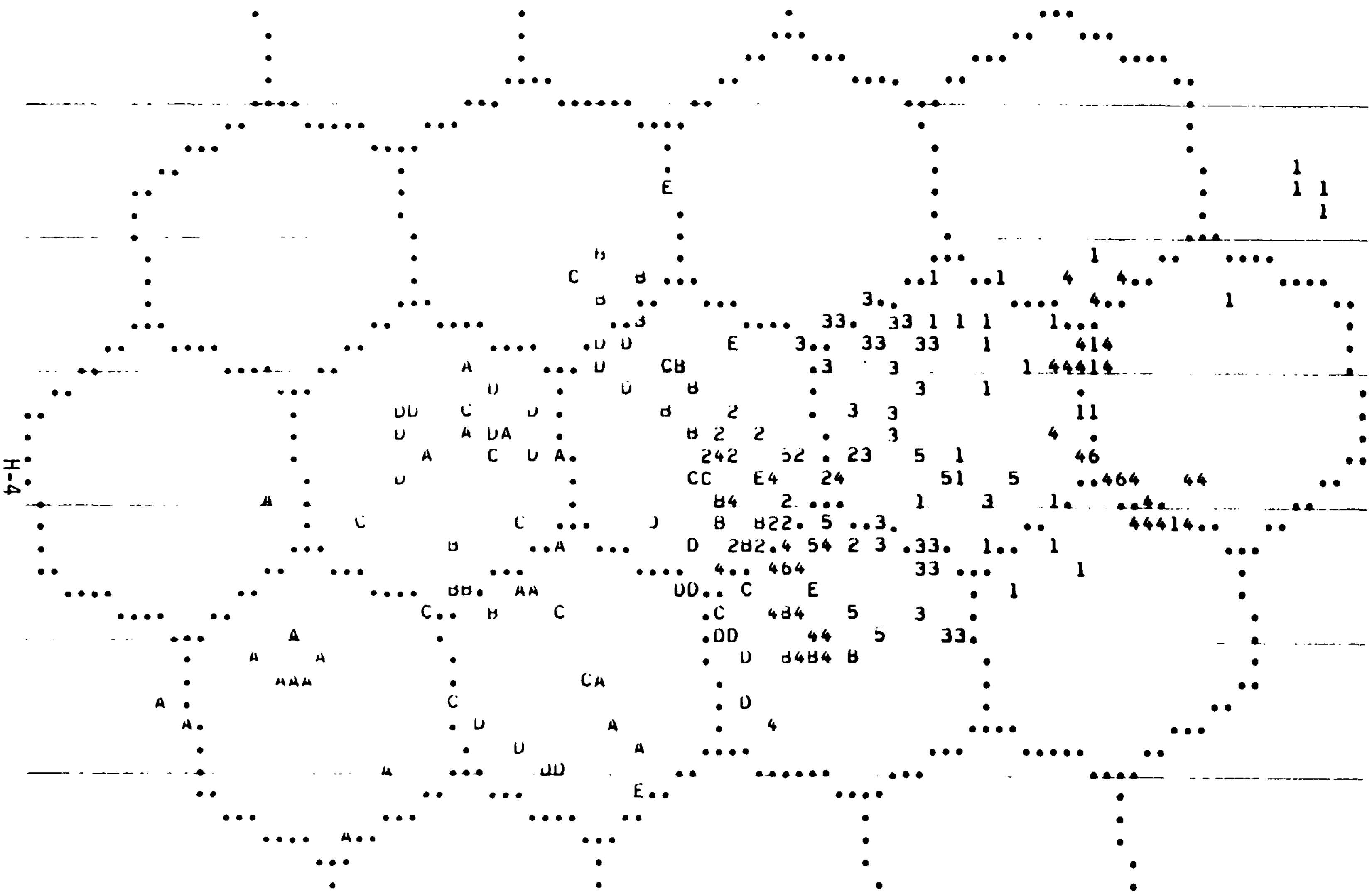


Figure H-3. Case III unit positions at 01:00 hours.

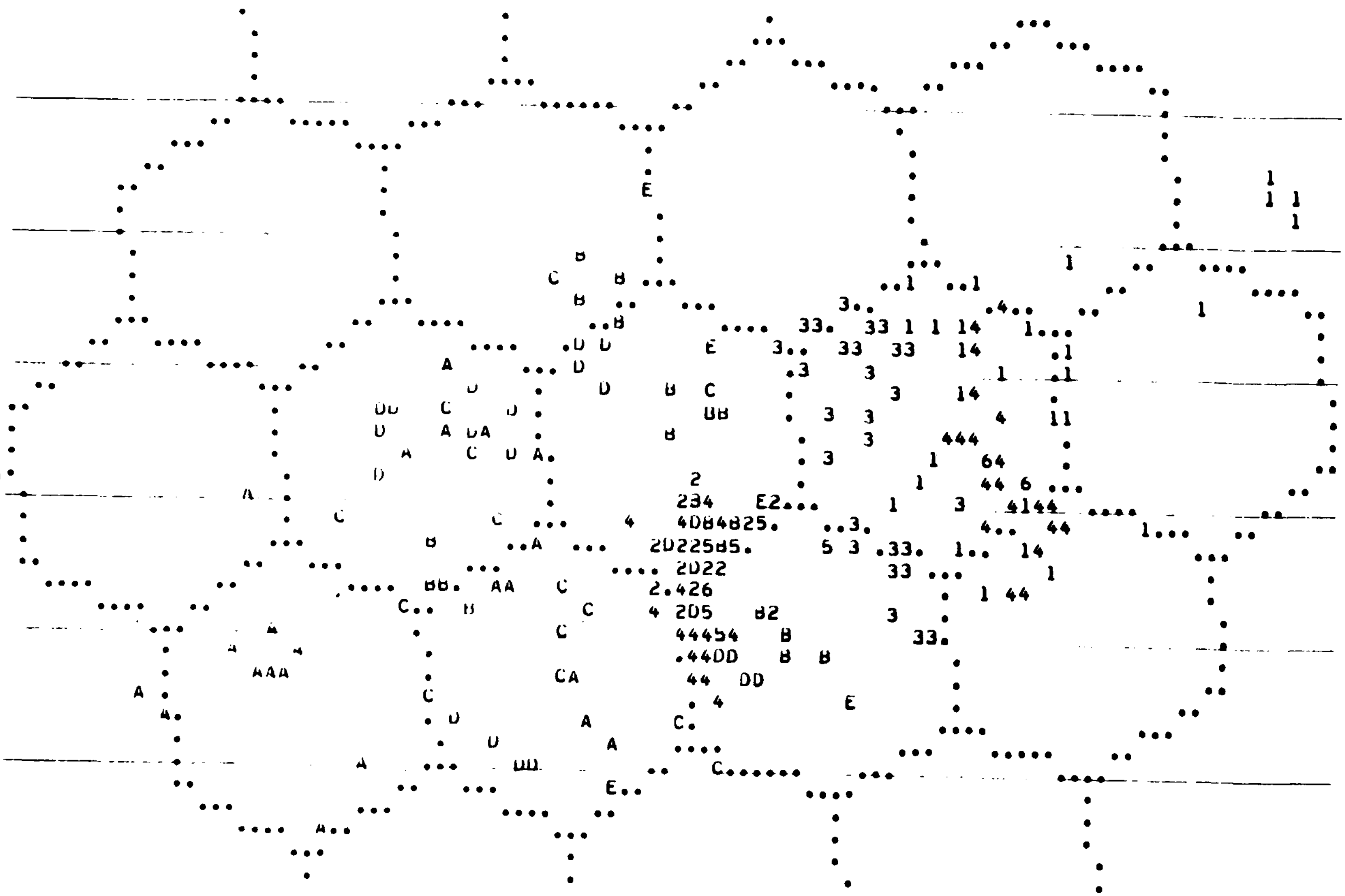


Figure H-4. Case III unit positions at 01:30 hours.

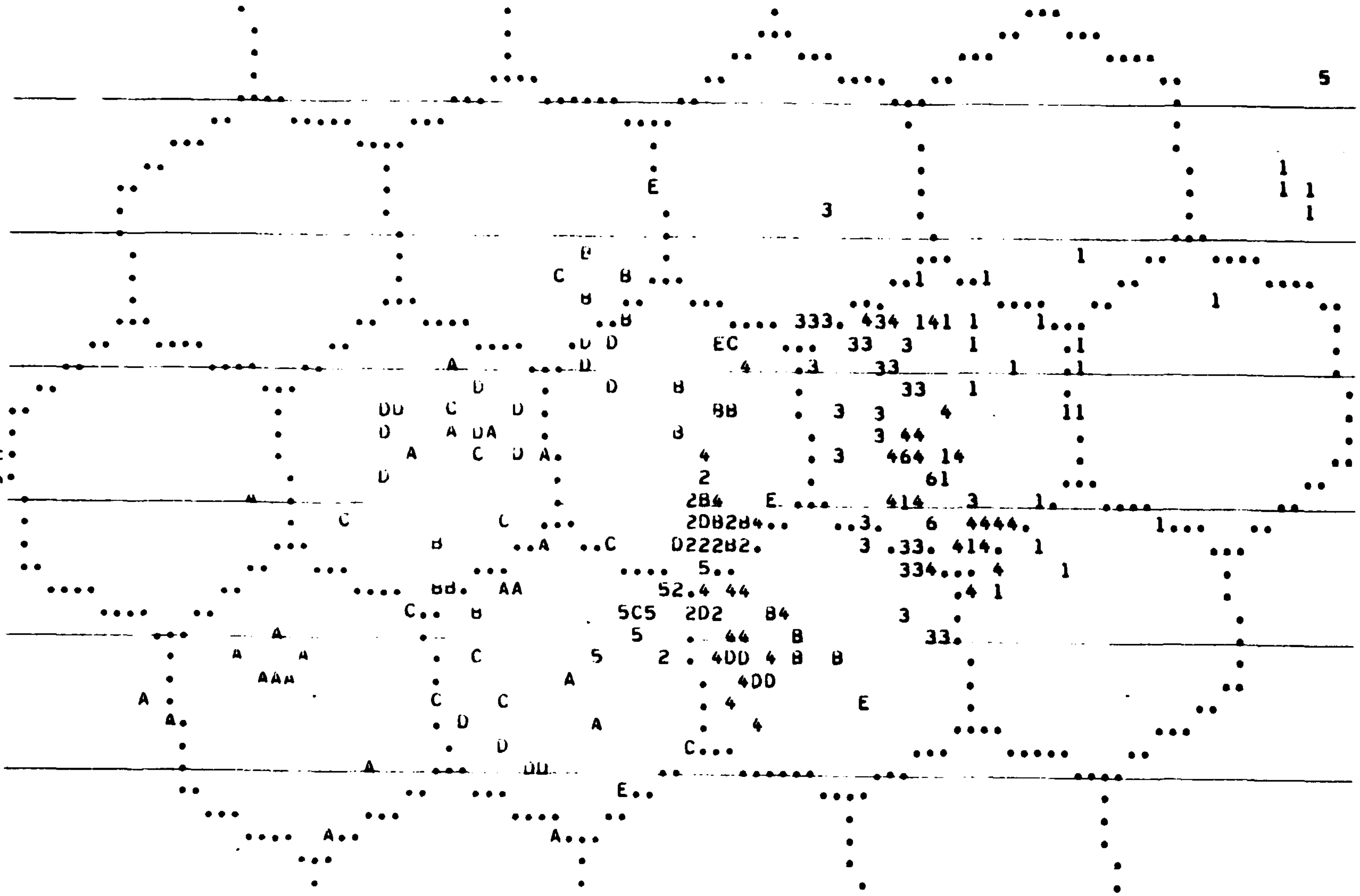


Figure H-5. Case III unit positions at 02:00 hours.

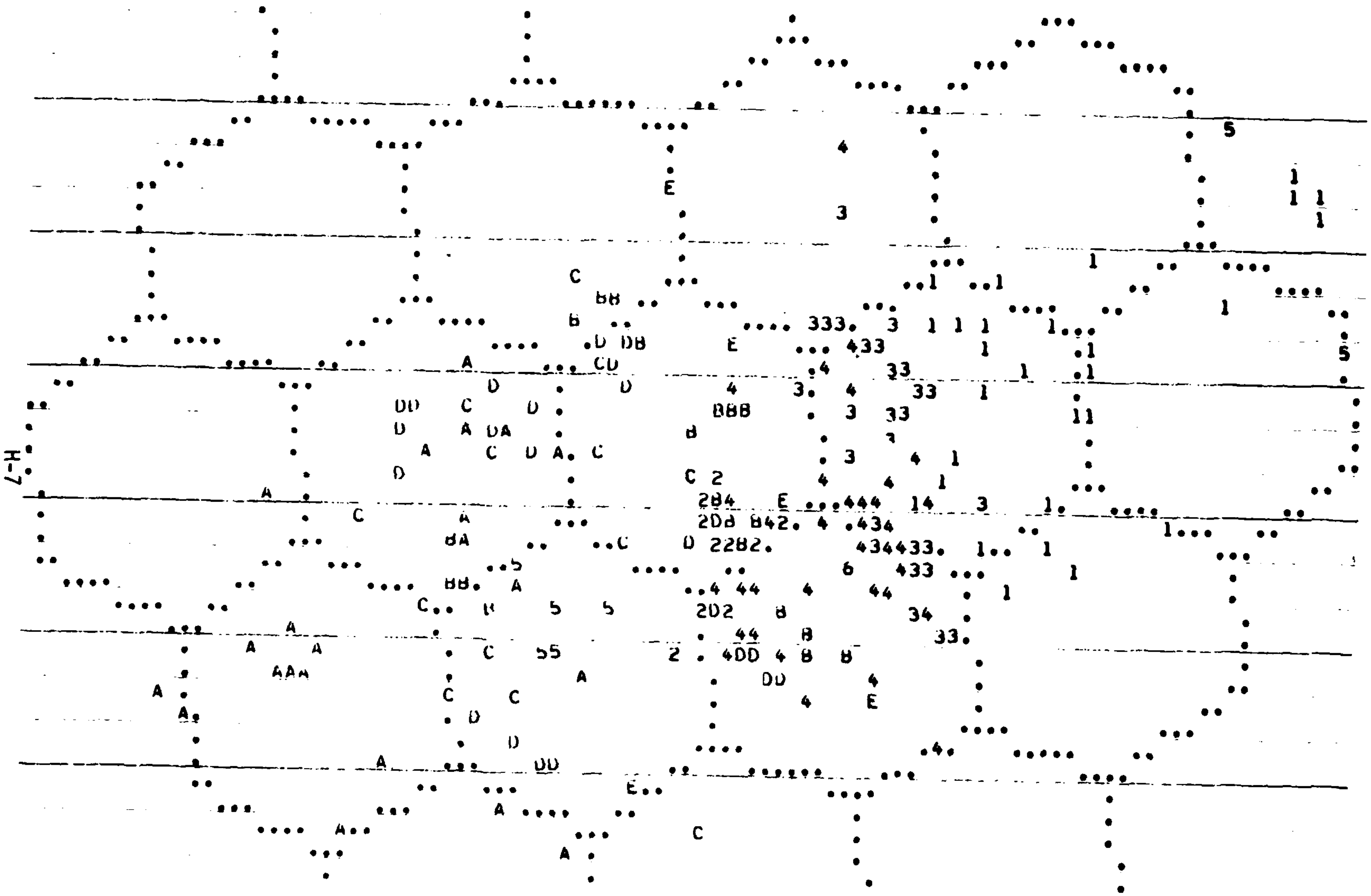


Figure H-6. Case III unit positions at 02:30 hours.

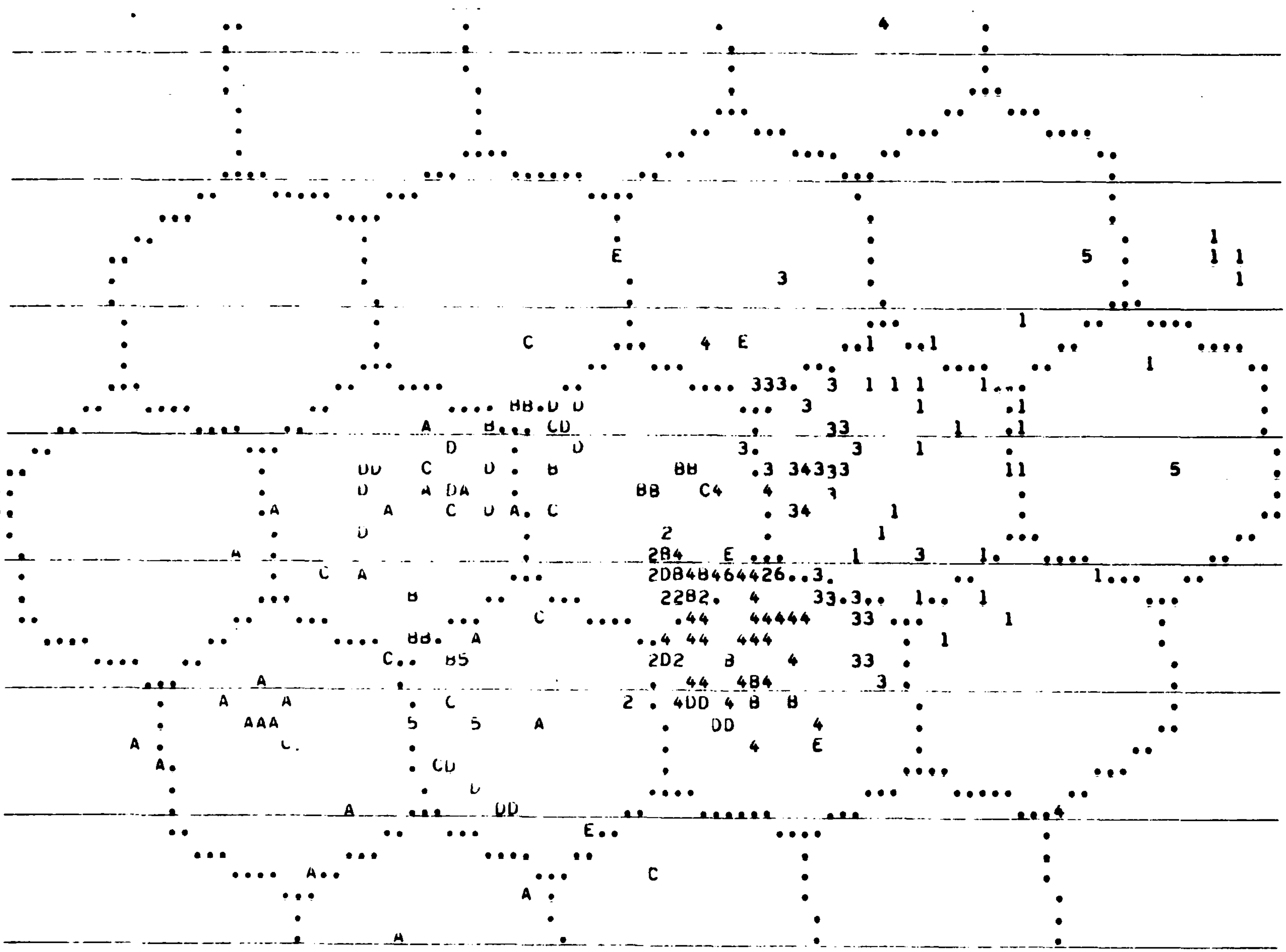


Figure H-7. Case III unit positions at 03:00 hours.

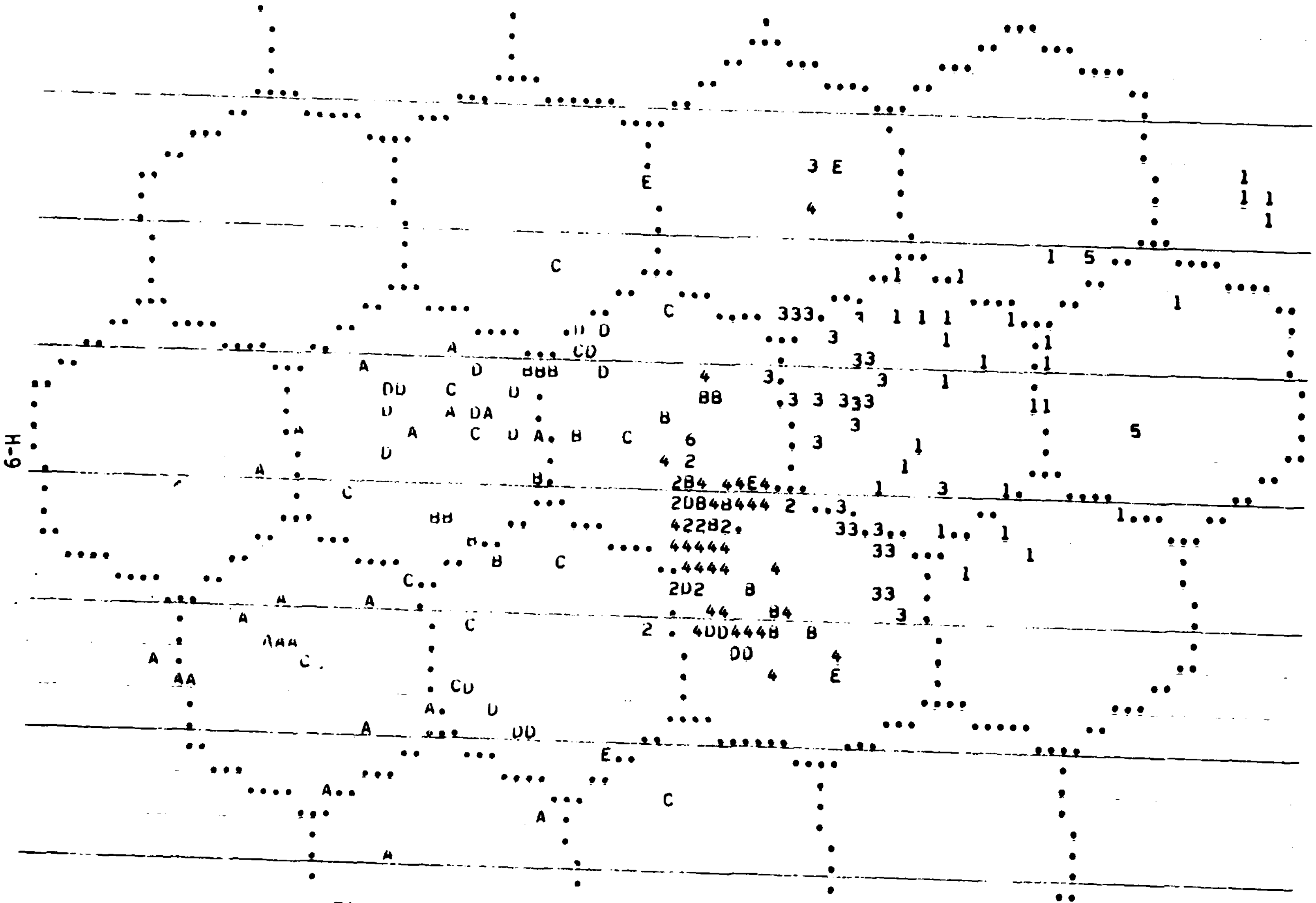


Figure H-8. Case III unit positions at 03:30 hours.

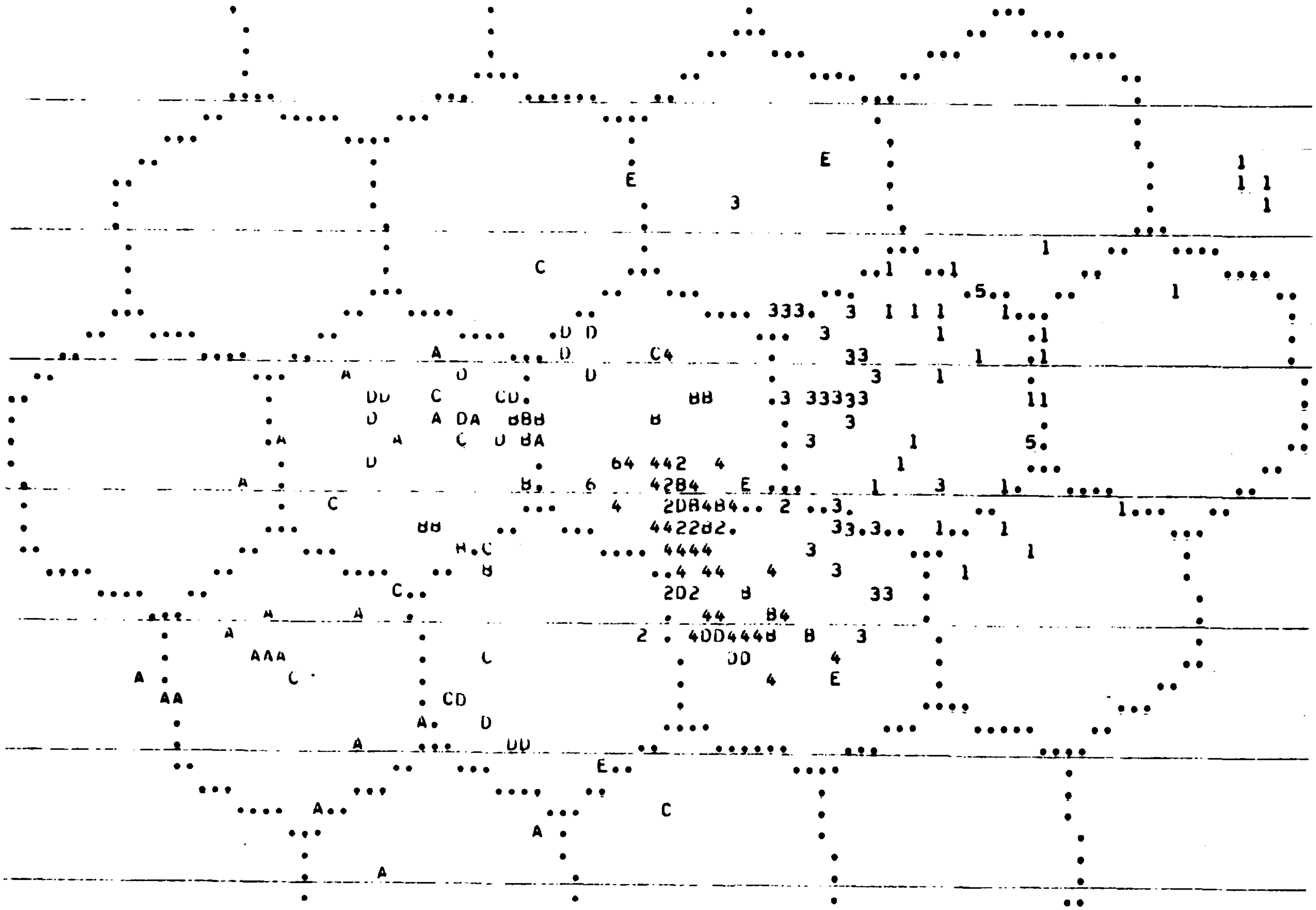


Figure H-9. Case III unit positions at 04:00 hours.

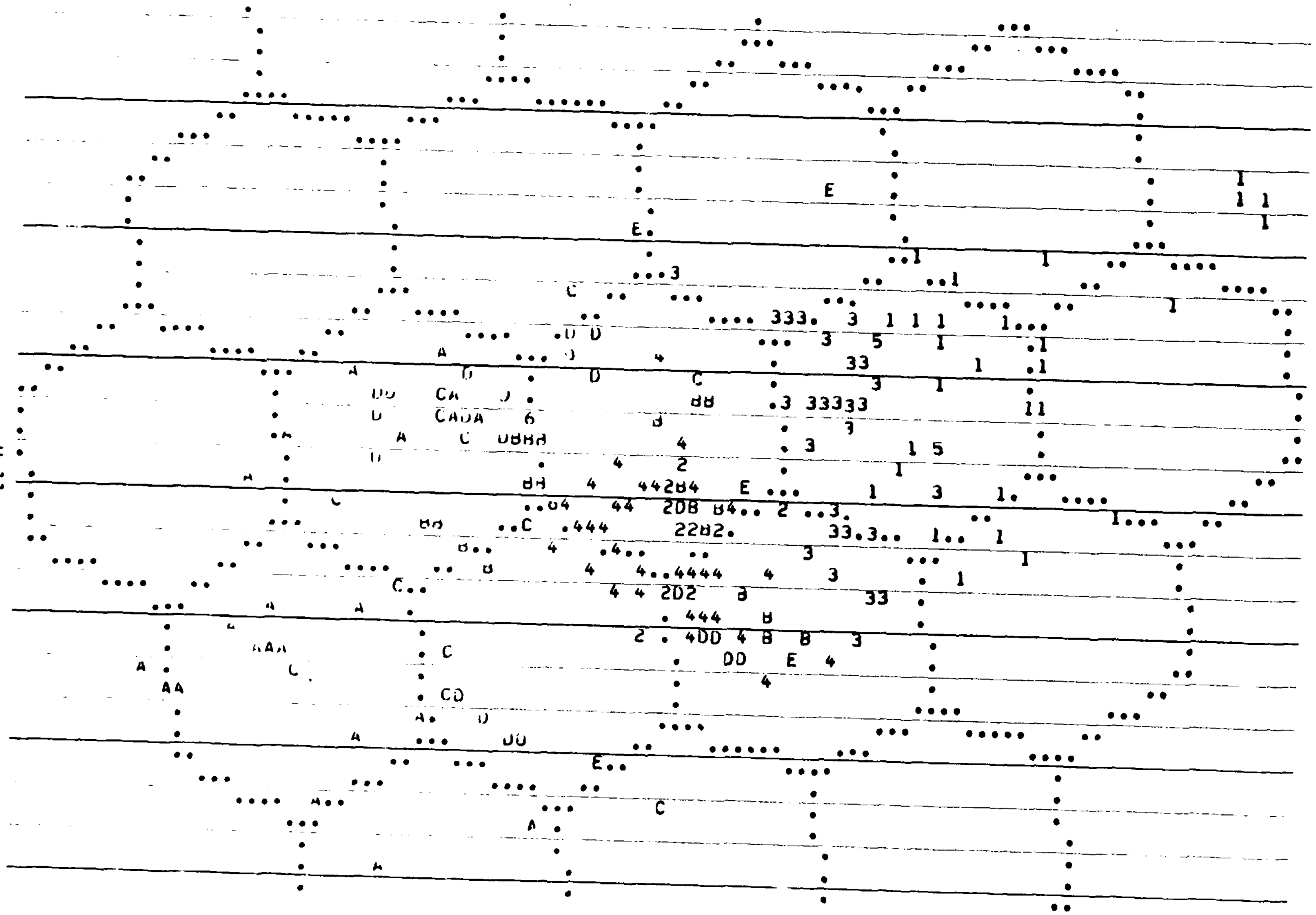


Figure H-10. Case III unit positions at 04:30 hours.

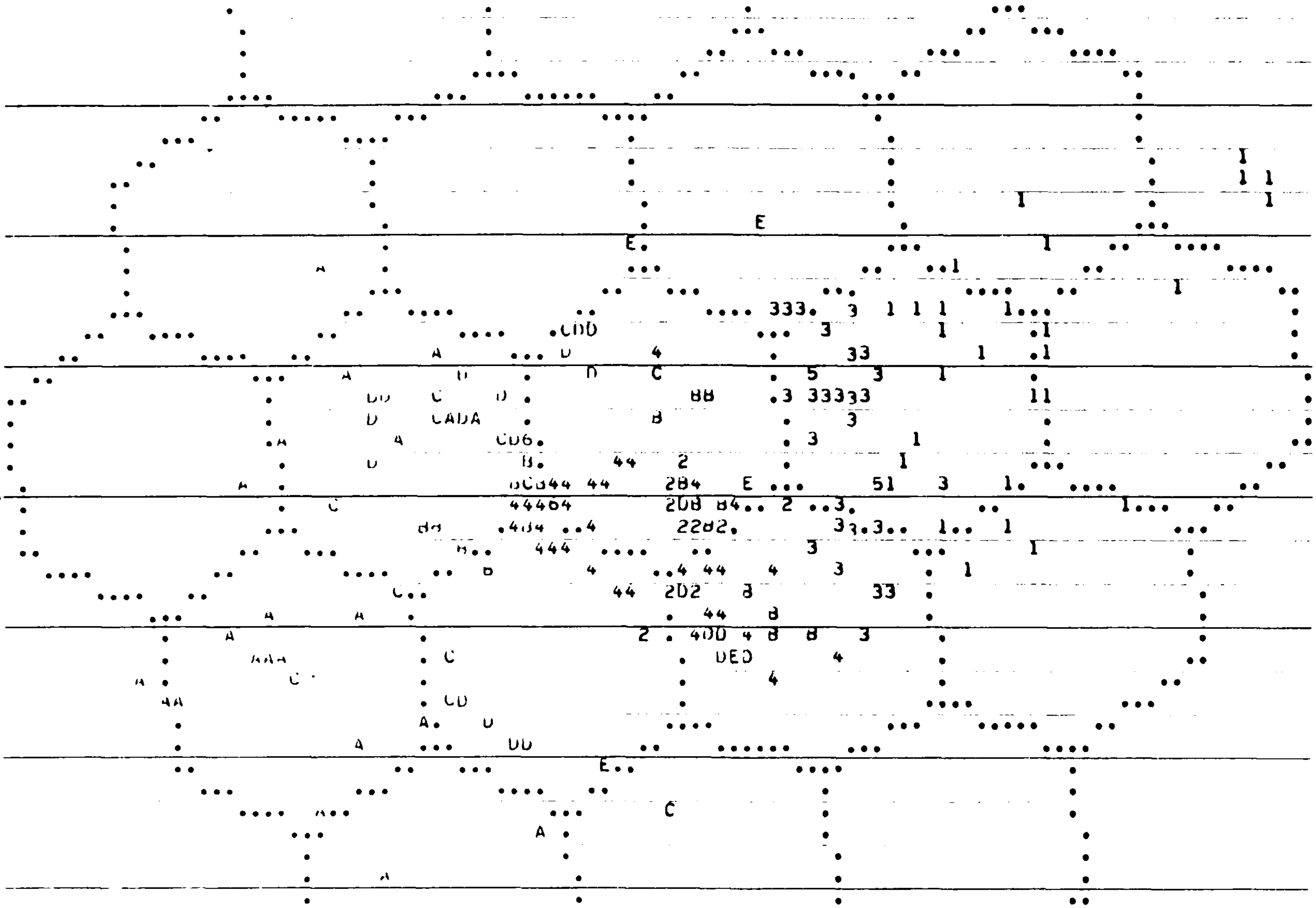


Figure H-11. Case III unit positions at 05:00 hours.

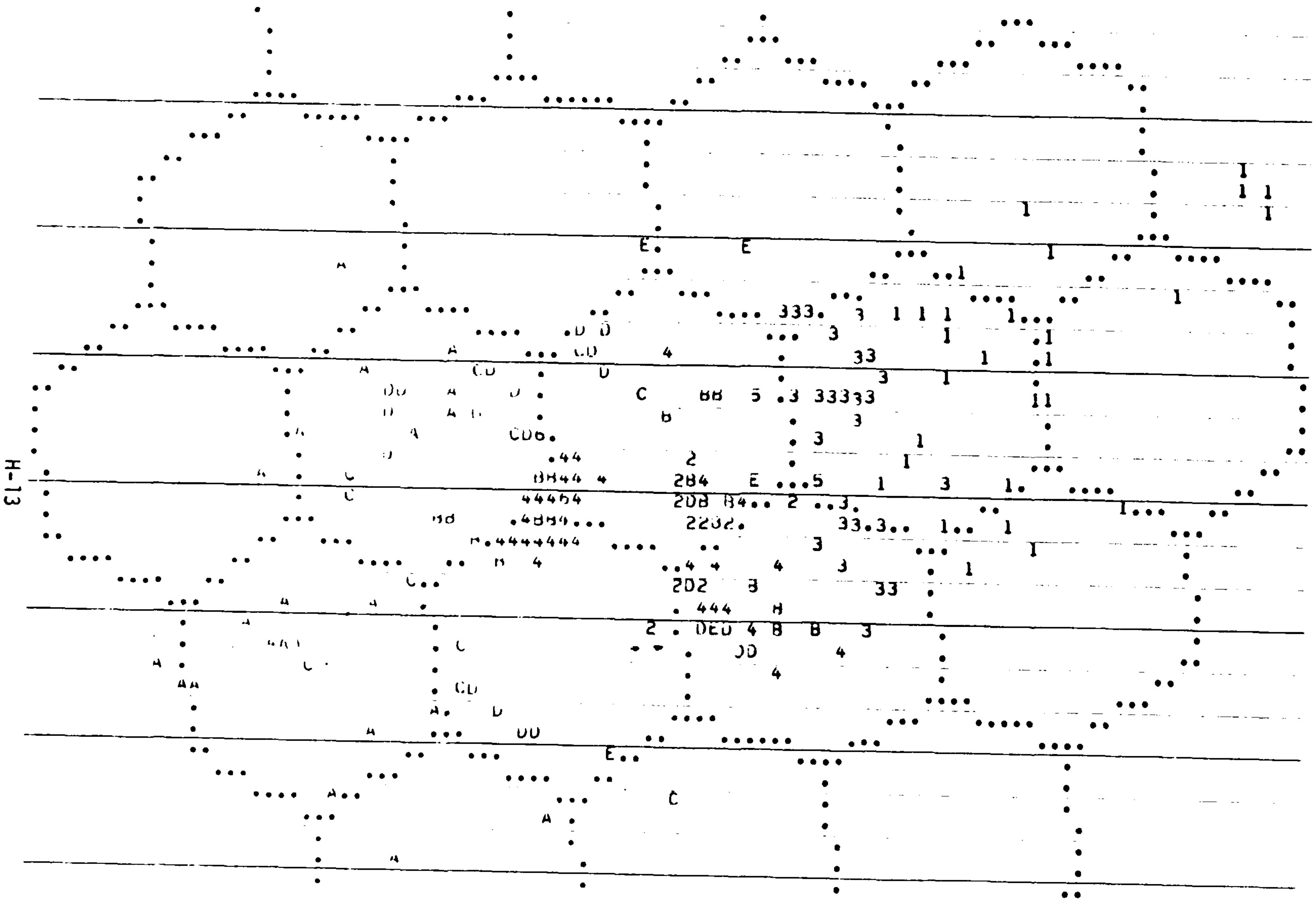


Figure H-12. Case III unit positions at 05:30 hours.

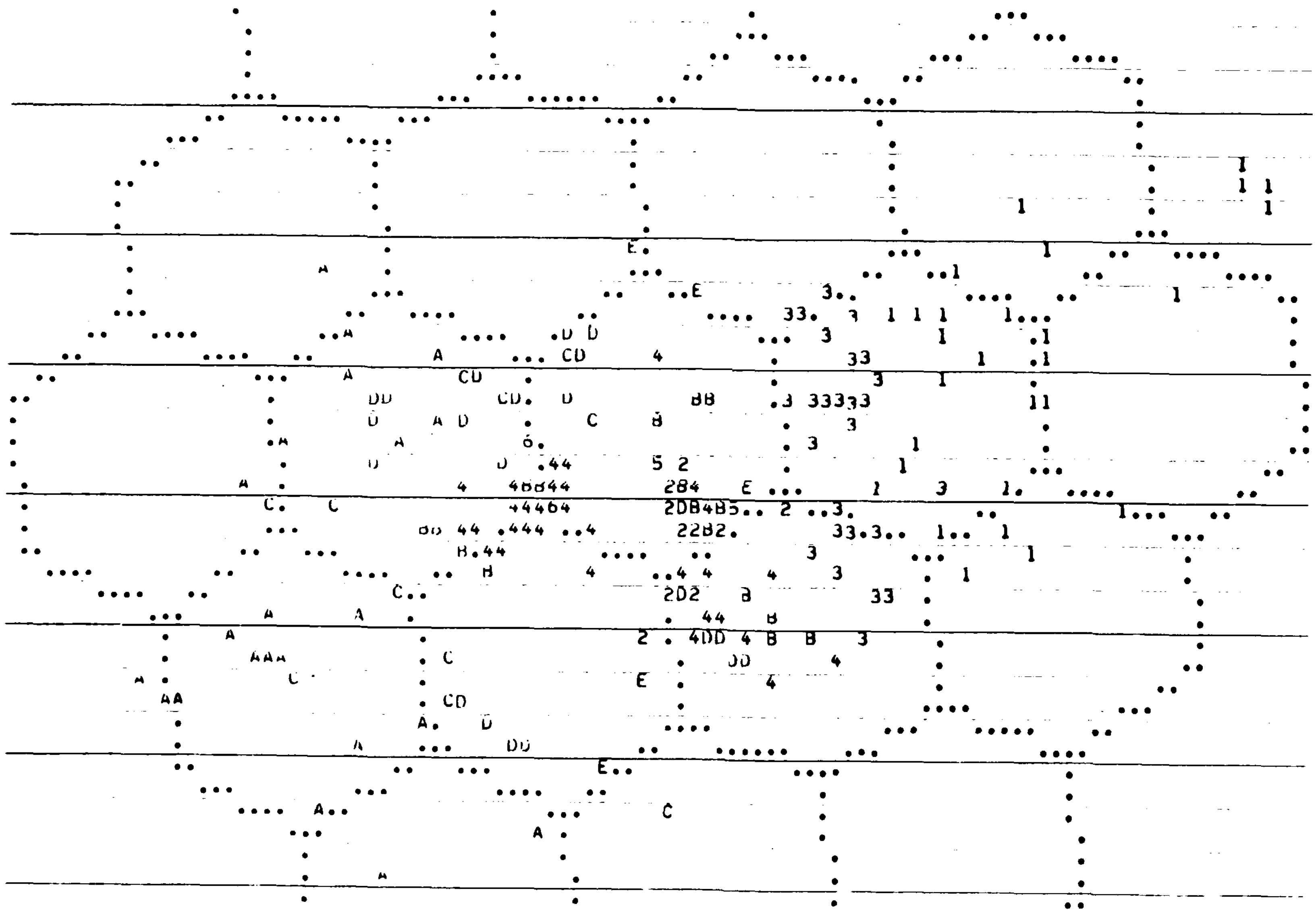


Figure H-13. Case III unit positions at 06:00 hours.

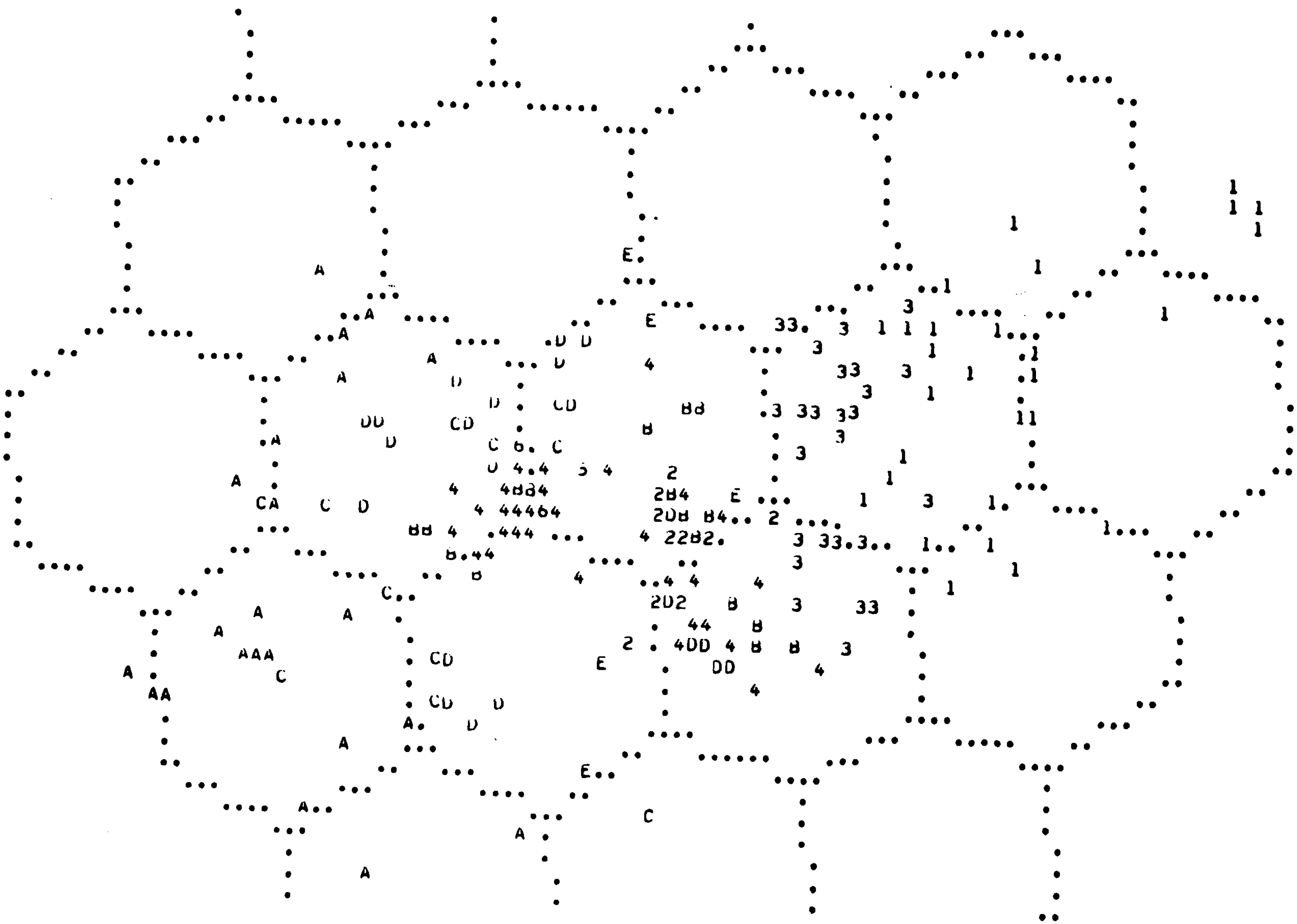


Figure H-14. Case III unit positions at 06:30 hours.

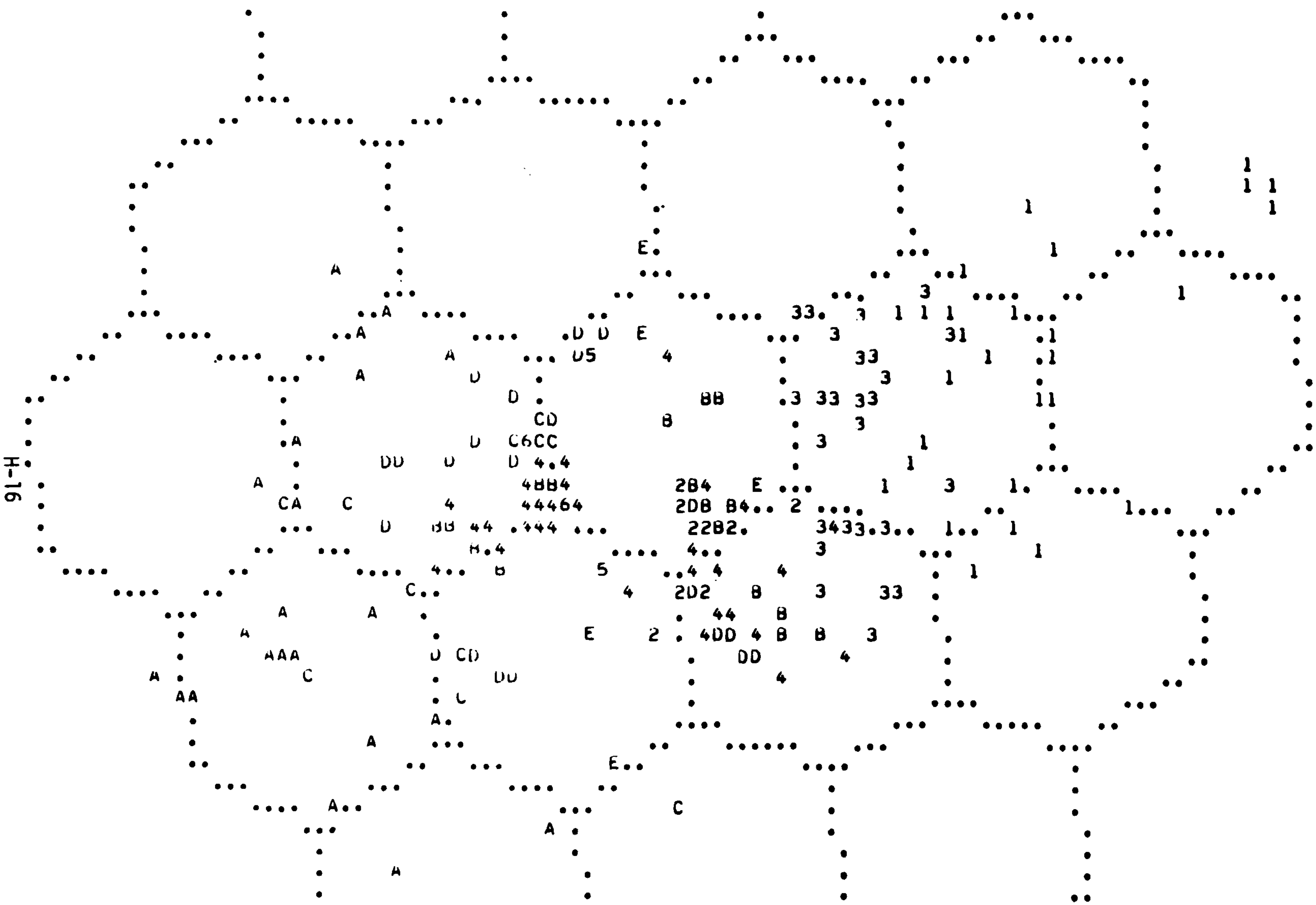


Figure H-15. Case III unit positions at 07:00 hours.

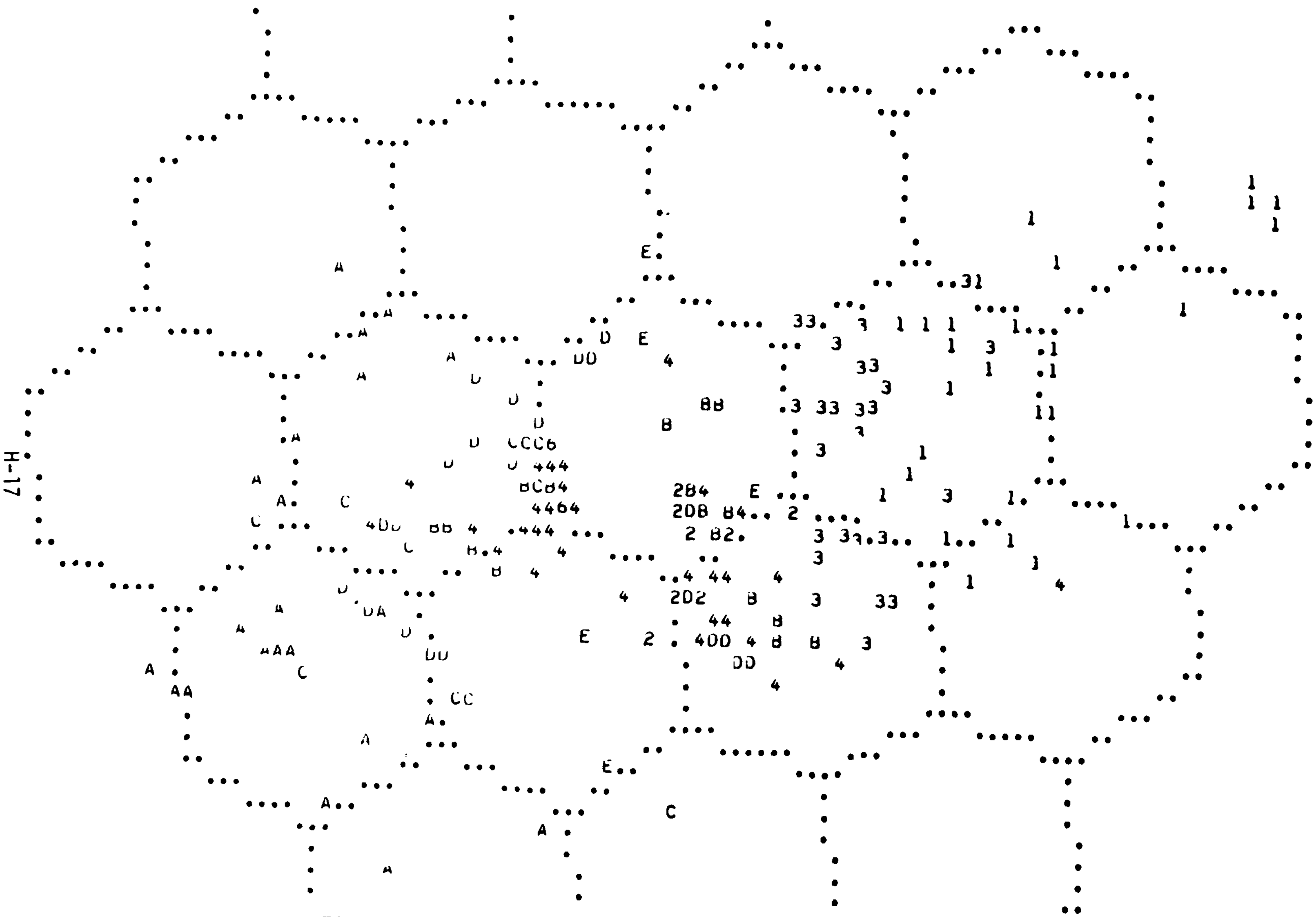


Figure H-16. Case III unit positions at 07:30 hours.

Figure H-17. Case III unit positions at 08:00 hours.

The quality of the original of this map was insufficient to be reproduced.

Figure H-18. Case III unit positions at 08:30 hours.

APPENDIX I

CASE IV TACTICAL POSITION MAPS

The 18 maps presented in this appendix show the dynamic combat positions of both combatants at the company/battery level from zero to 0830 hours in one-half hour increments. Legend and other pertinent information concerning these maps is the same as for Case I, Appendix F.

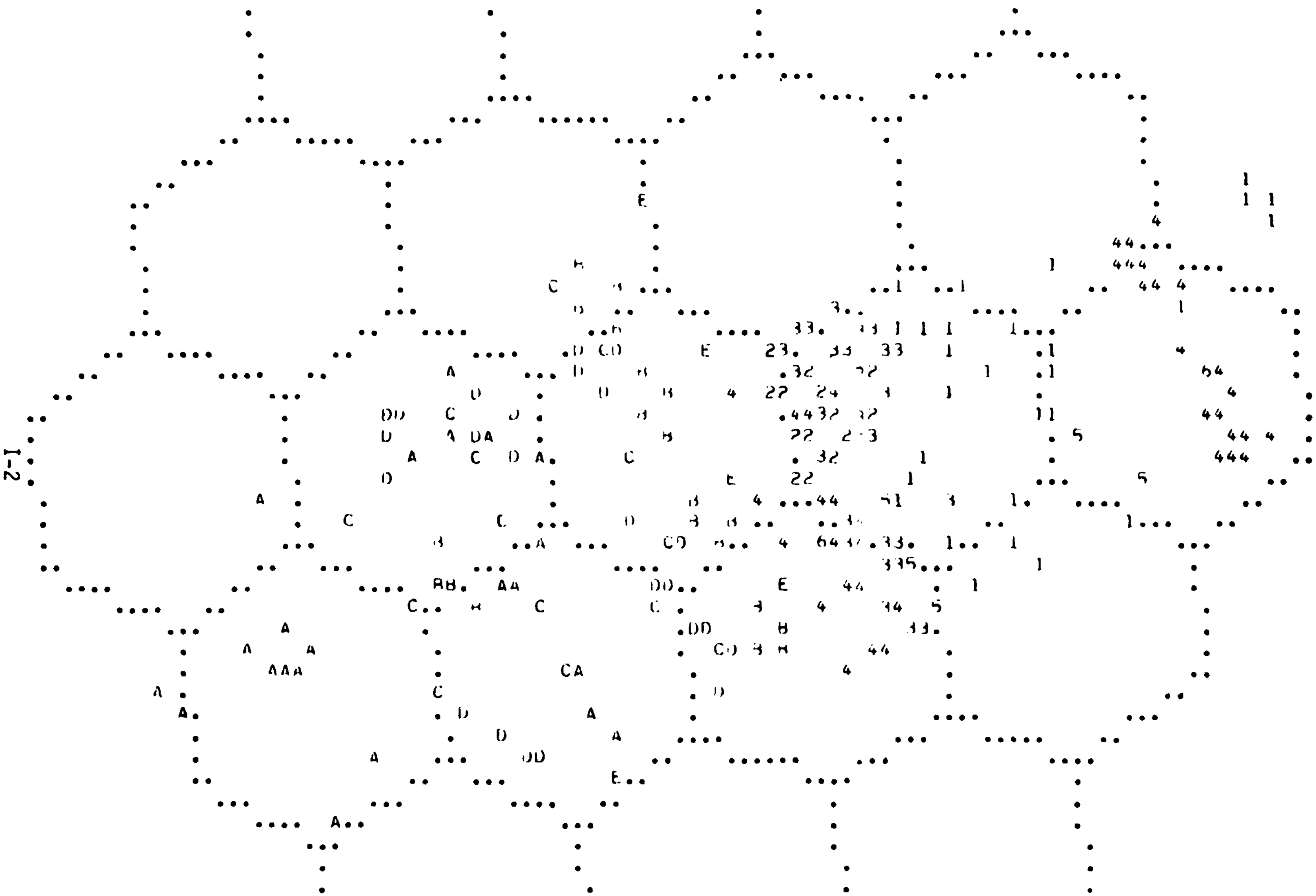


Figure I-1. Case IV unit positions at 00:00 hours.

The quality of the original of this map
was insufficient to be reproduced.

Figure I-2. Case IV unit positions at 00:30 hours.

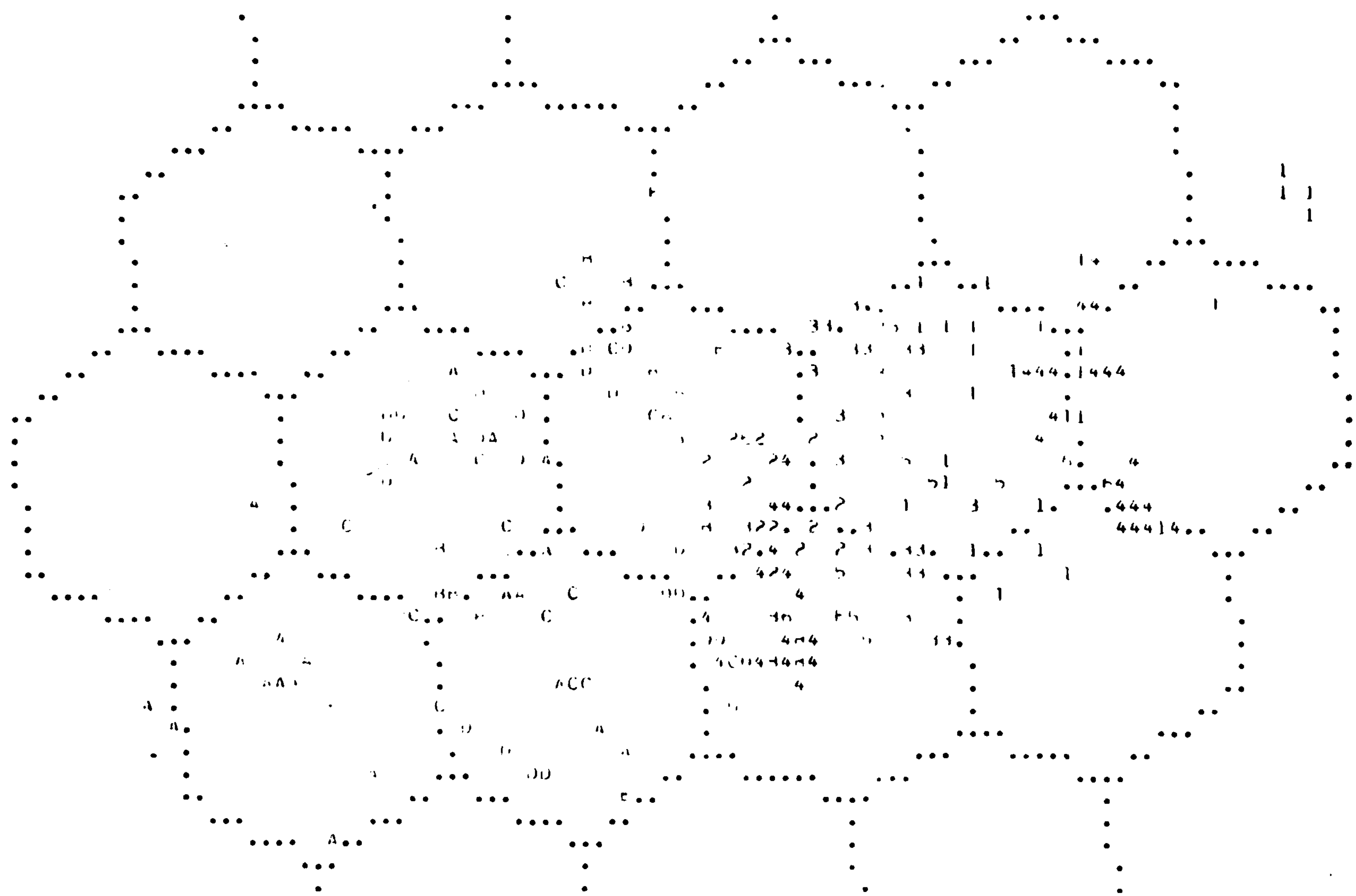


Figure I-3. Case IV unit positions at 01:00 hours.

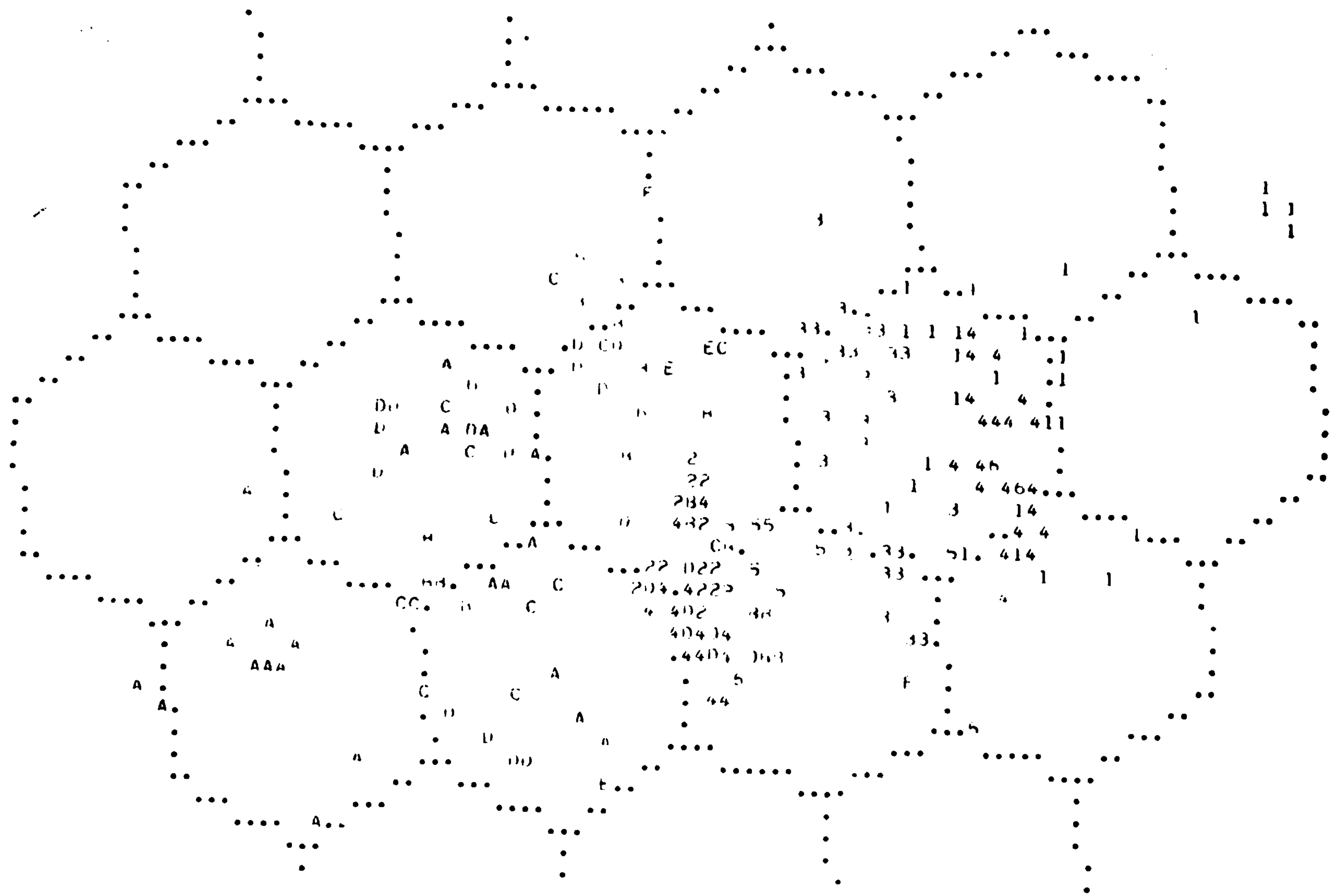


Figure I-4. Case IV unit positions at 01:30 hours.

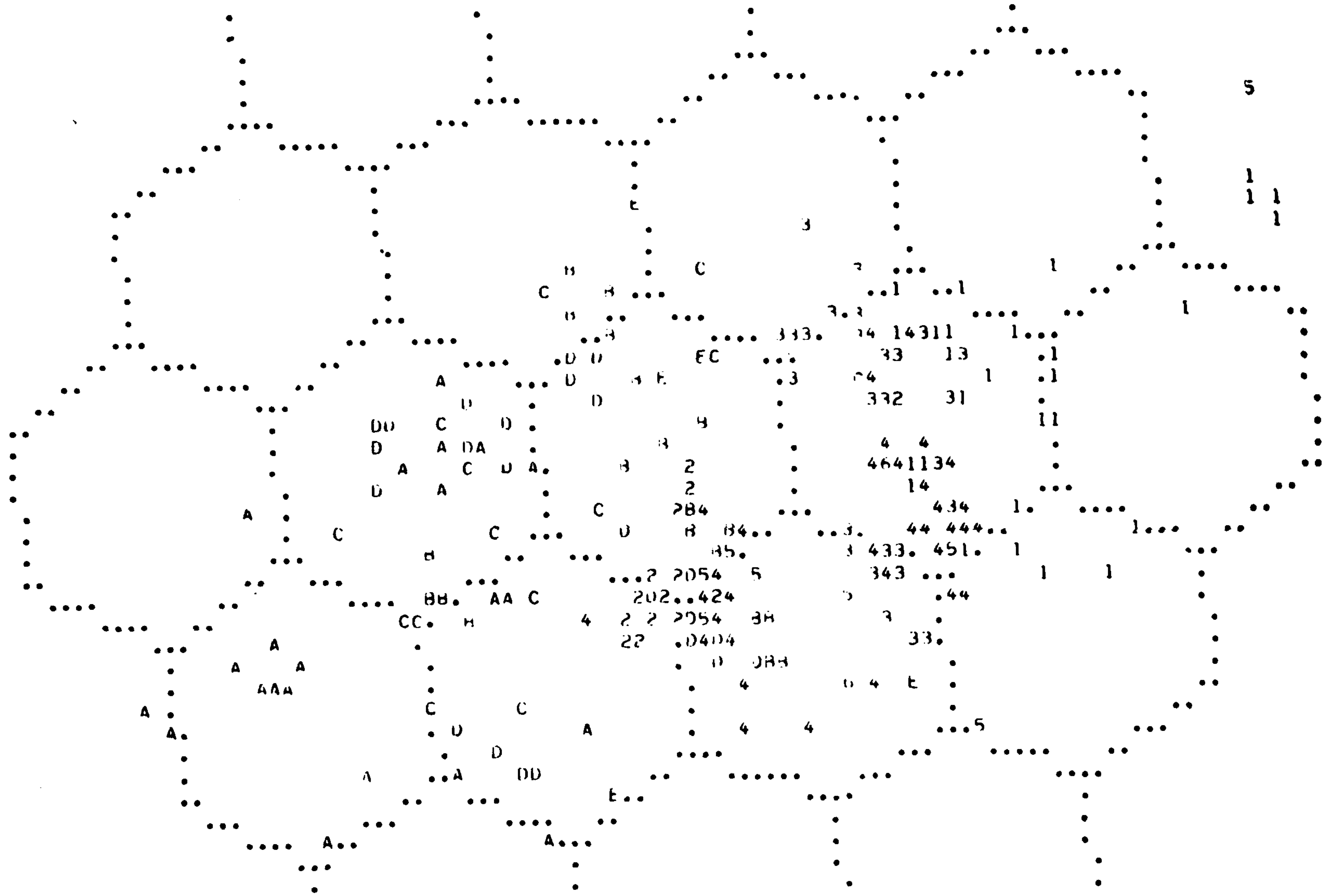


Figure I-5. Case IV unit positions at 02:00 hours.

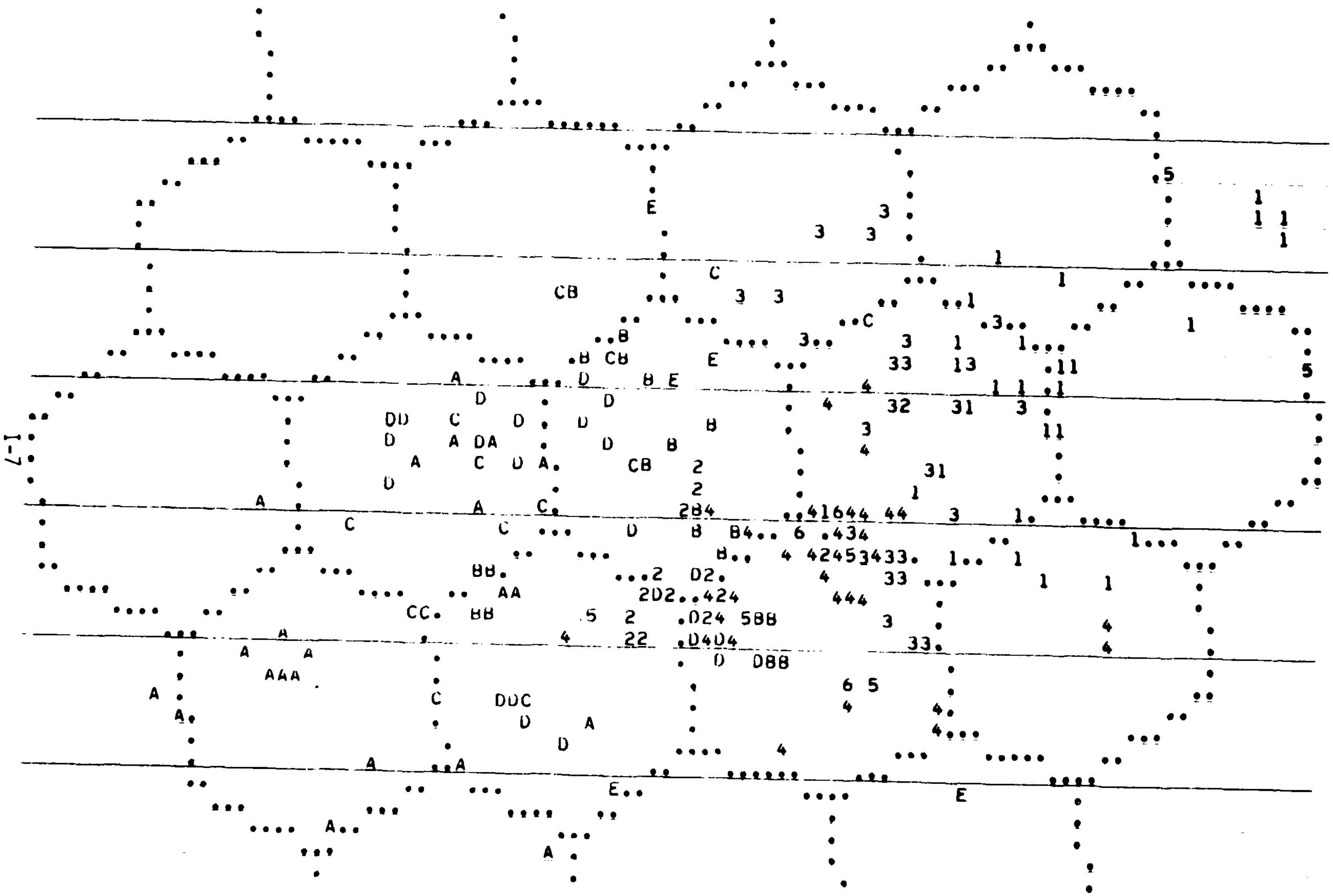


Figure I-6. Case IV unit positions at 02:30 hours.

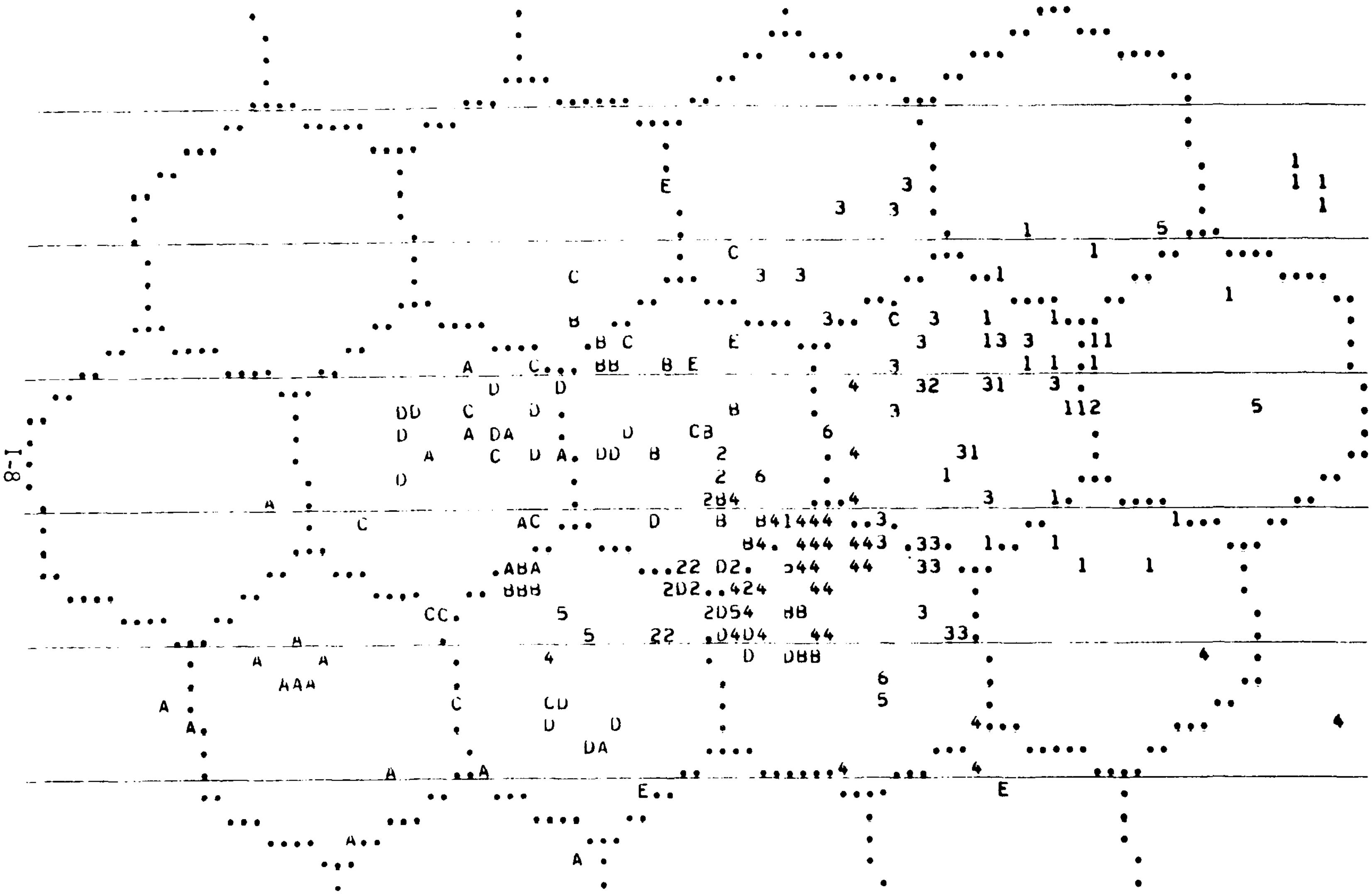


Figure I-7. Case IV unit positions at 03:00 hours.

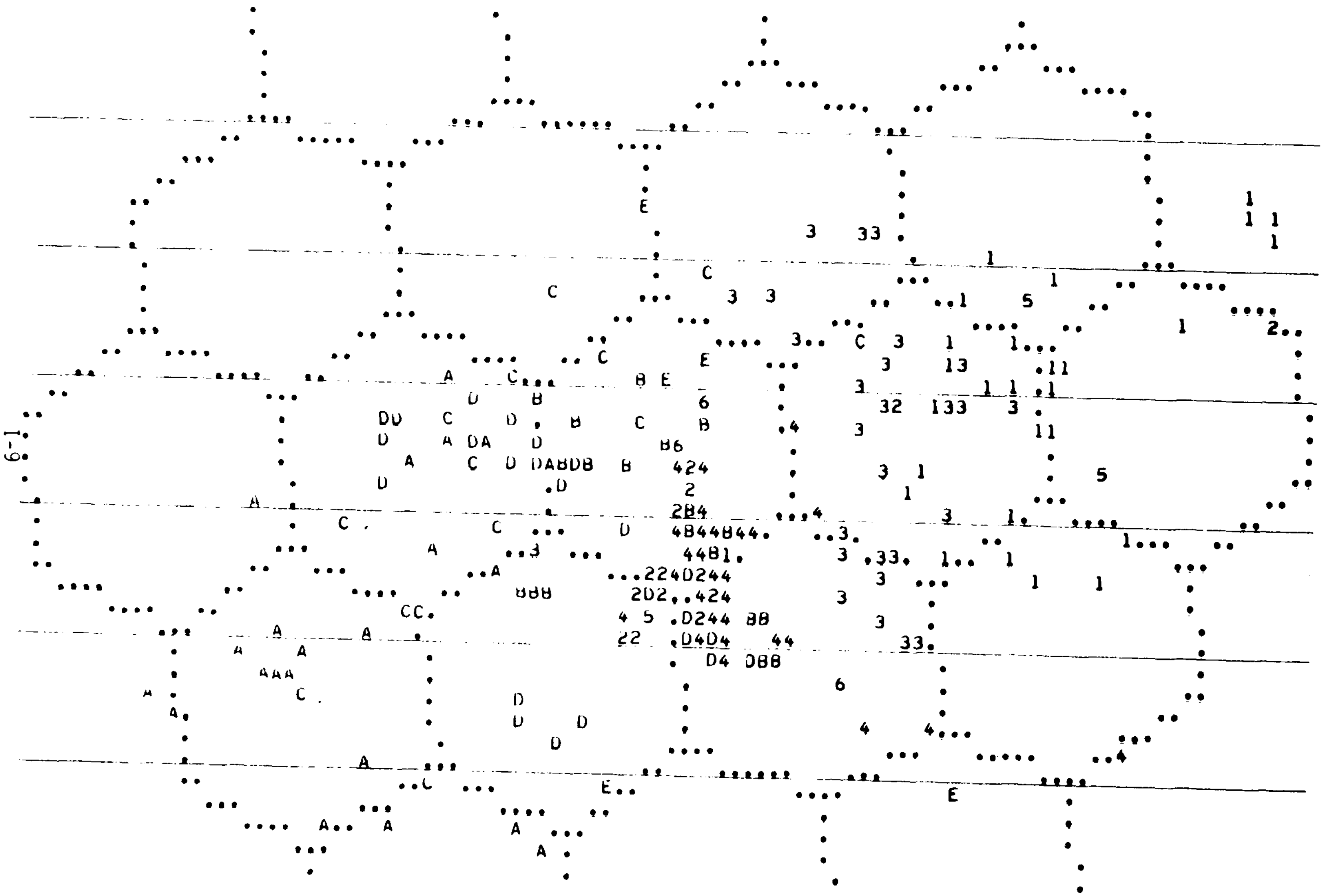


Figure I-8. Case IV unit positions at 03:30 hours.

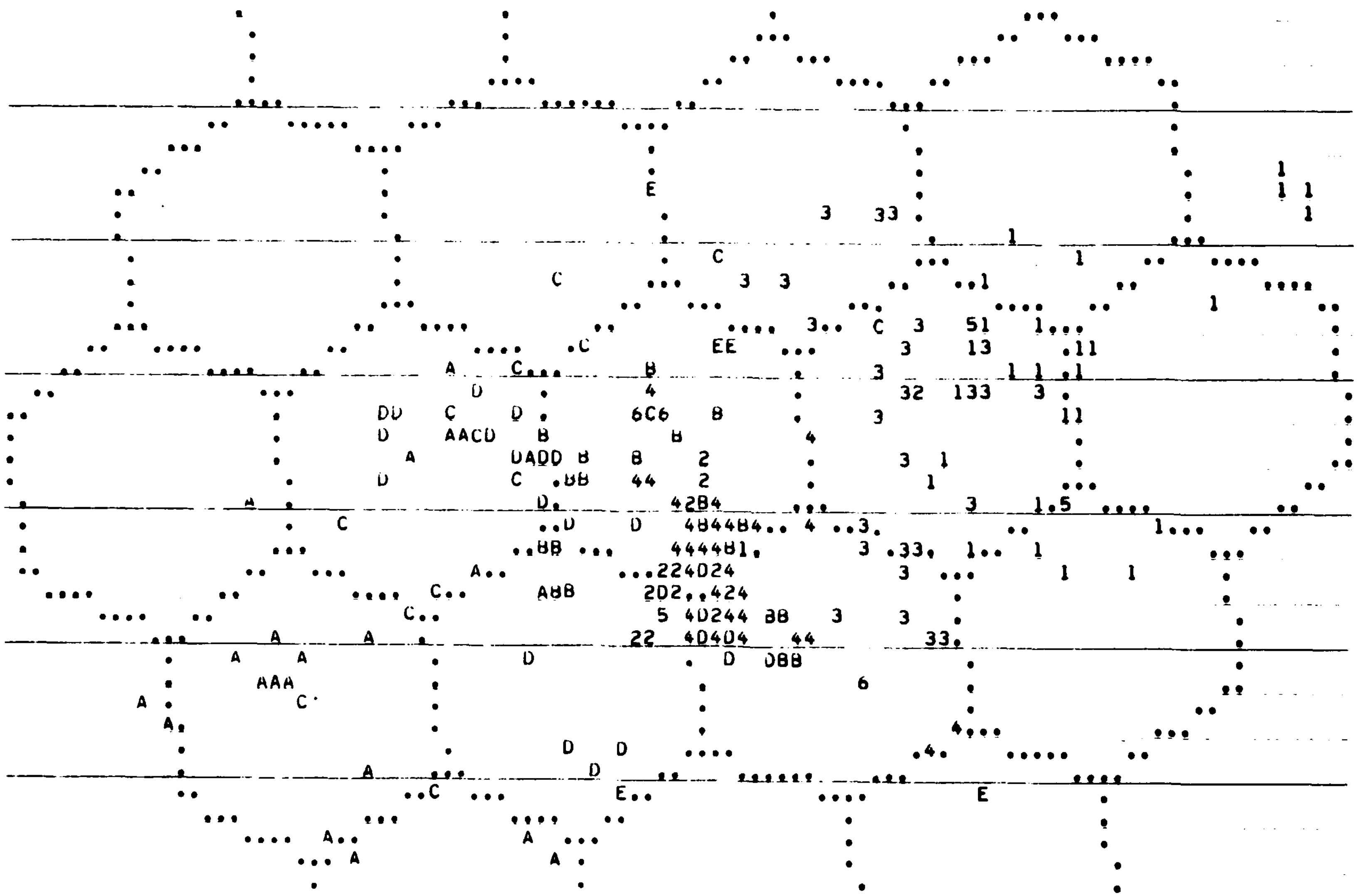


Figure I-9. Case IV unit positions at 04:00 hours.

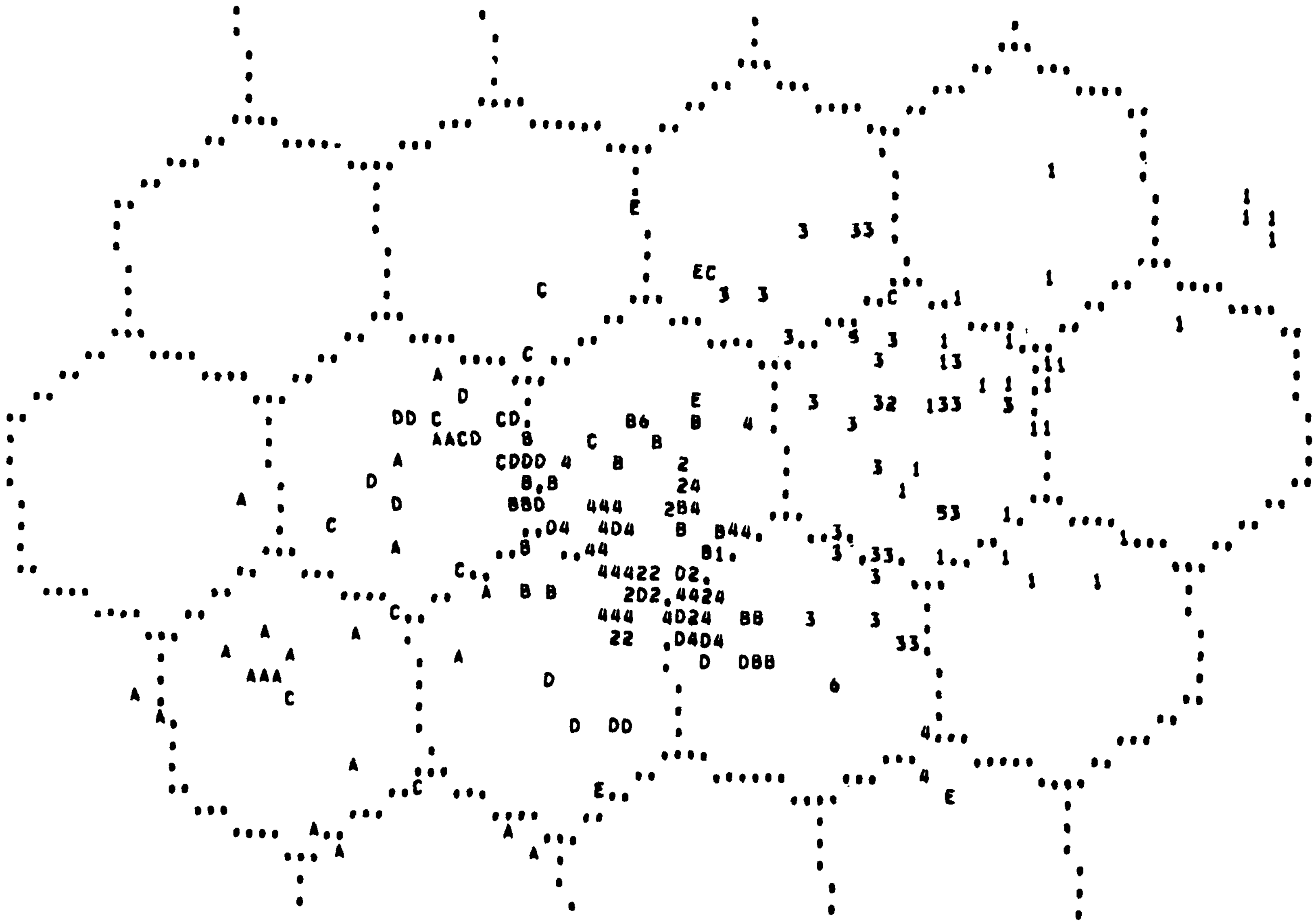


Figure I-10. Case IV unit positions at 04:30 hours.

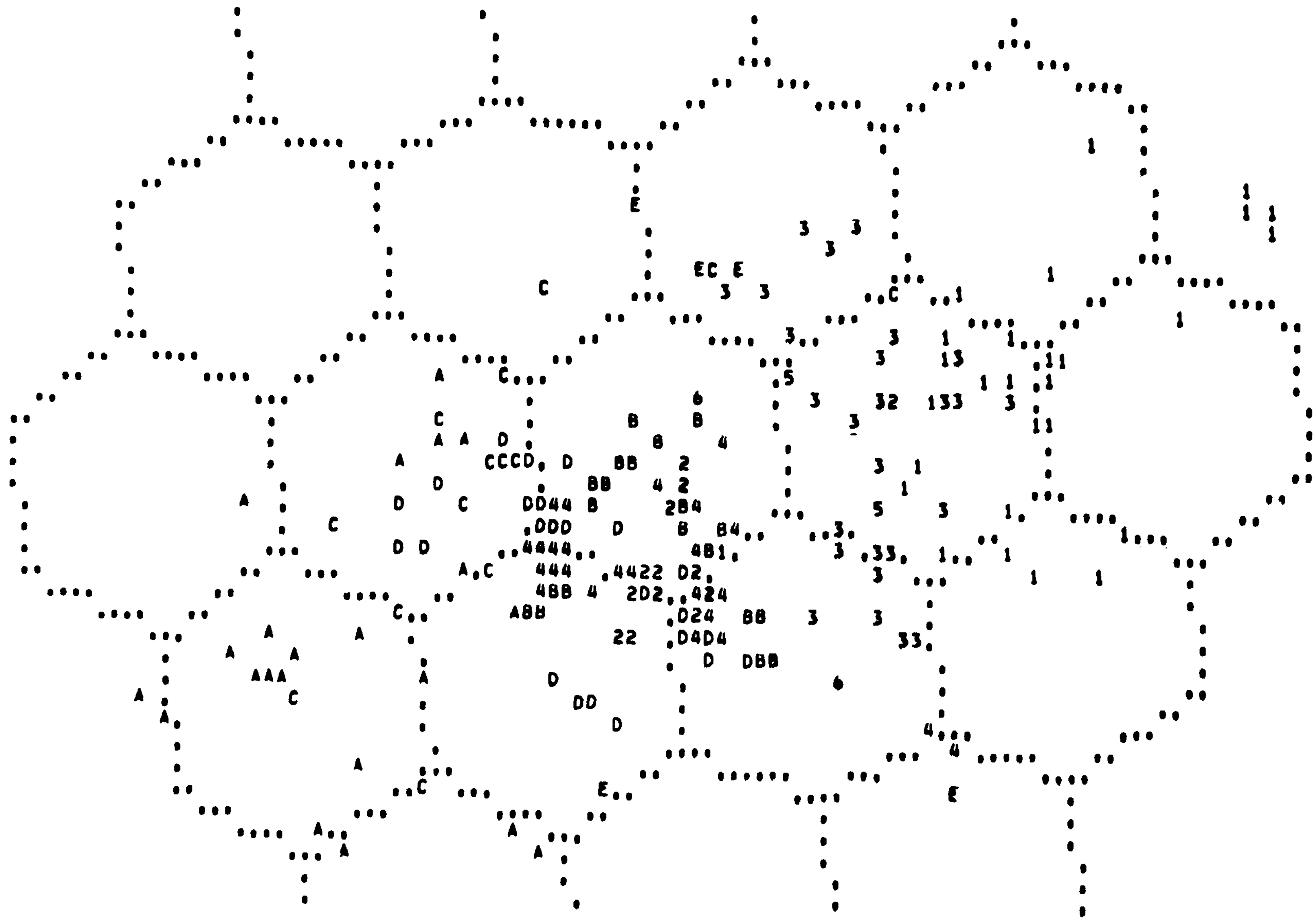


Figure I-11. Case IV unit positions at 05:00 hours.

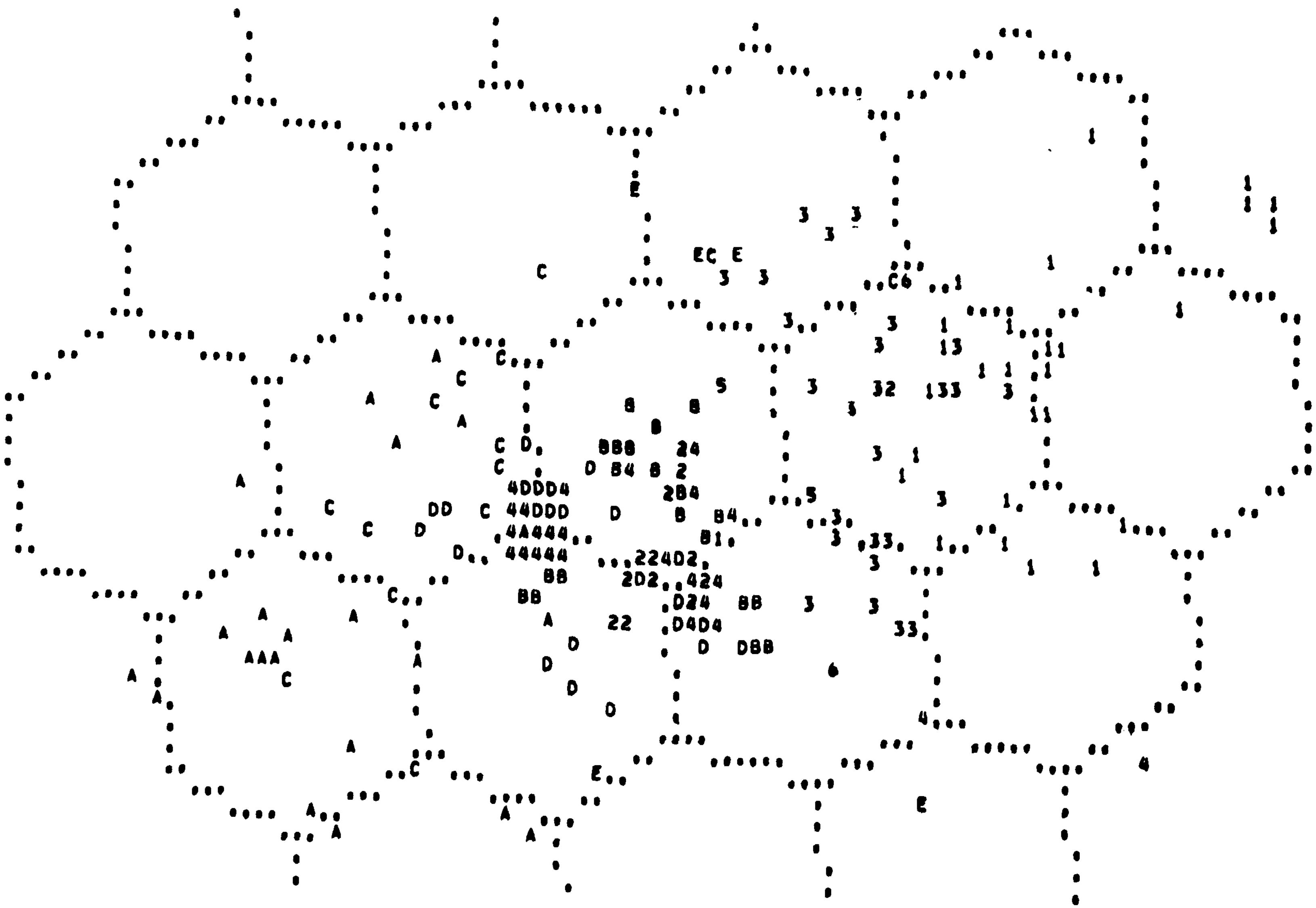


Figure I-12. Case IV unit positions at 05:30 hours.

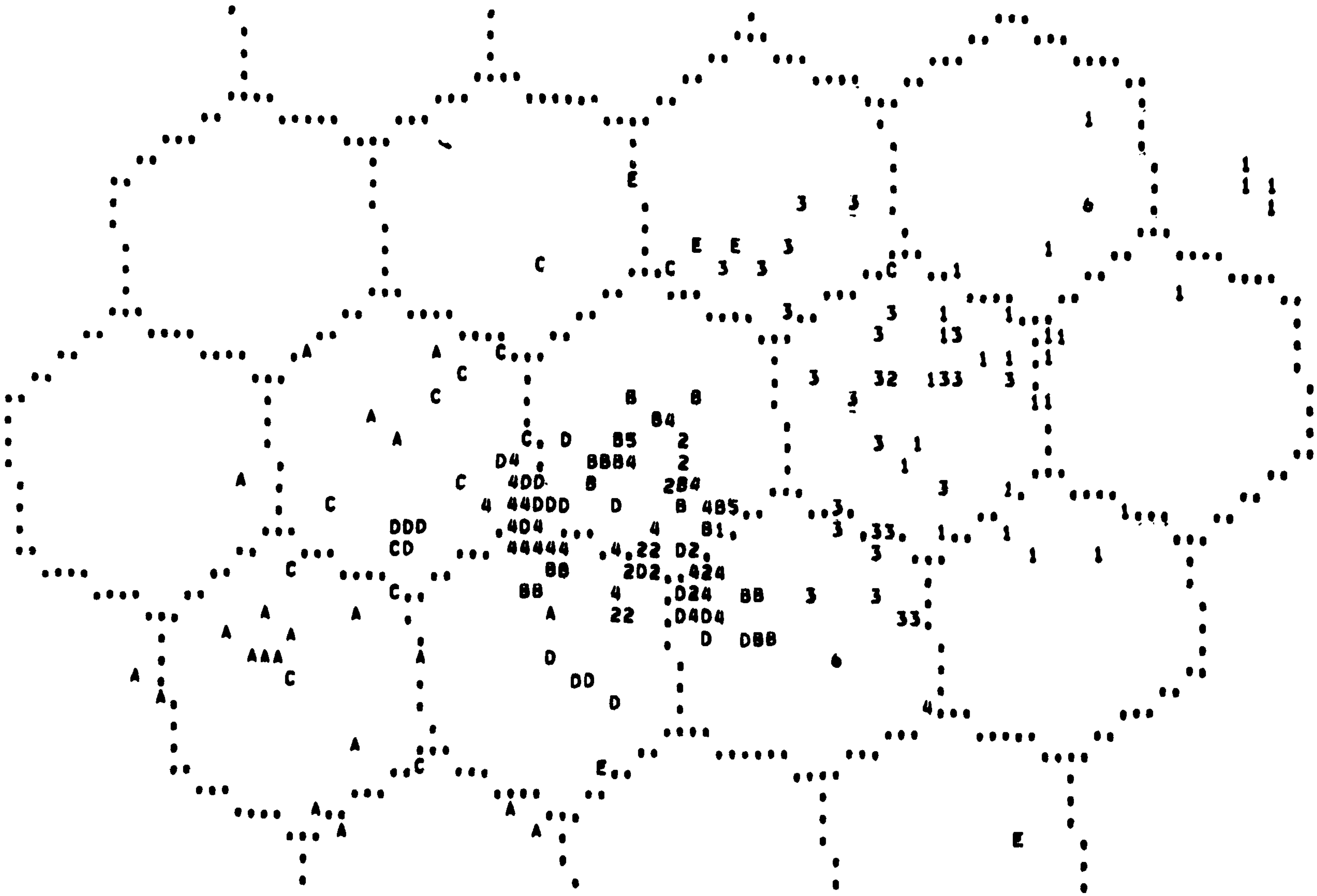


Figure I-13. Case IV unit positions at 06:00 hours.

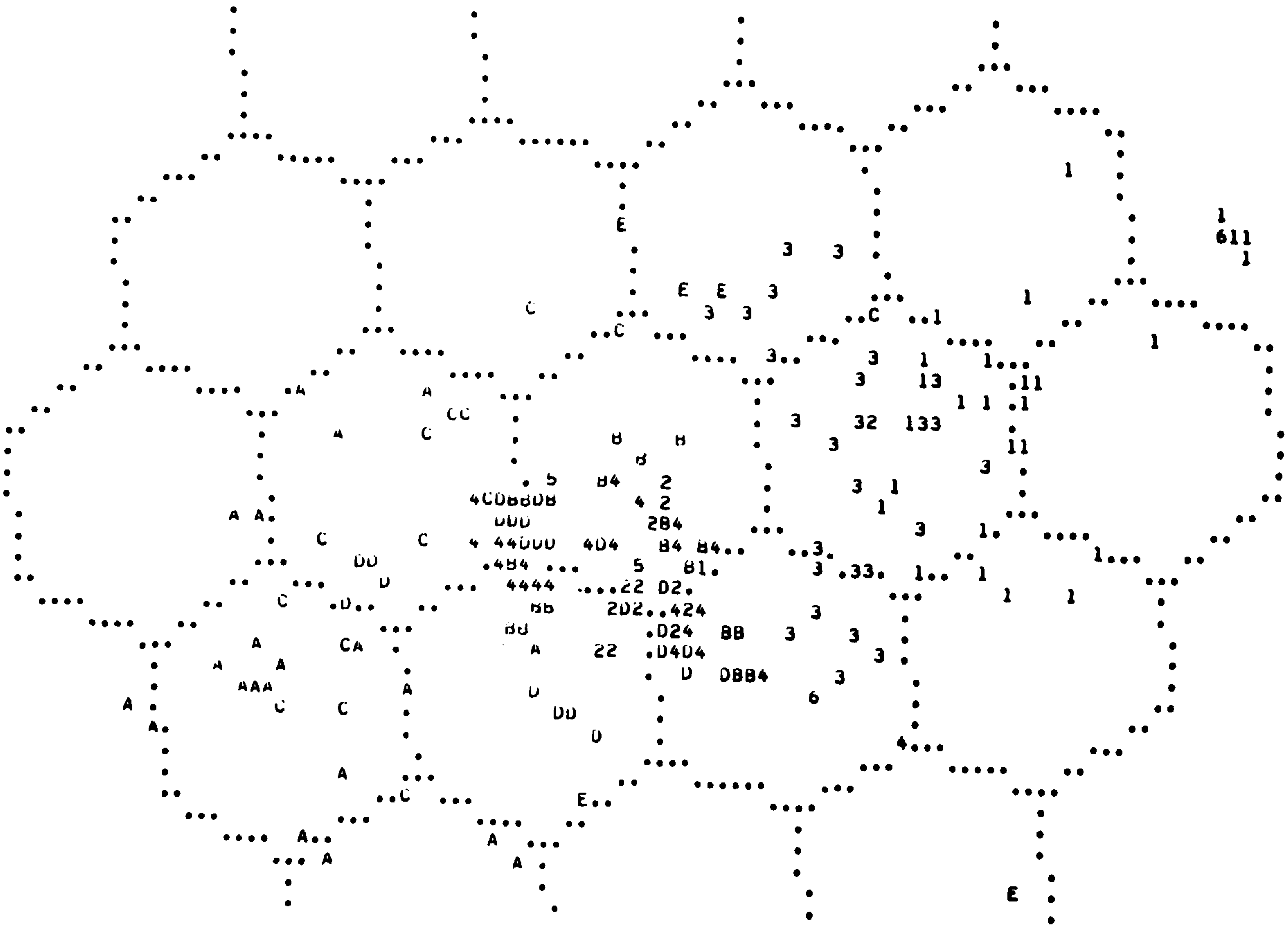


Figure I-14. Case IV unit positions at 06:30 hours.

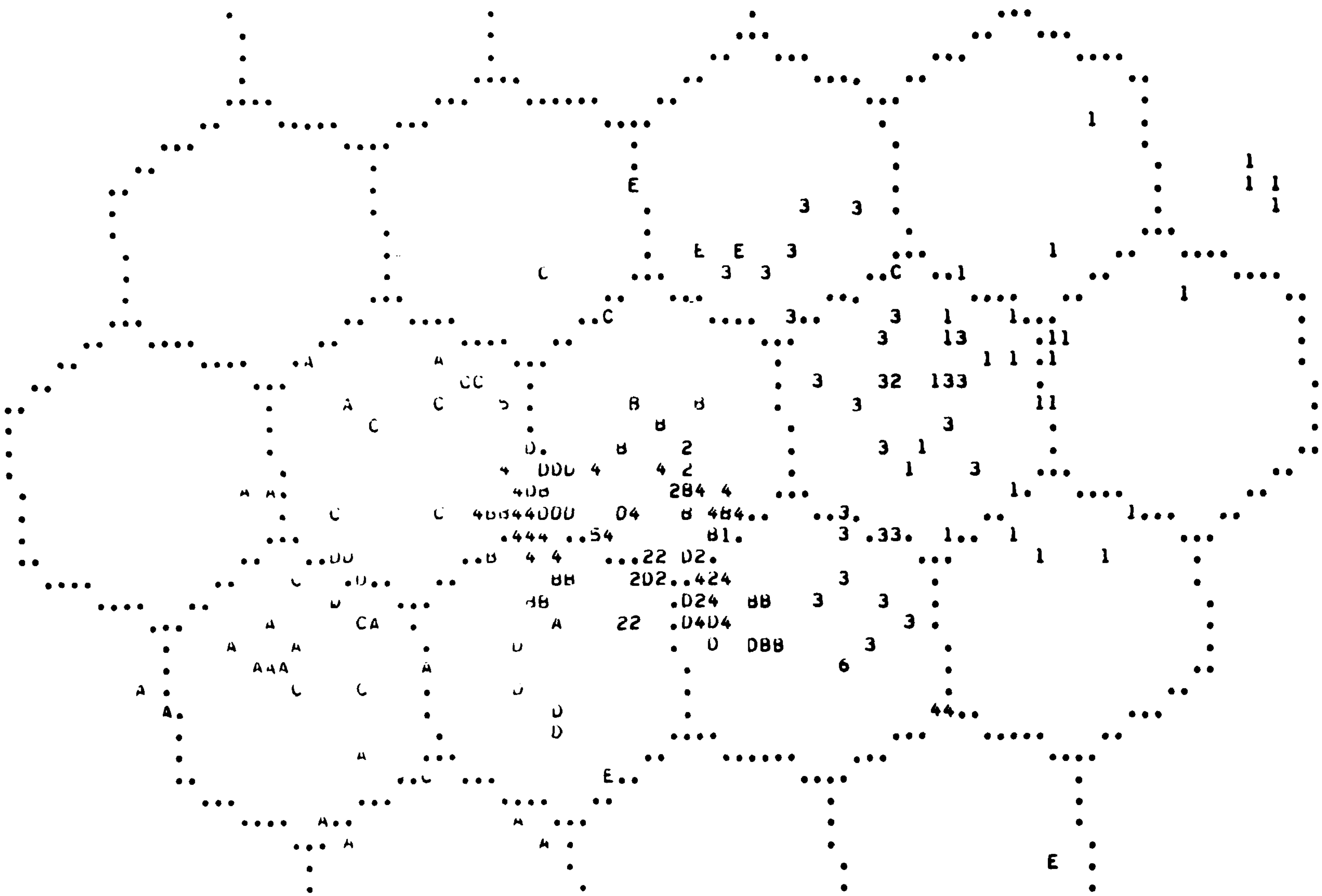


Figure I-15. Case IV unit positions at 07:00 hours.

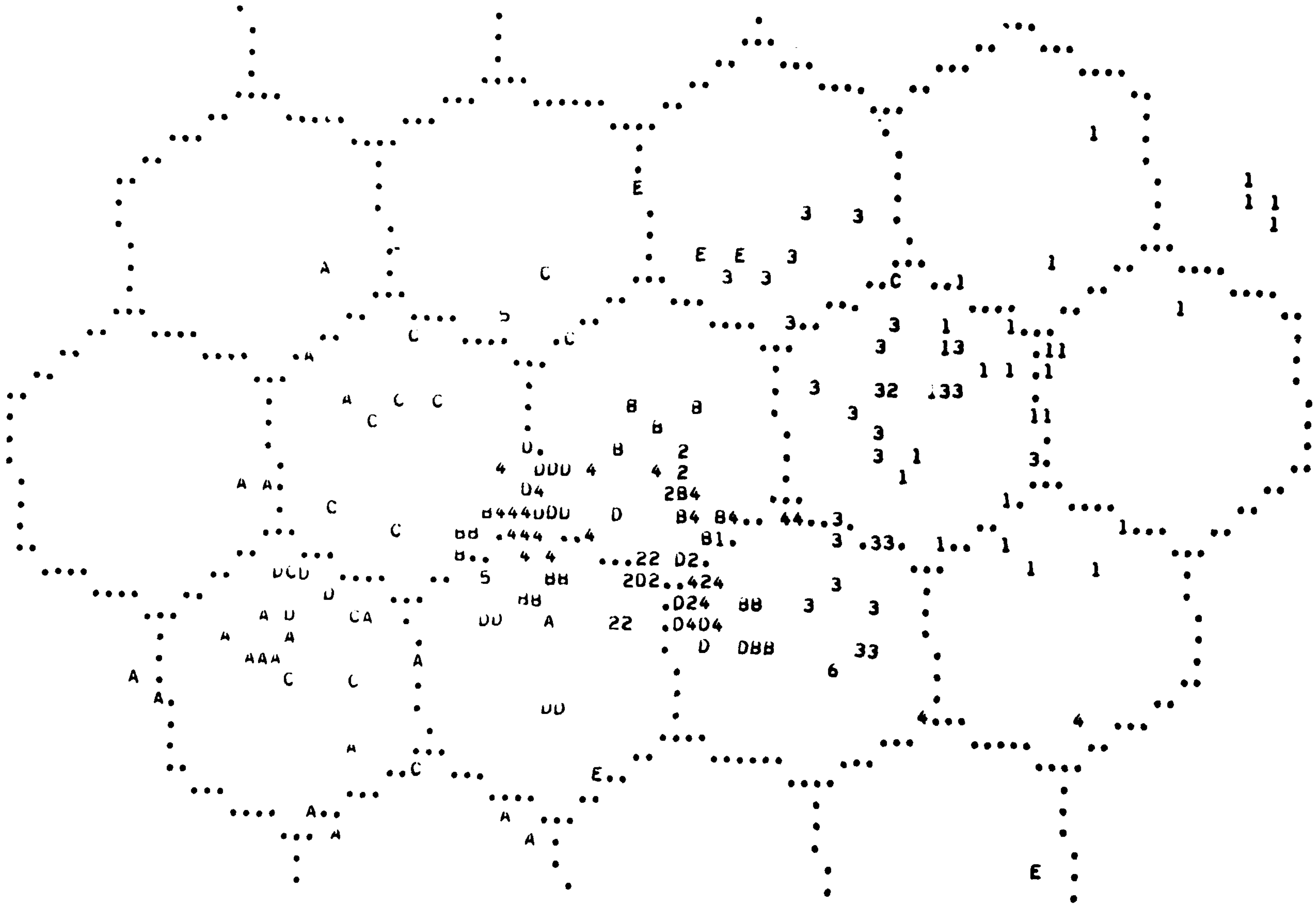


Figure I-16. Case IV unit positions at 07:30 hours.

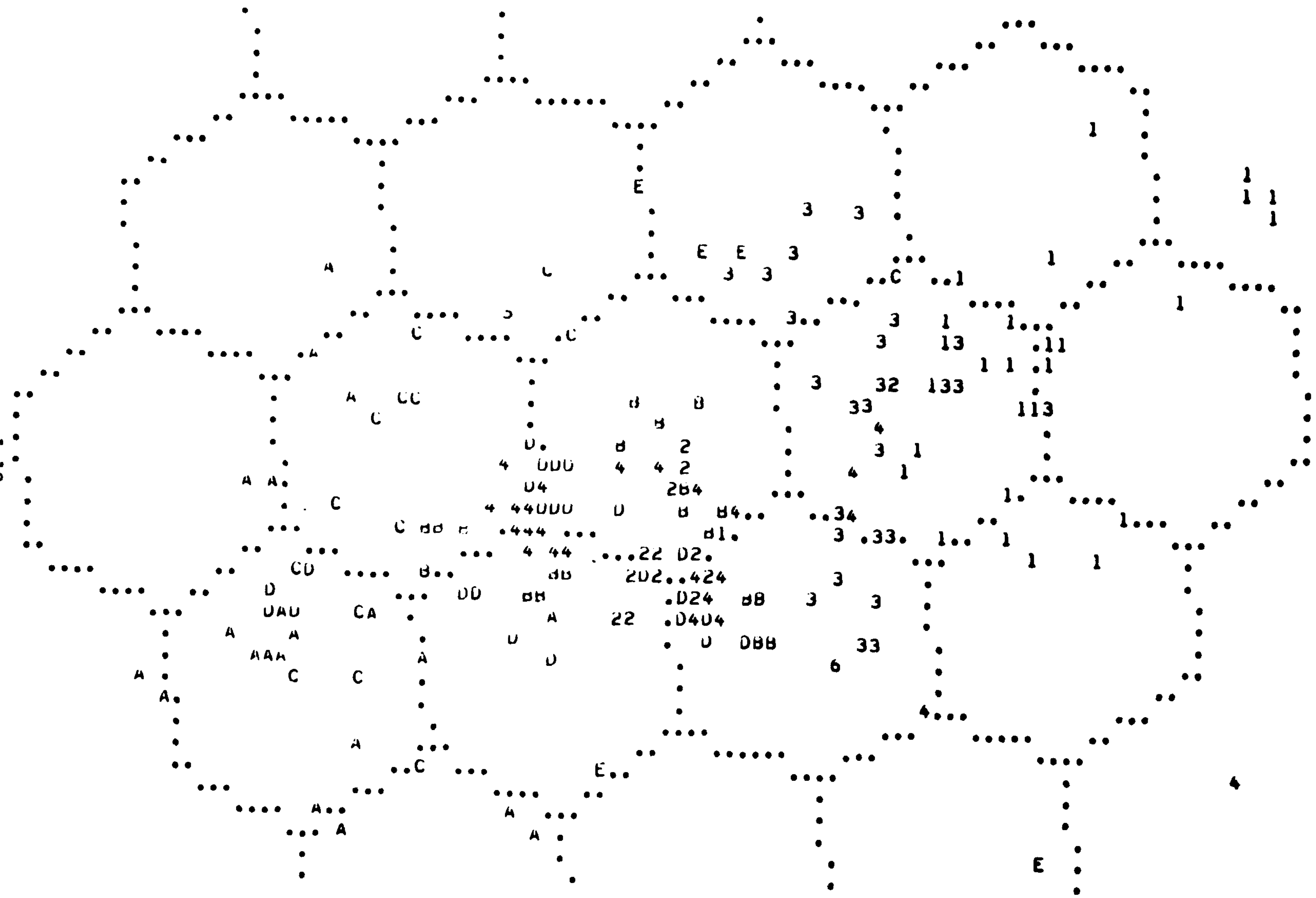


Figure I-17. Case IV unit positions at 08:00 hours.

The quality of the original of this map
was insufficient to be reproduced.

Figure I-18. Case IV unit positions at 08:30 hours.

APPENDIX J

CASE III-FP TACTICAL POSITION MAPS

The 18 maps presented in this appendix show the dynamic combat positions of both combatants at the company/battery level from zero to 0830 hours in one-half hour increments. Legend and other pertinent information concerning these maps is the same as for Case I, Appendix F.

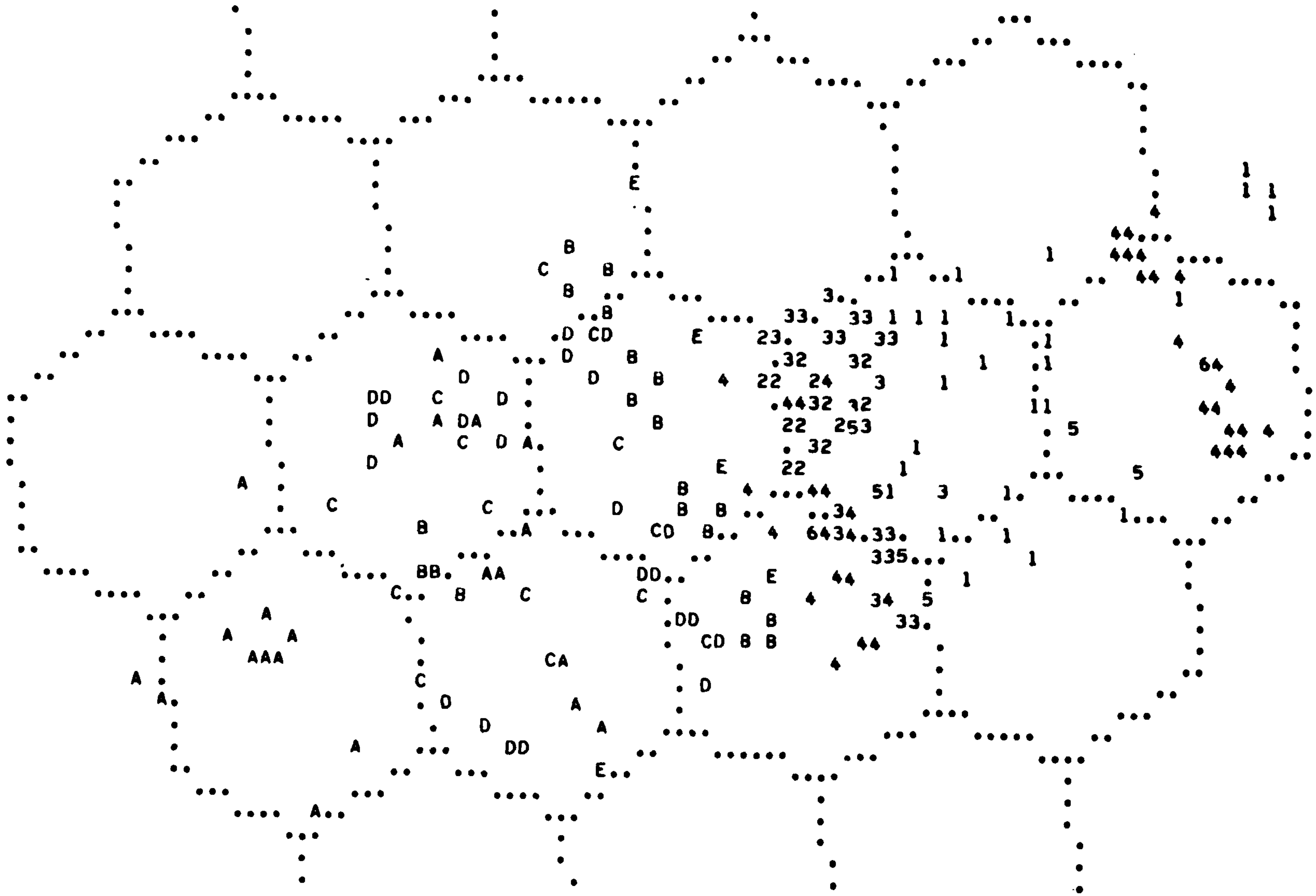


Figure J-1. Case III-FP unit positions at 00:00 hours.

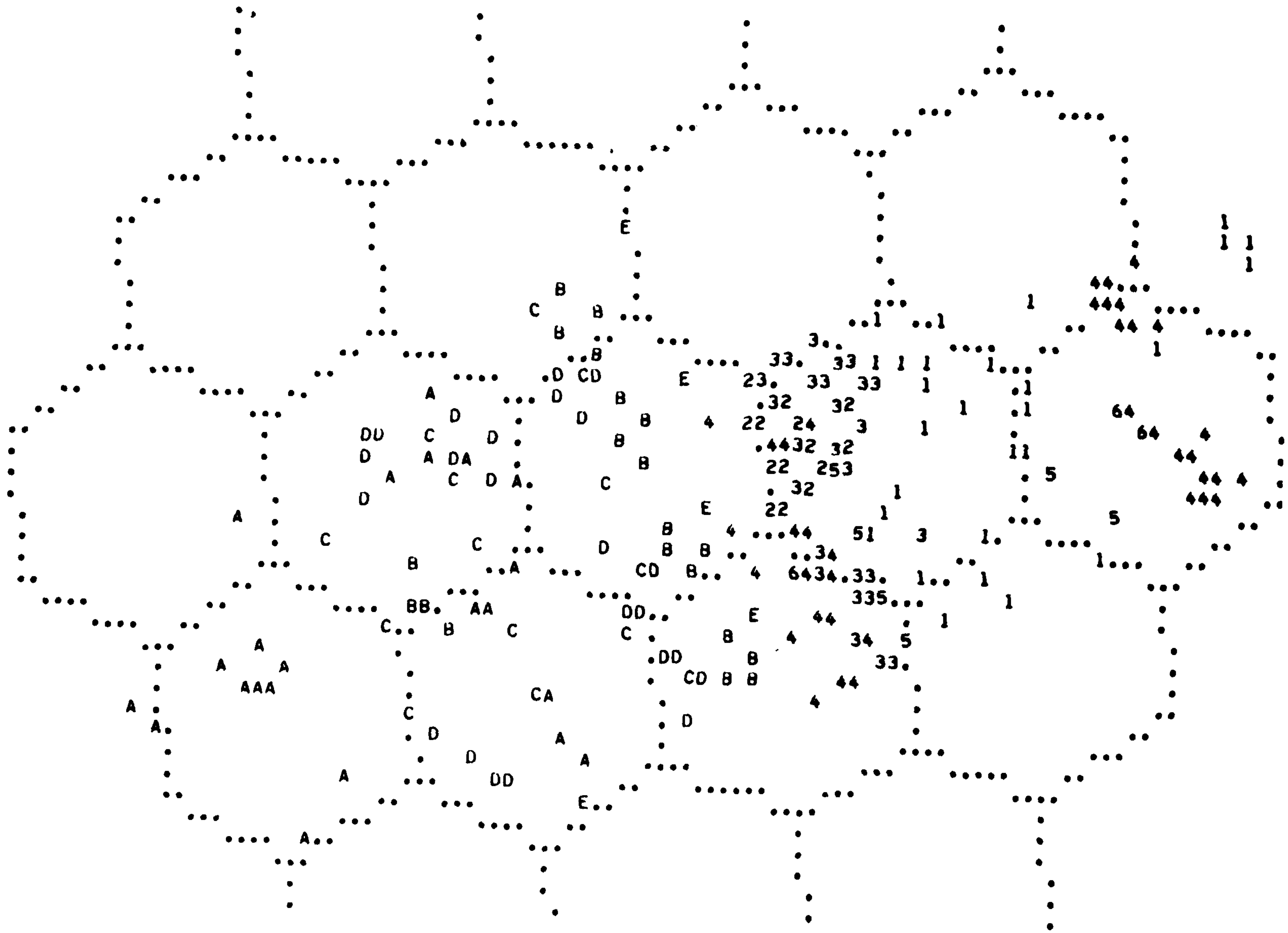


Figure J-2. Case III-FP unit positions at 00:30 hours.

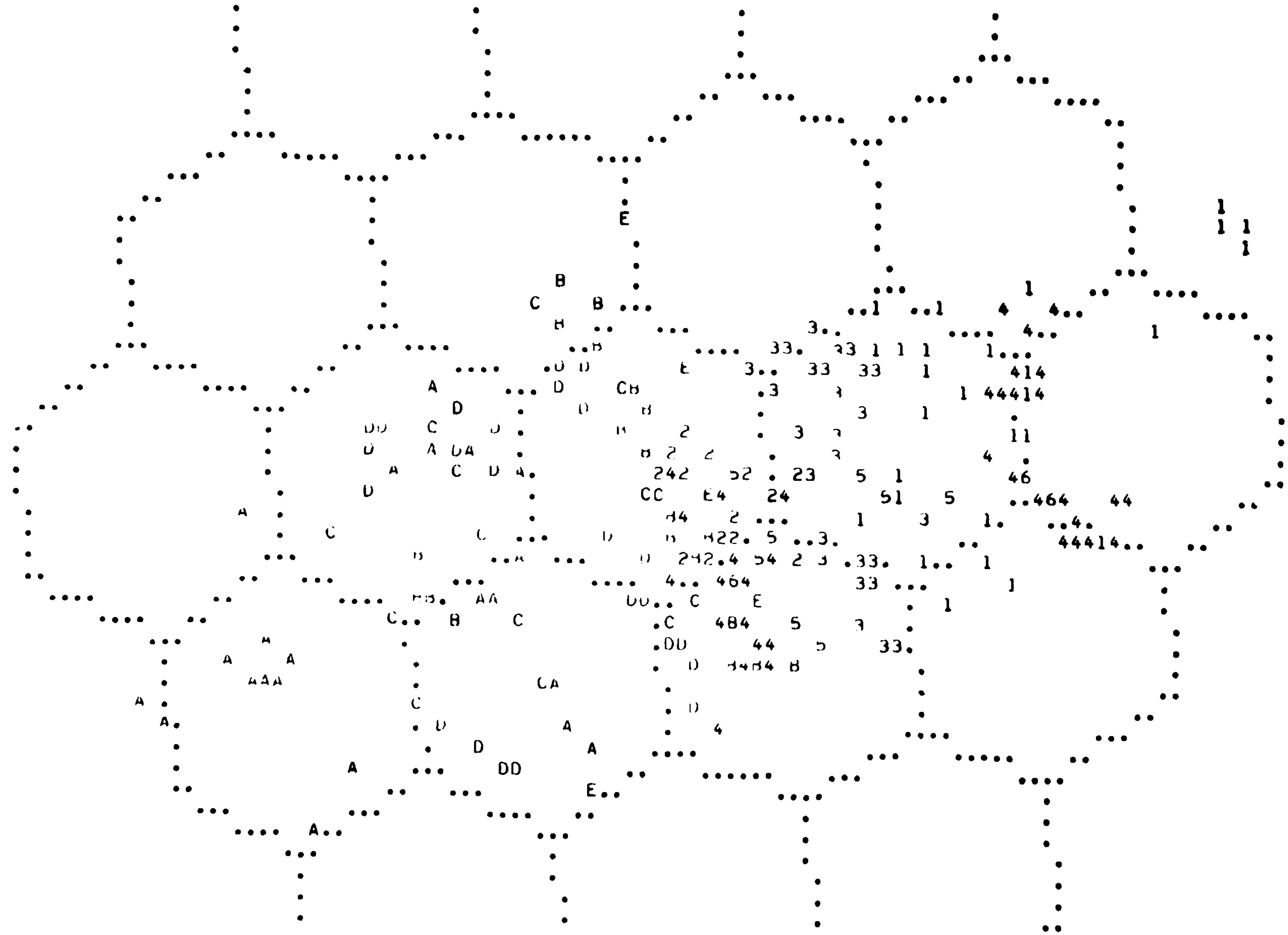


Figure J-3. Case III-FP unit positions at 01:00 hours.

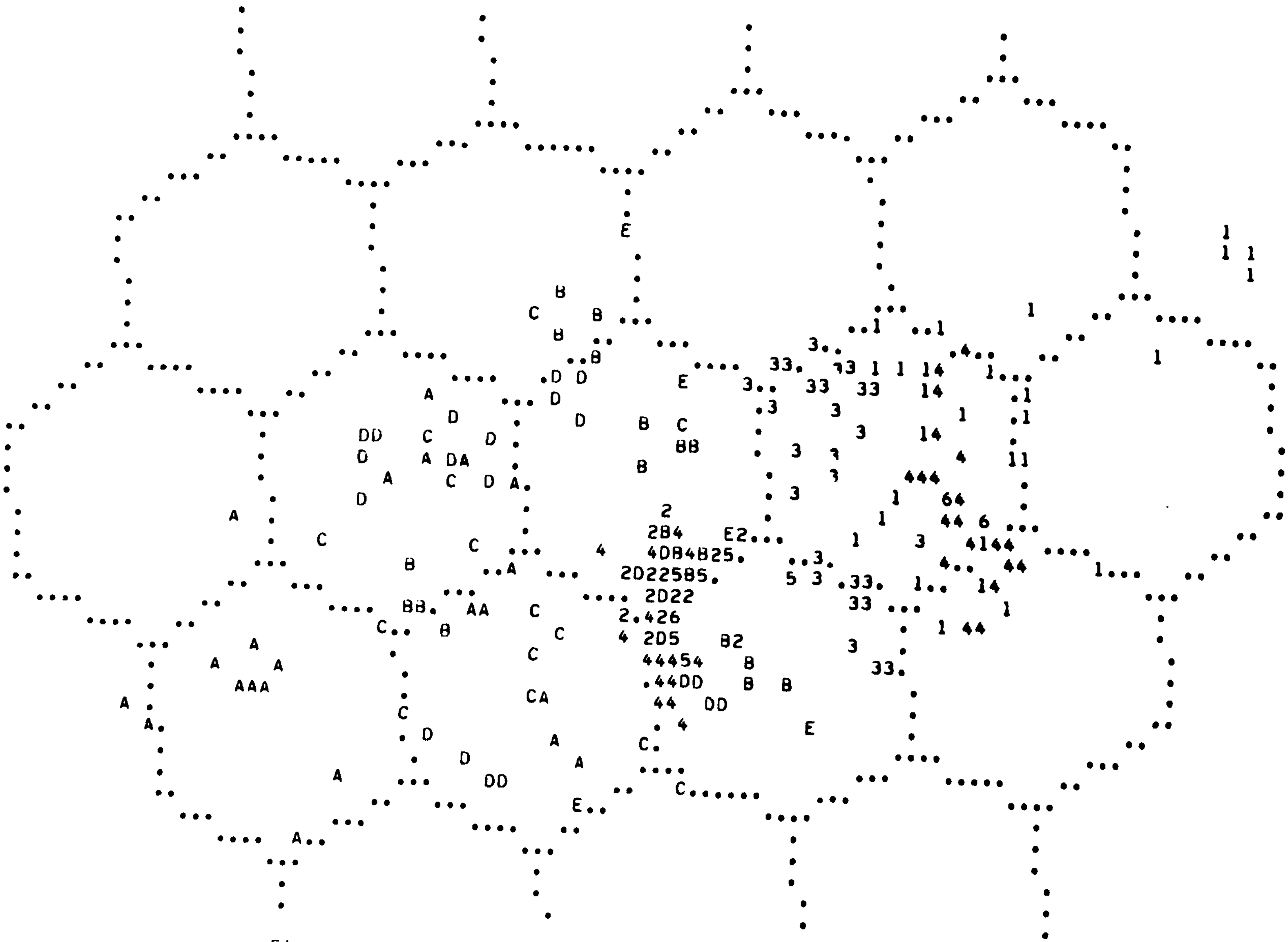


Figure J-4. Case III-FP unit positions at 01:30 hours.

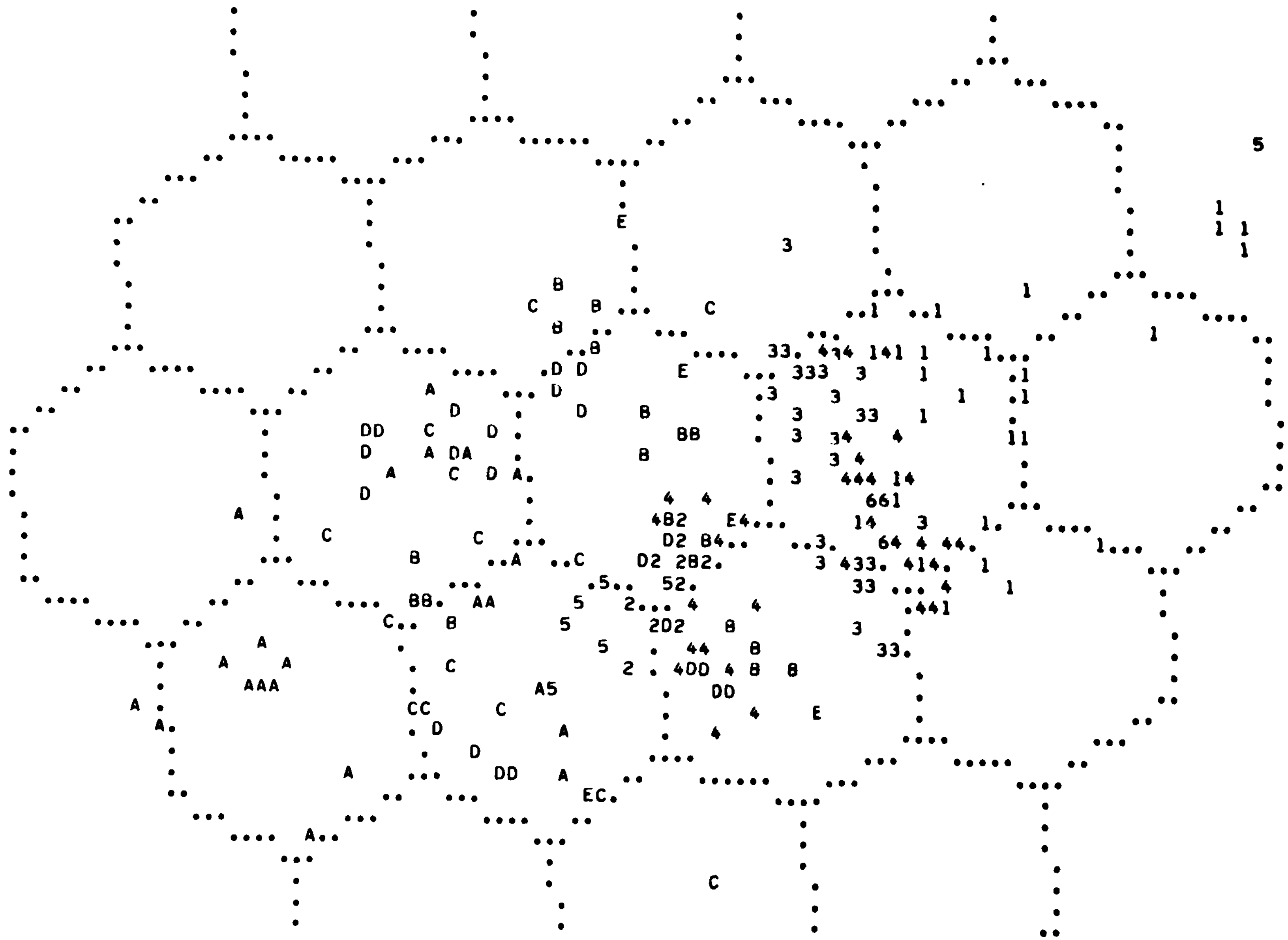


Figure J-5. Case III-FP unit positions at 02:00 hours.

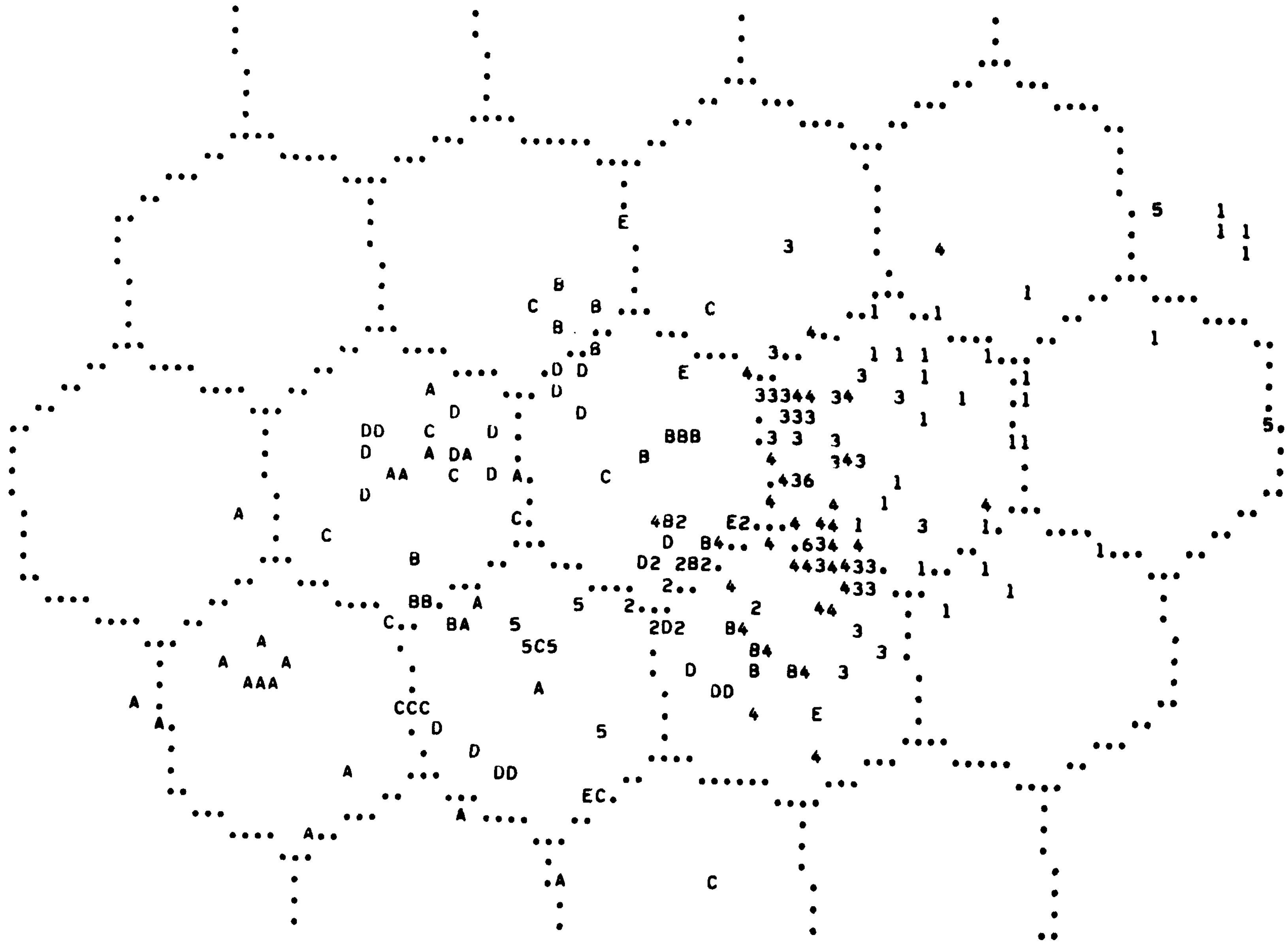


Figure J-6. Case III-FP unit positions at 02:30 hours.

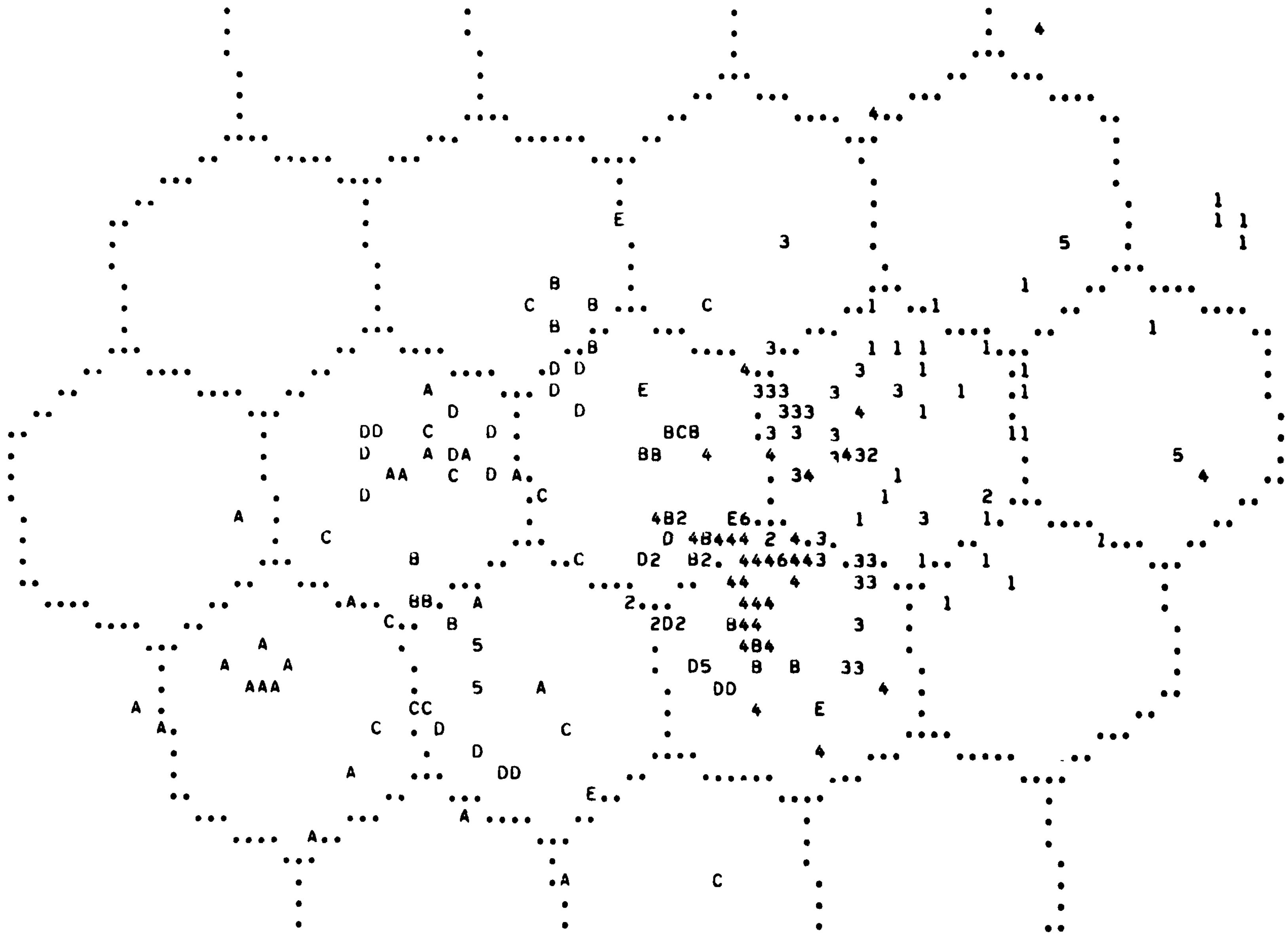


Figure J-7. Case III-FP unit positions at 03:00 hours.

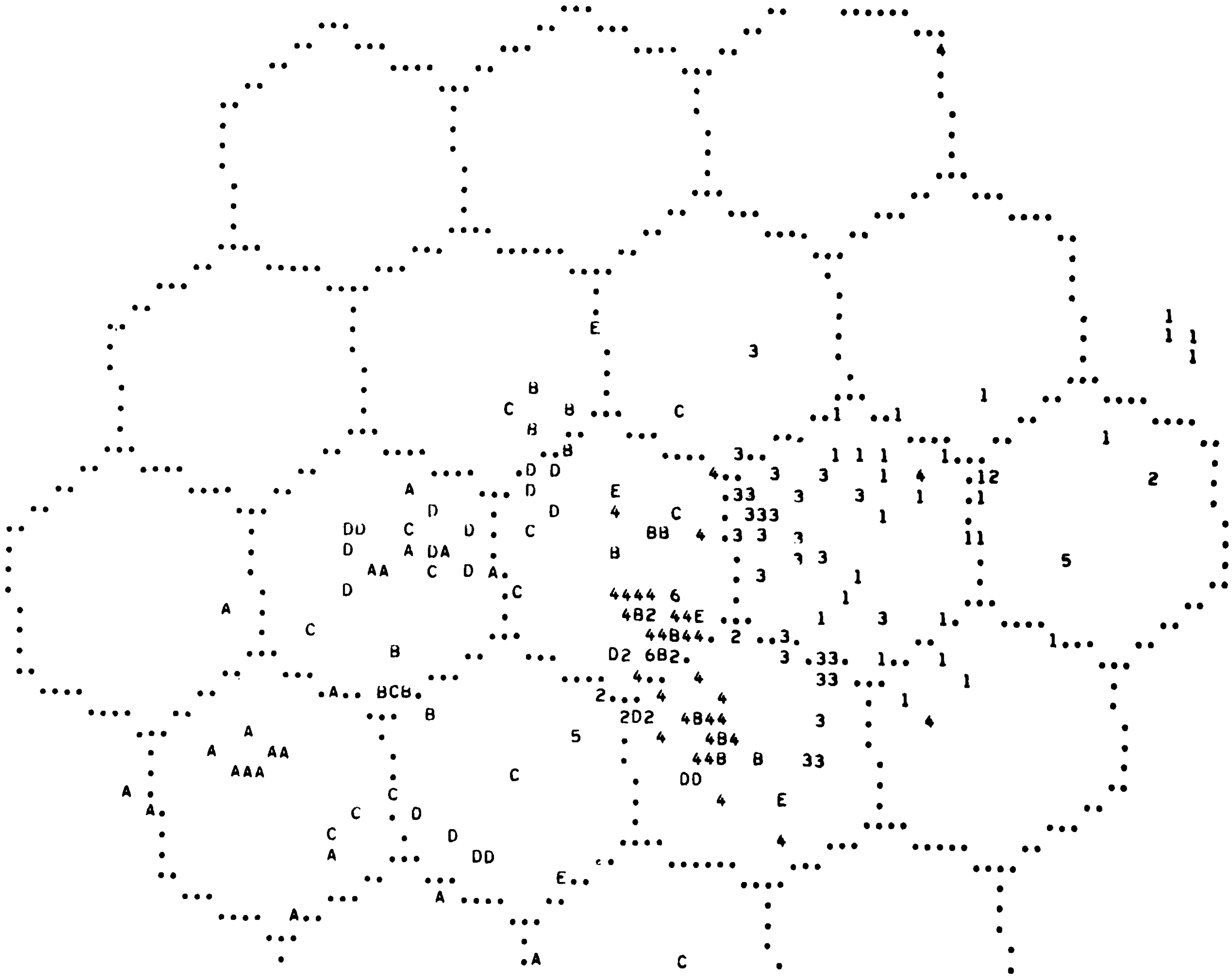


Figure J-8. Case III-FP unit positions at 03:30 hours.

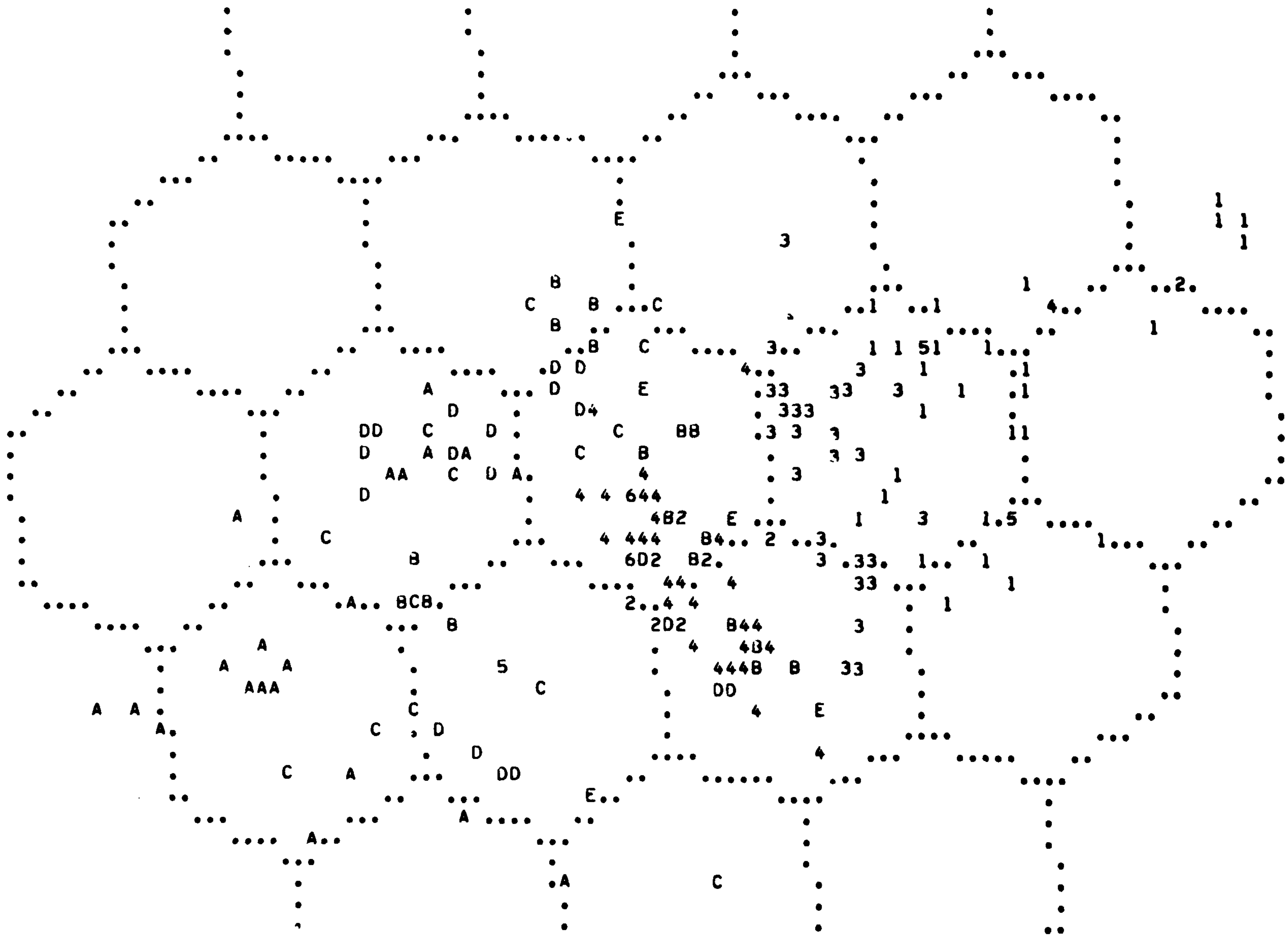


Figure J-9. Case III-FP unit positions at 04:00 hours.

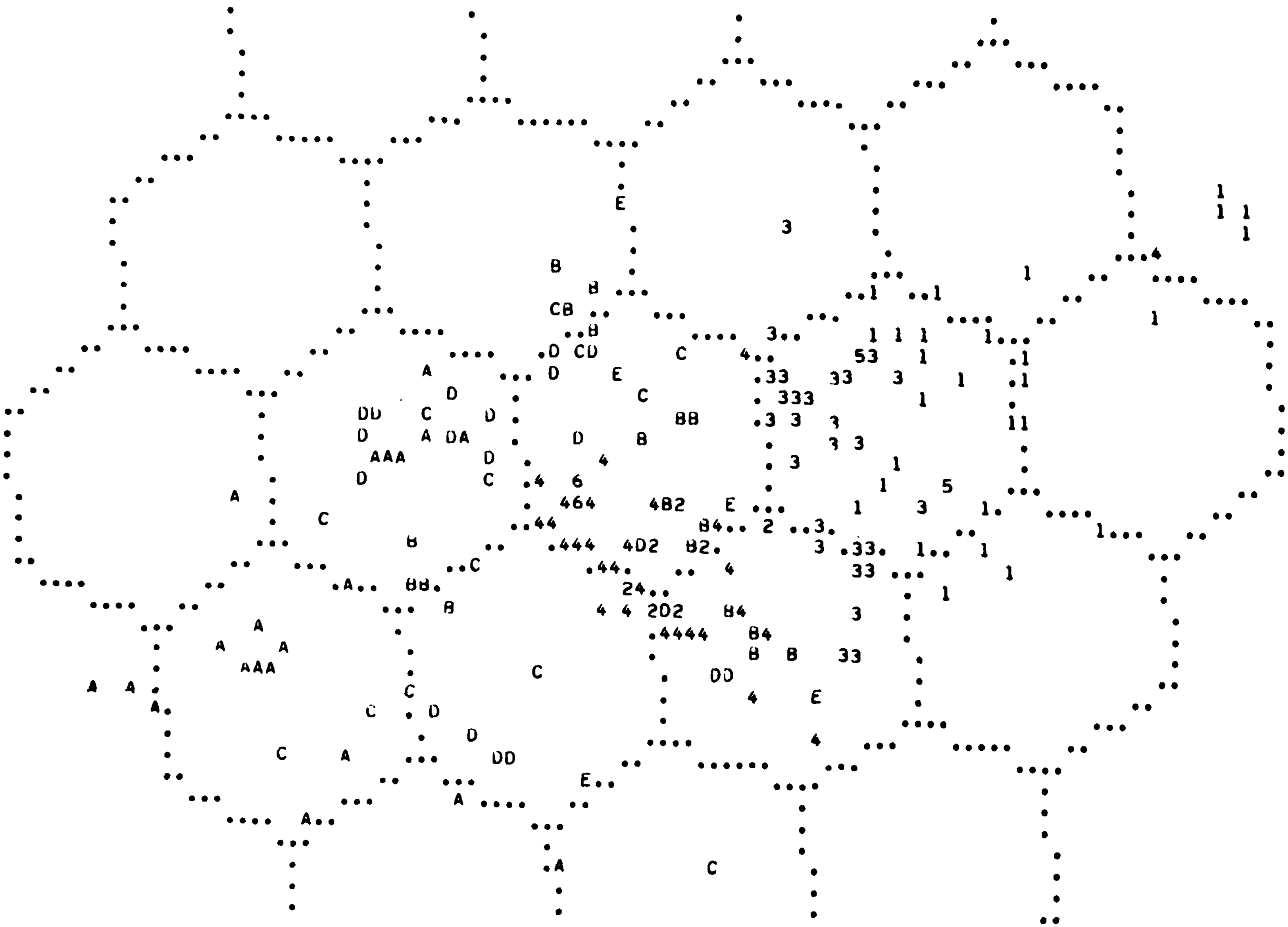


Figure J-10. Case III-FP unit positions at 04:30 hours.

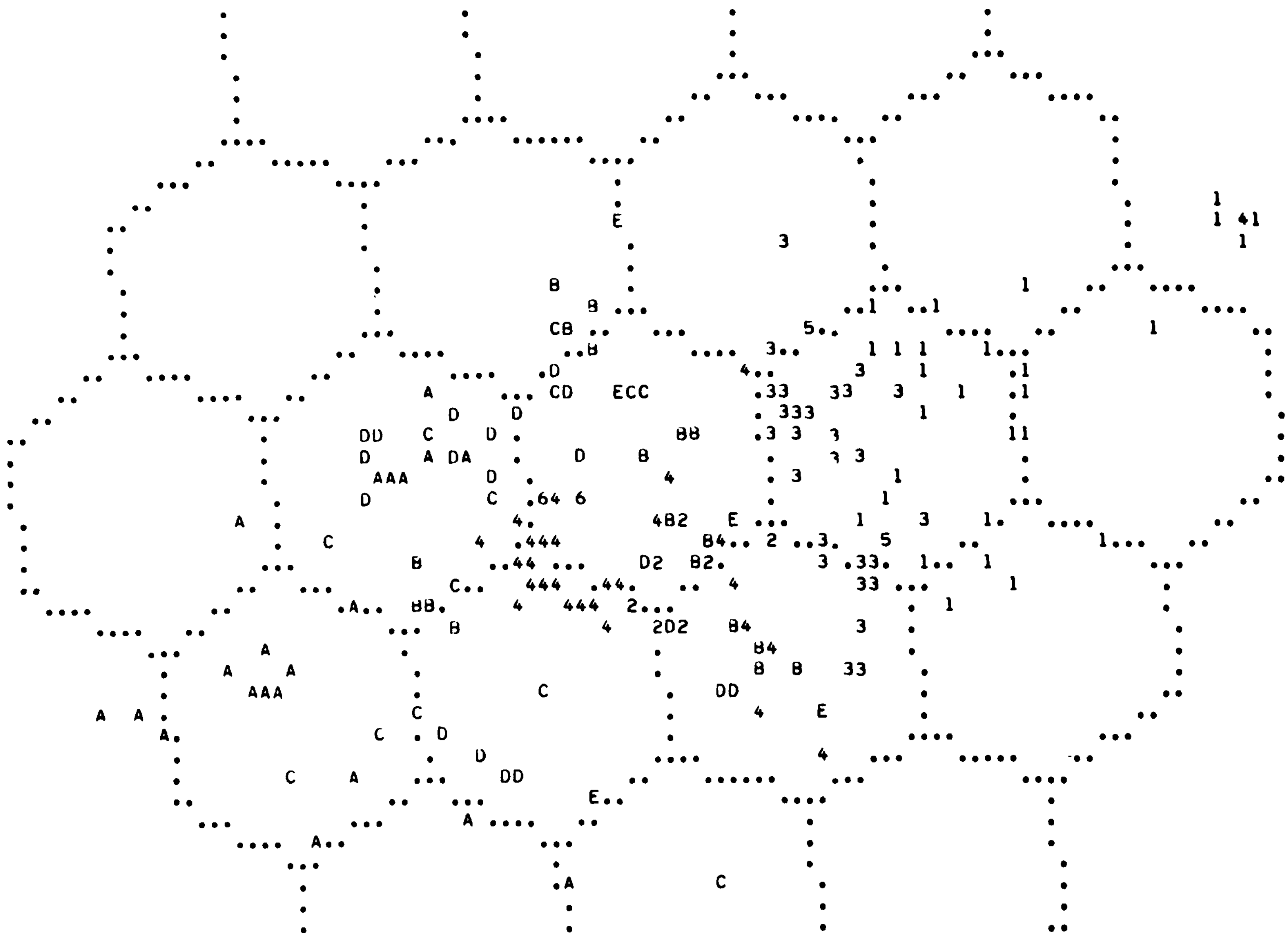


Figure J-11. Case III-FP unit positions at 05:00 hours.

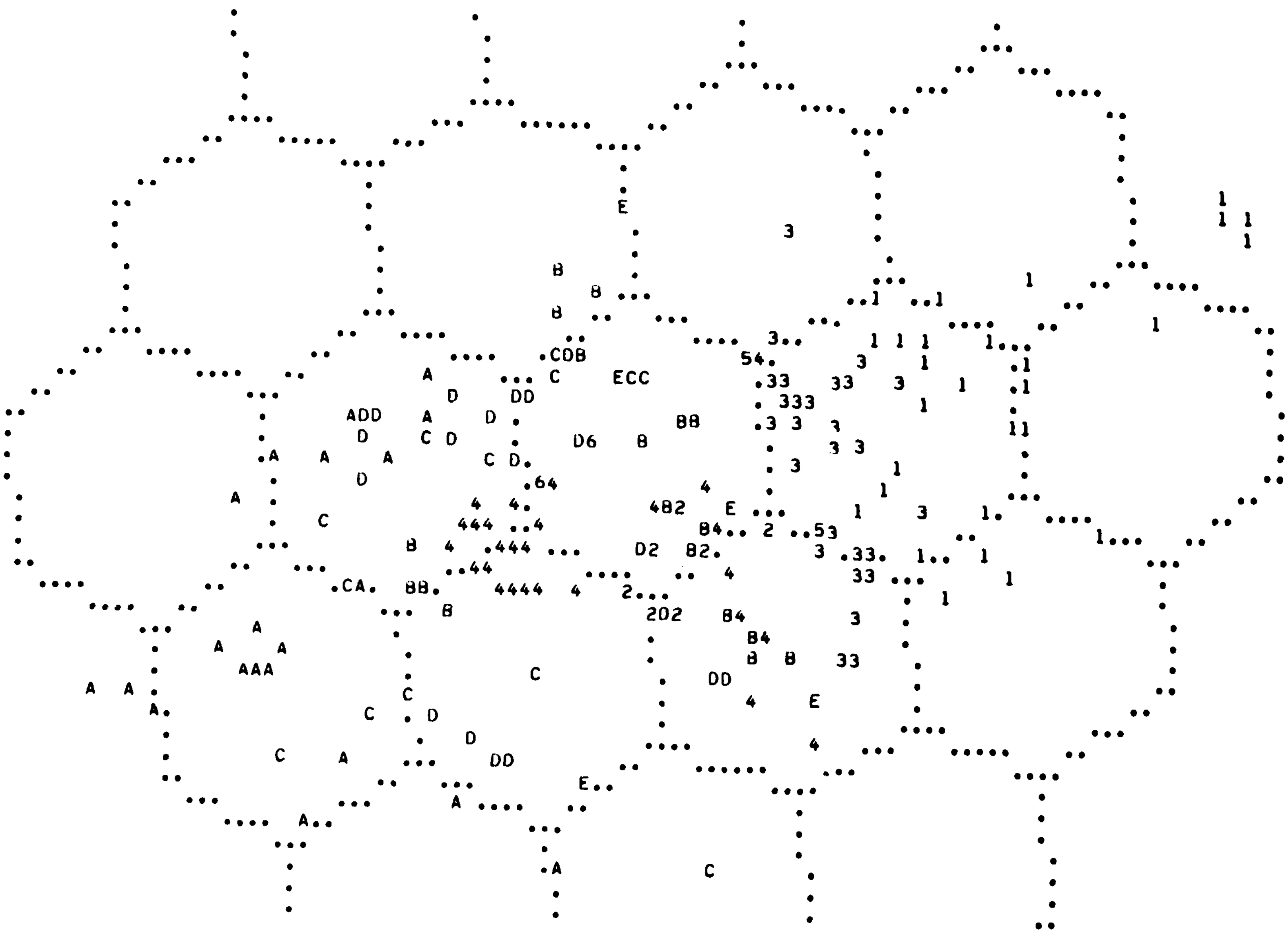


Figure J-12. Case III-FP unit positions at 05:30 hours.

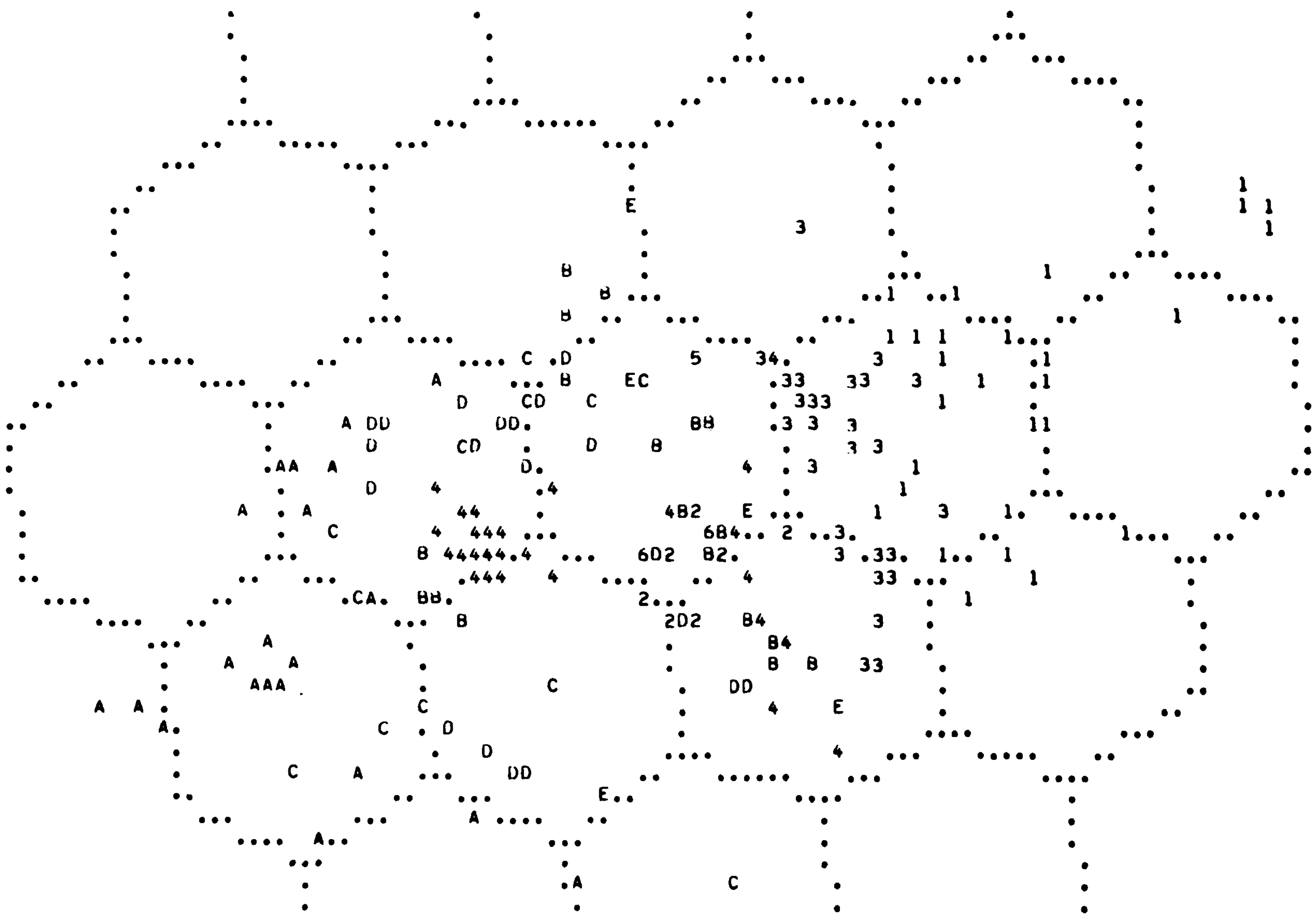


Figure J-13. Case III-FP unit positions at 06:00 hours.

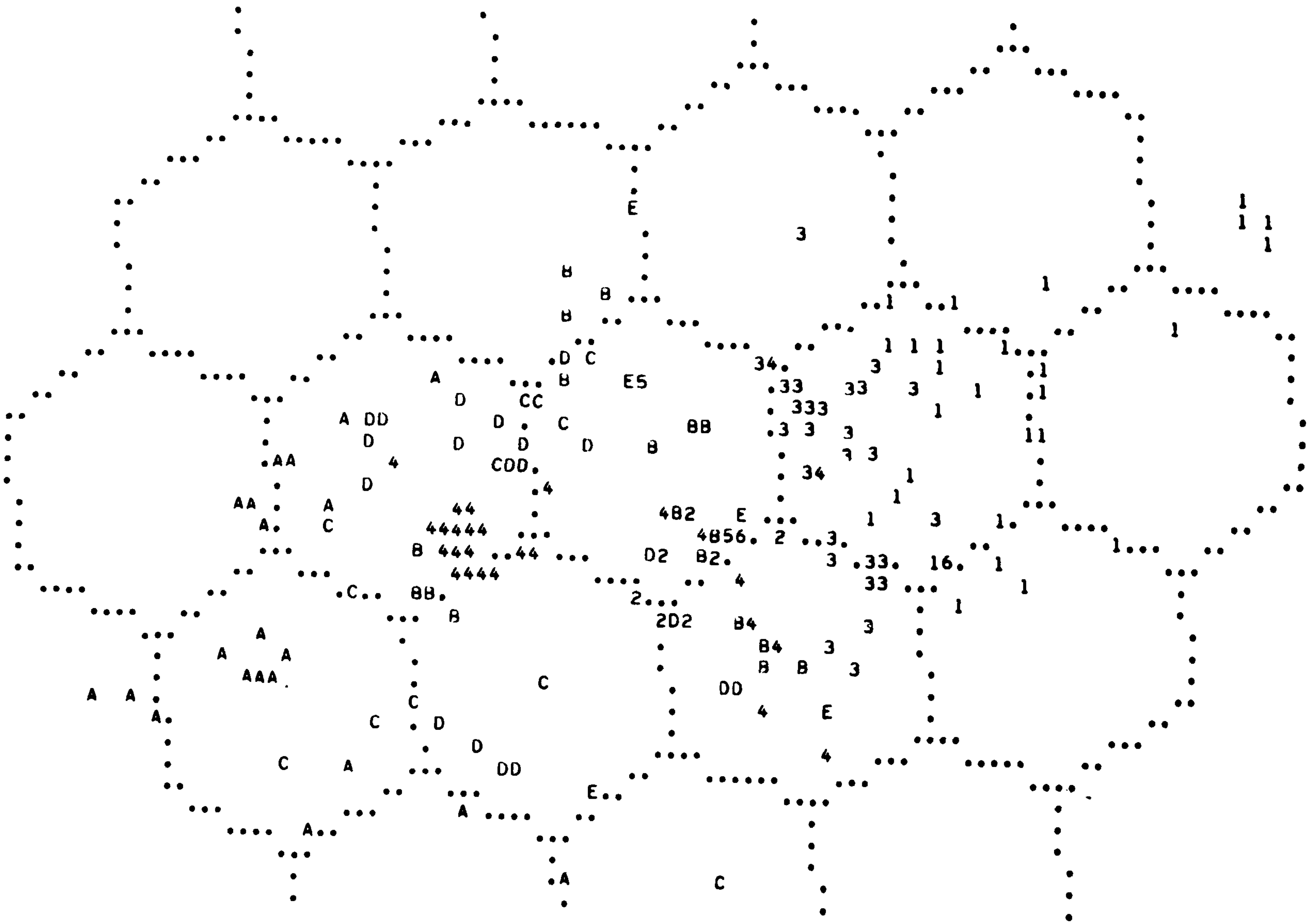


Figure J-14. Case III-FP unit positions at 06:30 hours.

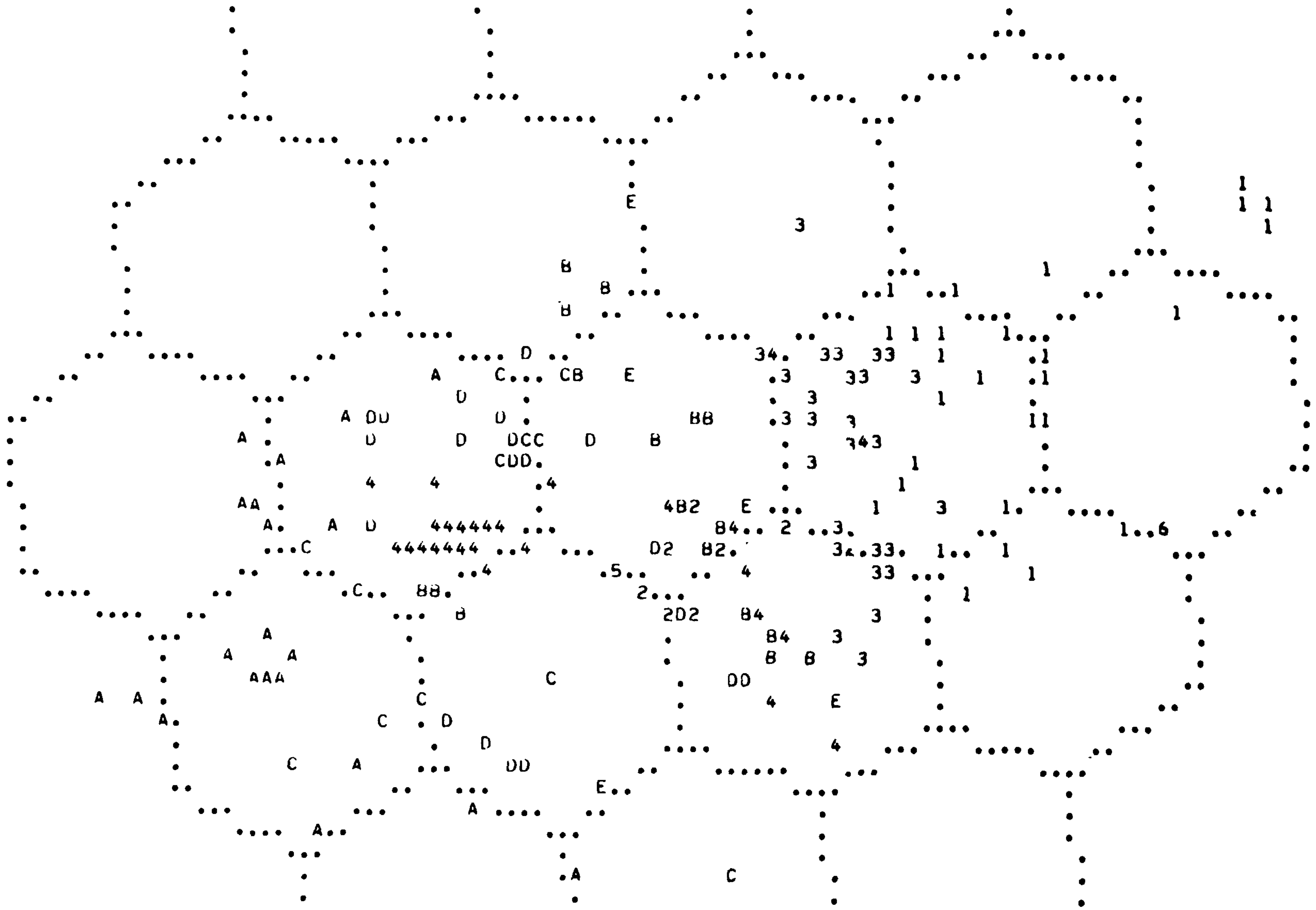


Figure J-15. Case III-FP unit positions at 07:00 hours.

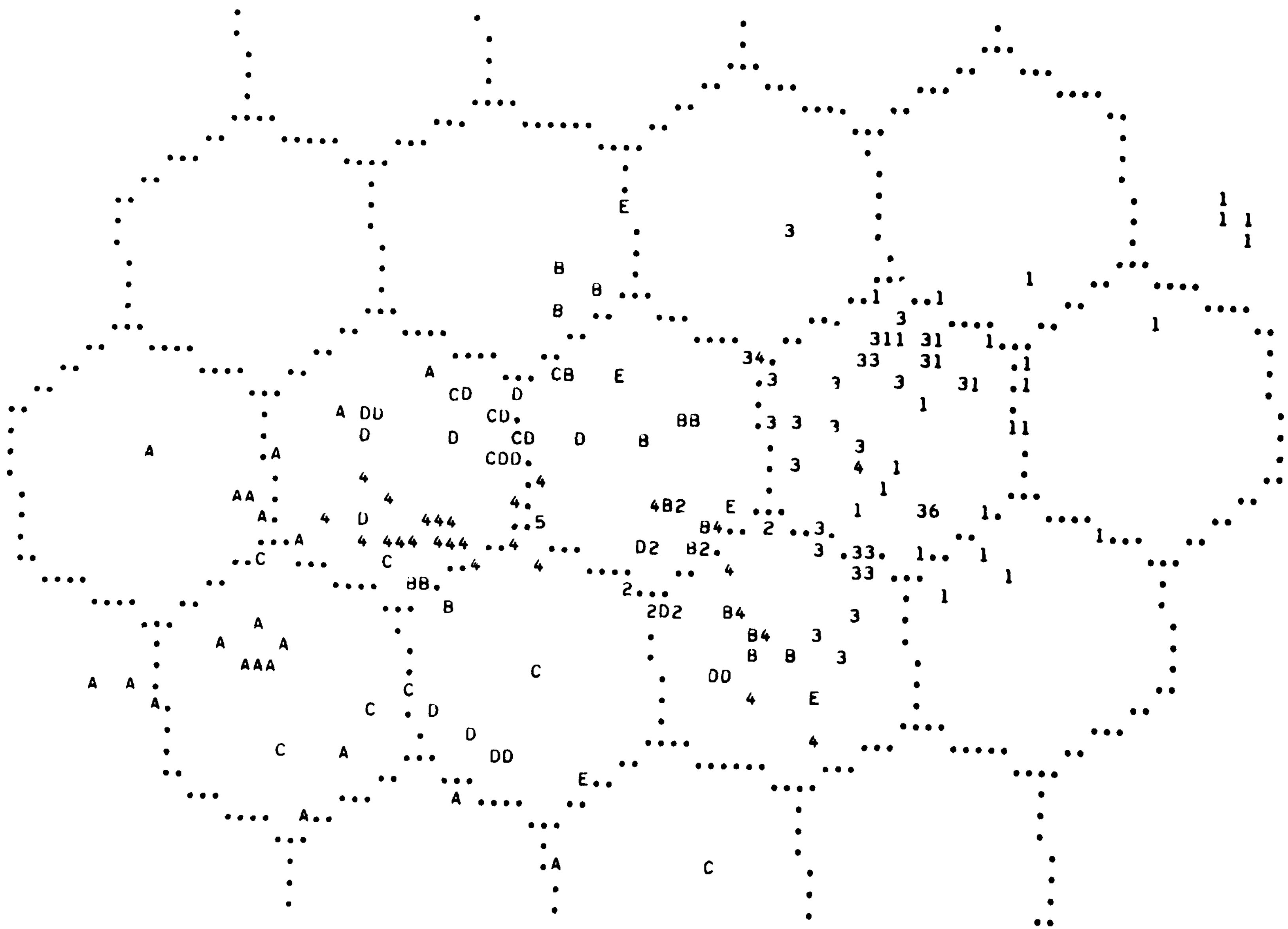


Figure J-16. Case III-FP unit positions at 07:30 hours.

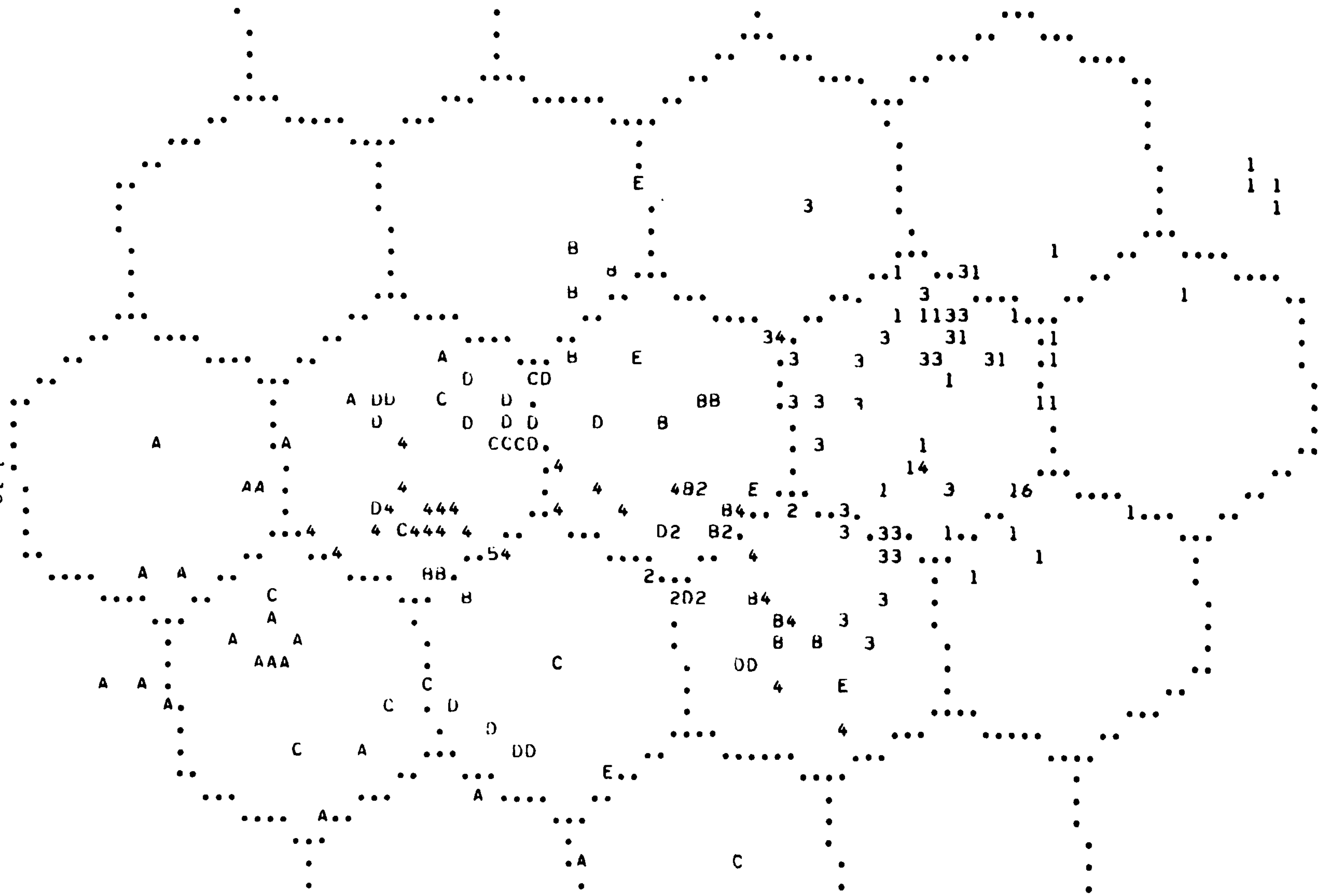


Figure J-17. Case III-FP unit positions at 08:00 hours.

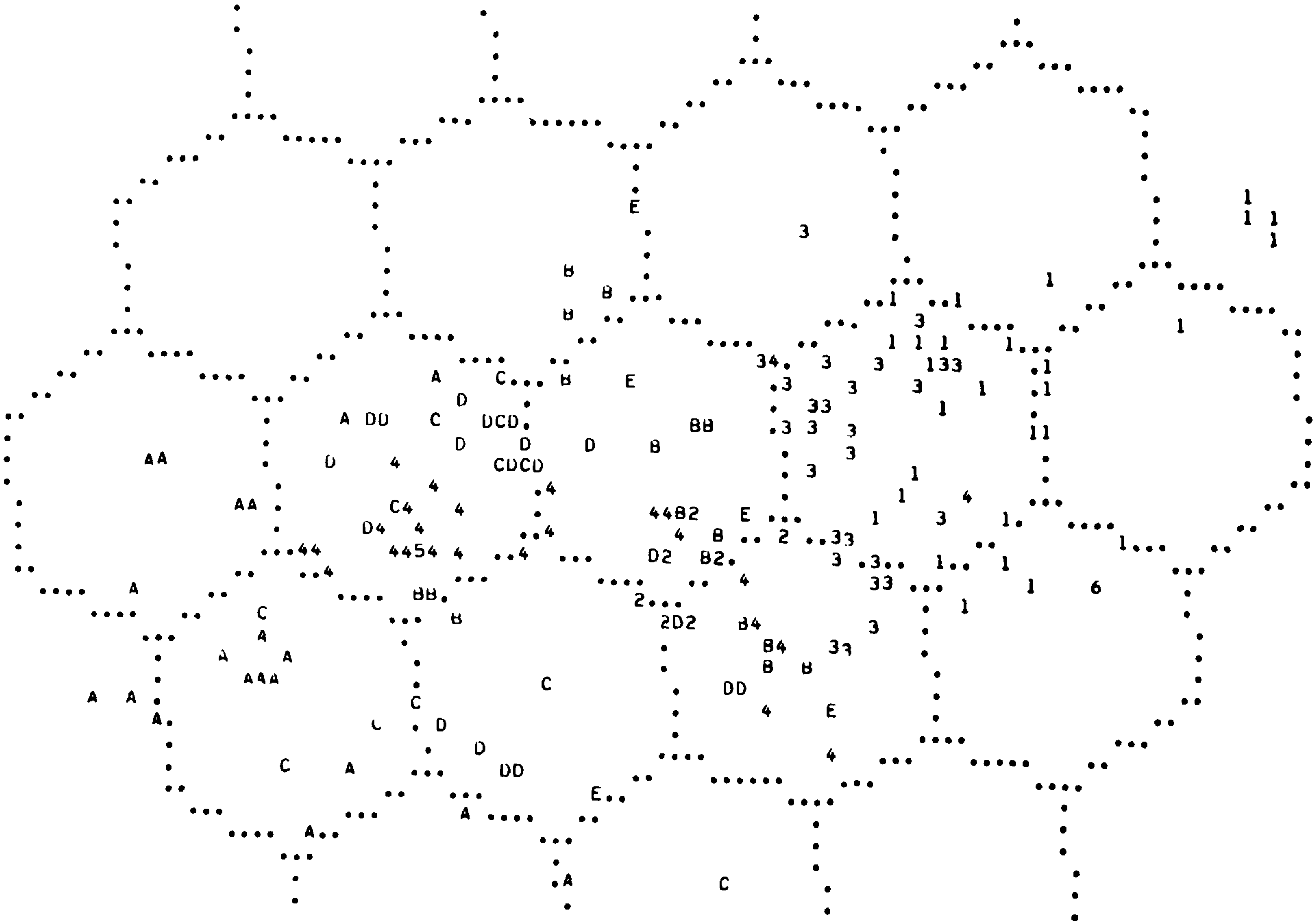


Figure J-18. Case III-FP unit positions at 08:30 hours.

APPENDIX K

CASE IV-FP TACTICAL POSITION MAPS

The 18 maps presented in this appendix show the dynamic combat positions of both combatants at the company/battery level from zero to 0830 hours in one-half hour increments. Legend and other pertinent information concerning these maps is the same as for Case I, Appendix F.

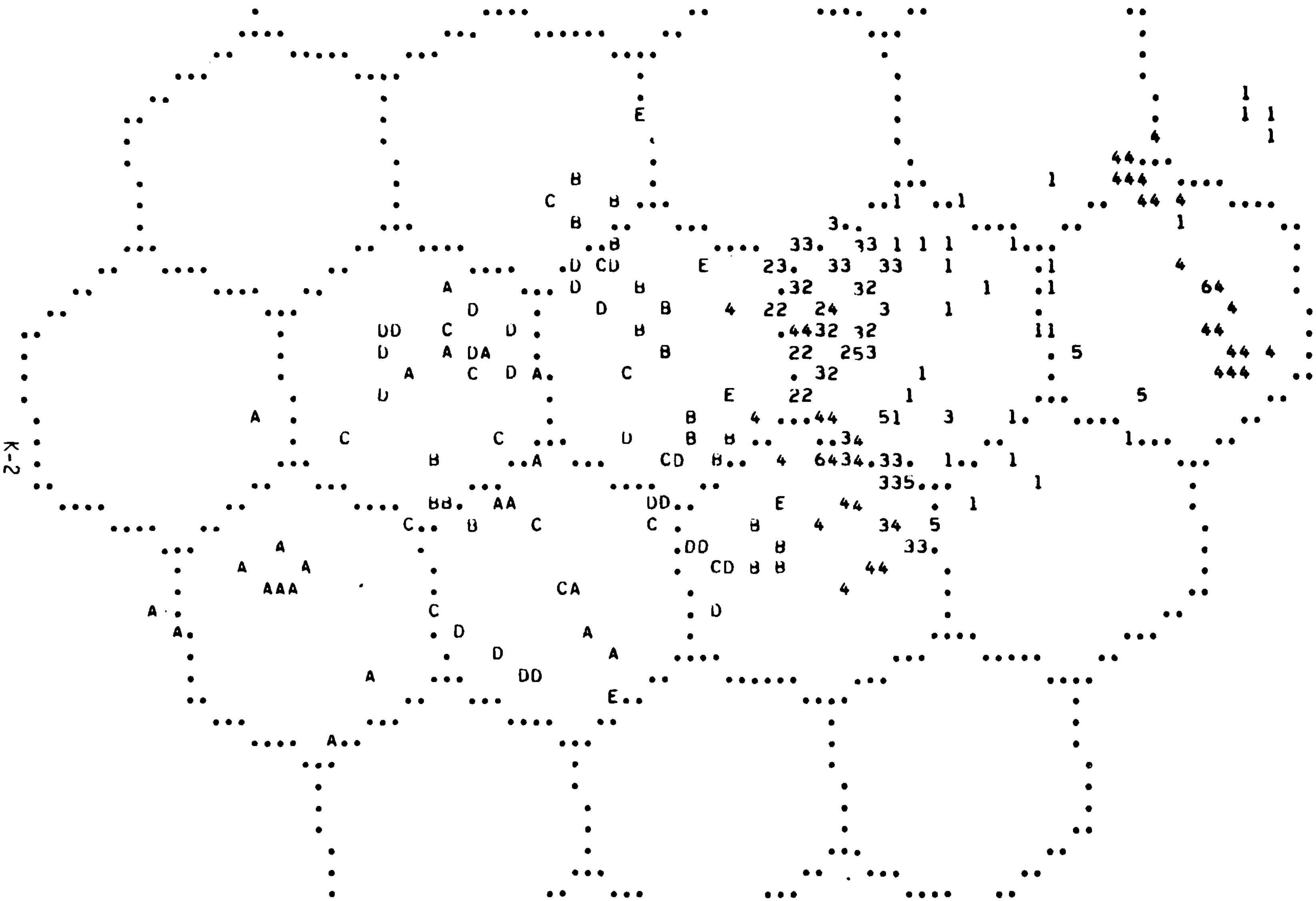


Figure K-1. Case IV-FP unit positions at 00:00 hours.

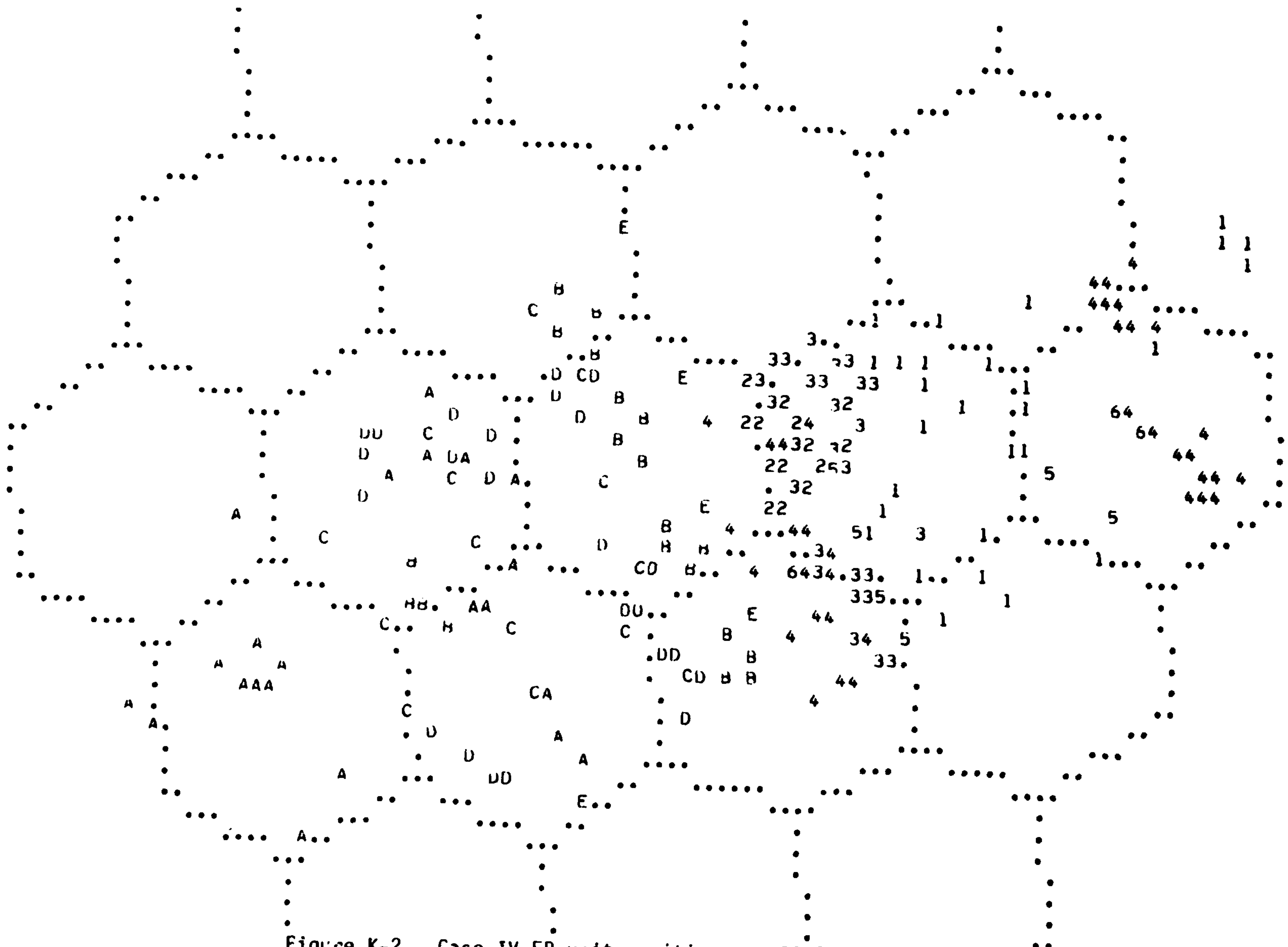


Figure K-2. Case IV-FP unit positions at 00:30 hours.

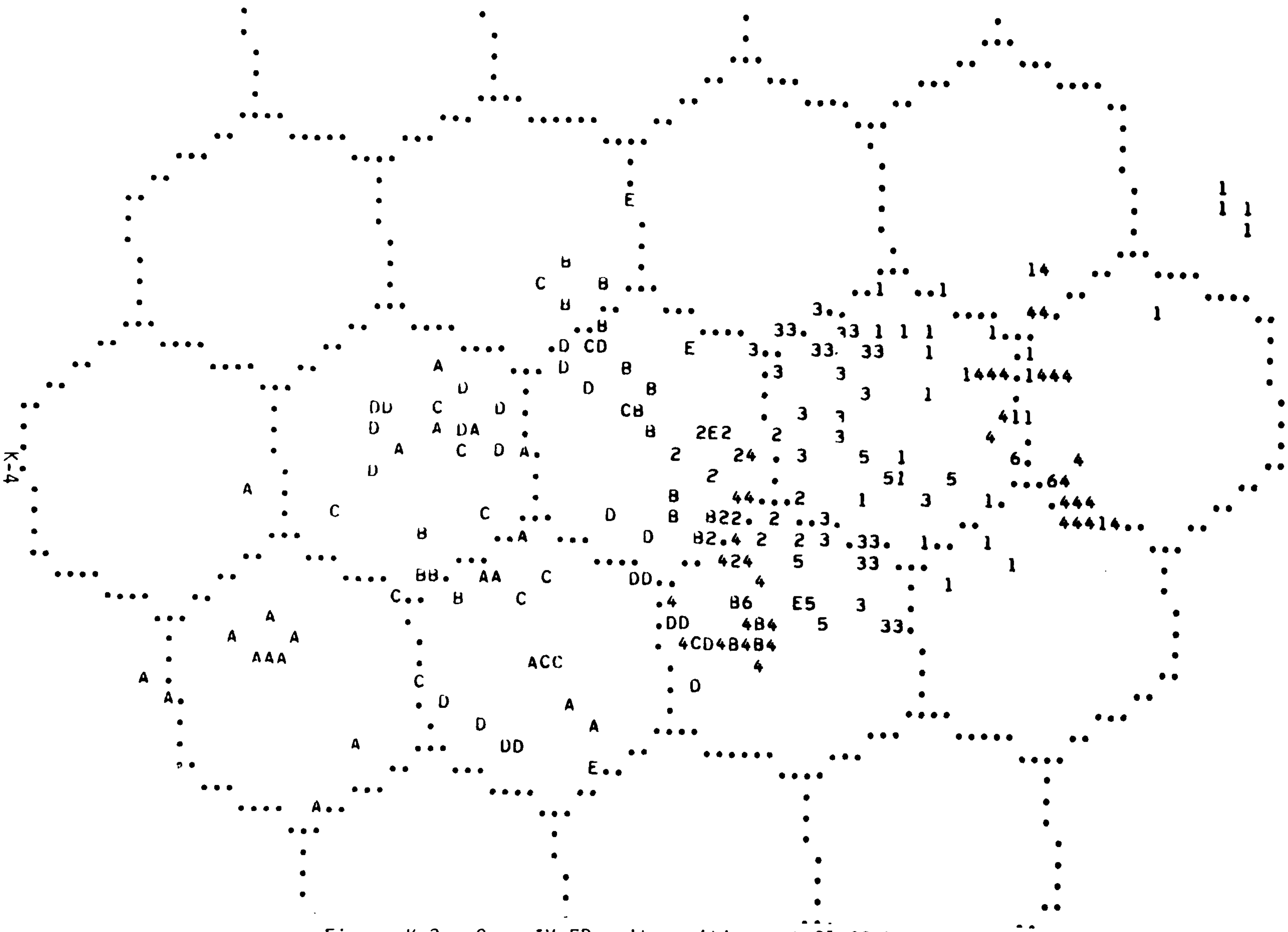


Figure K-3. Case IV-FP unit positions at 01:00 hours.

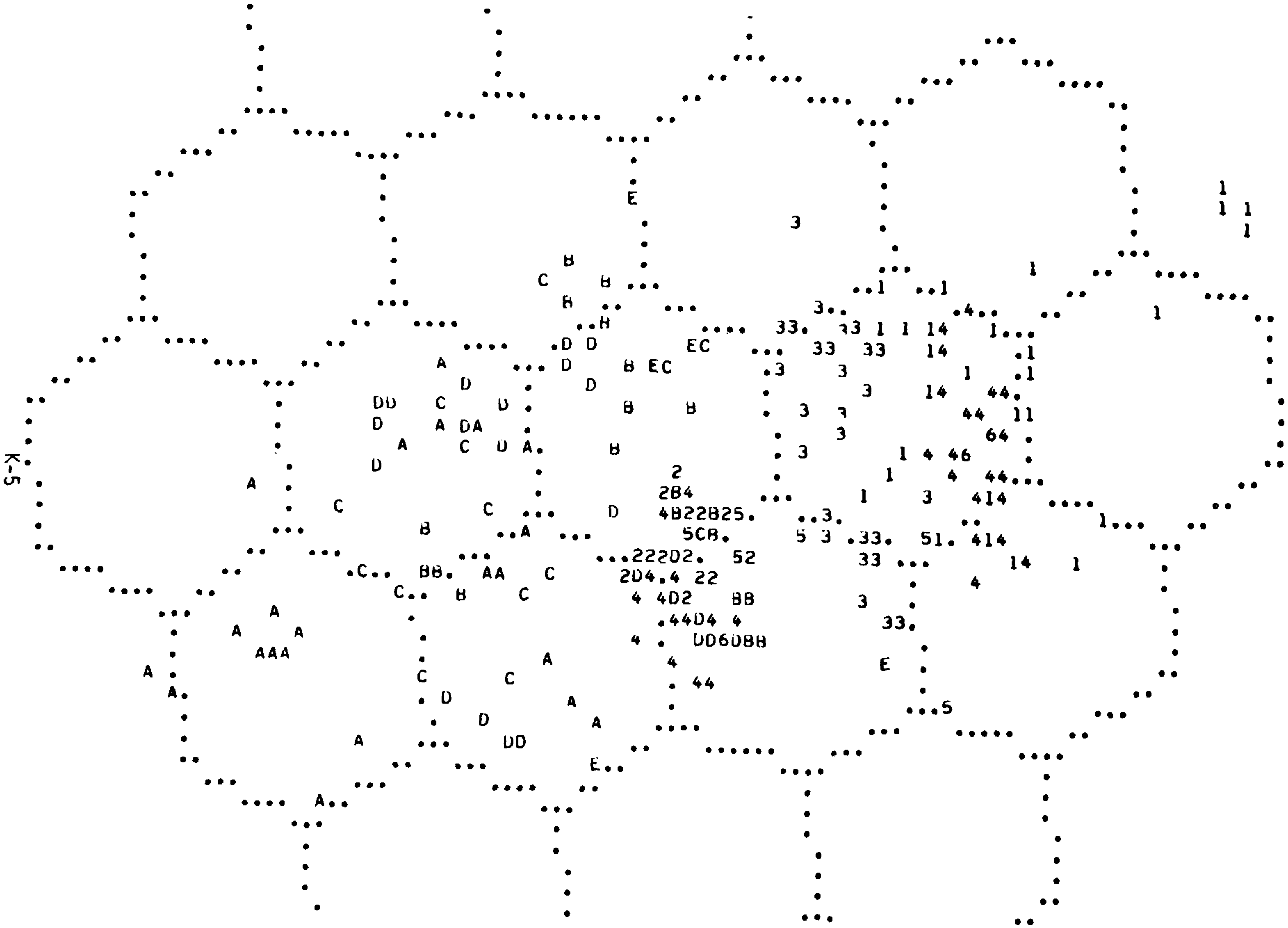


Figure K-4. Case IV-FP unit positions at 01:30 hours.

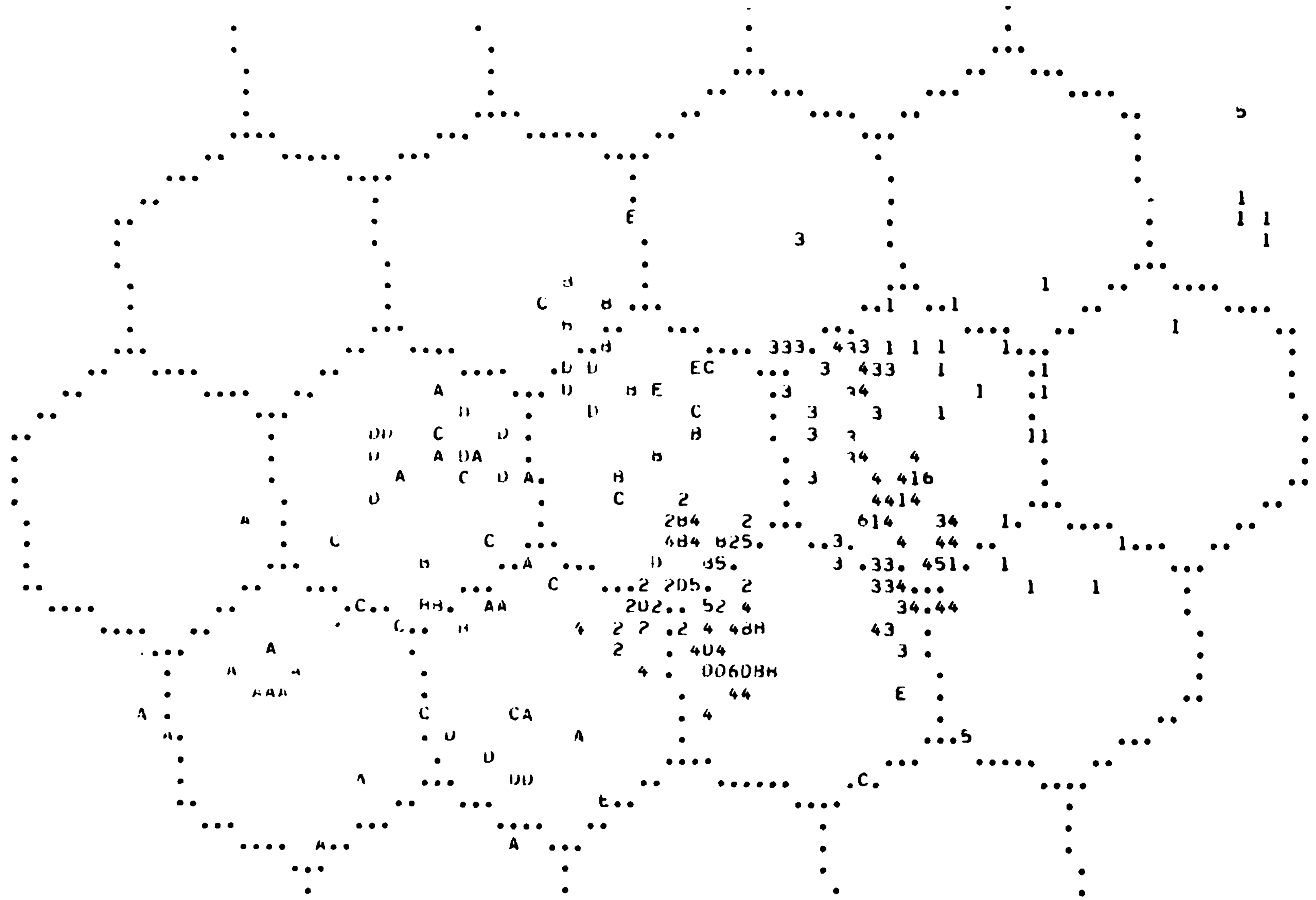


Figure K-5. Case IV-FP unit positions at 02:00 hours.

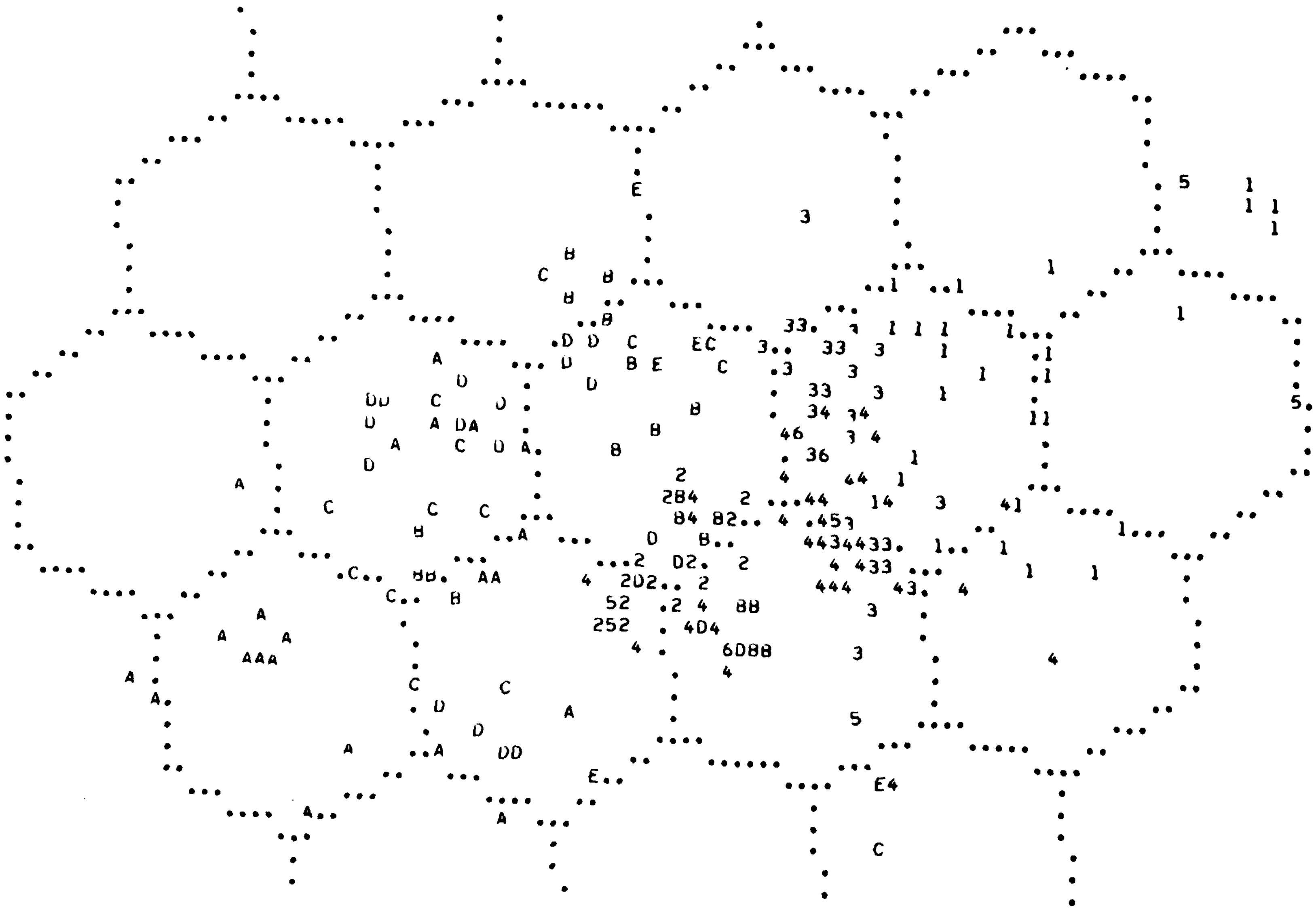


Figure K-6. Case IV-FP unit positions at 02:30 hours.

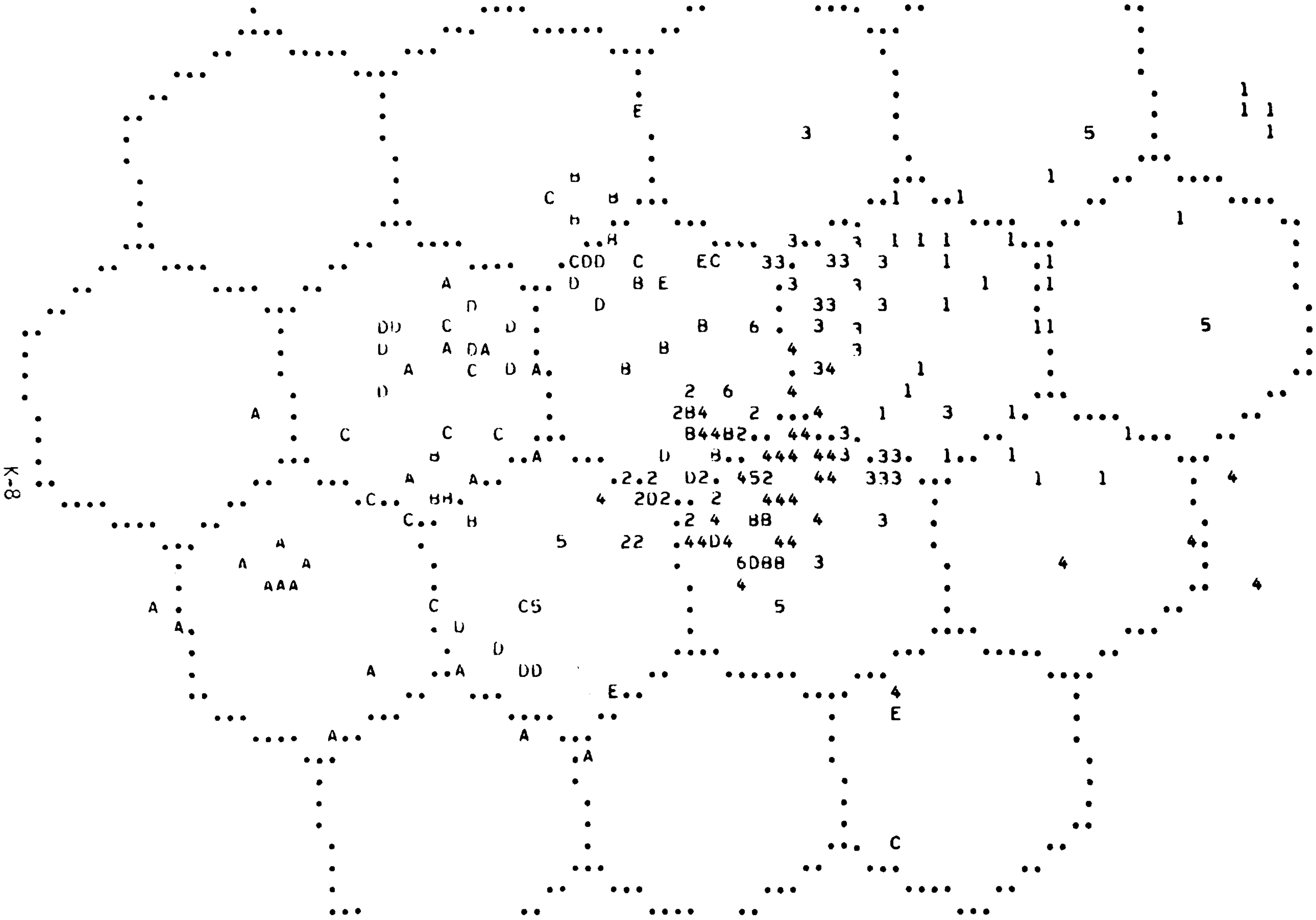


Figure K-7. Case IV-FP unit positions at 03:00 hours.

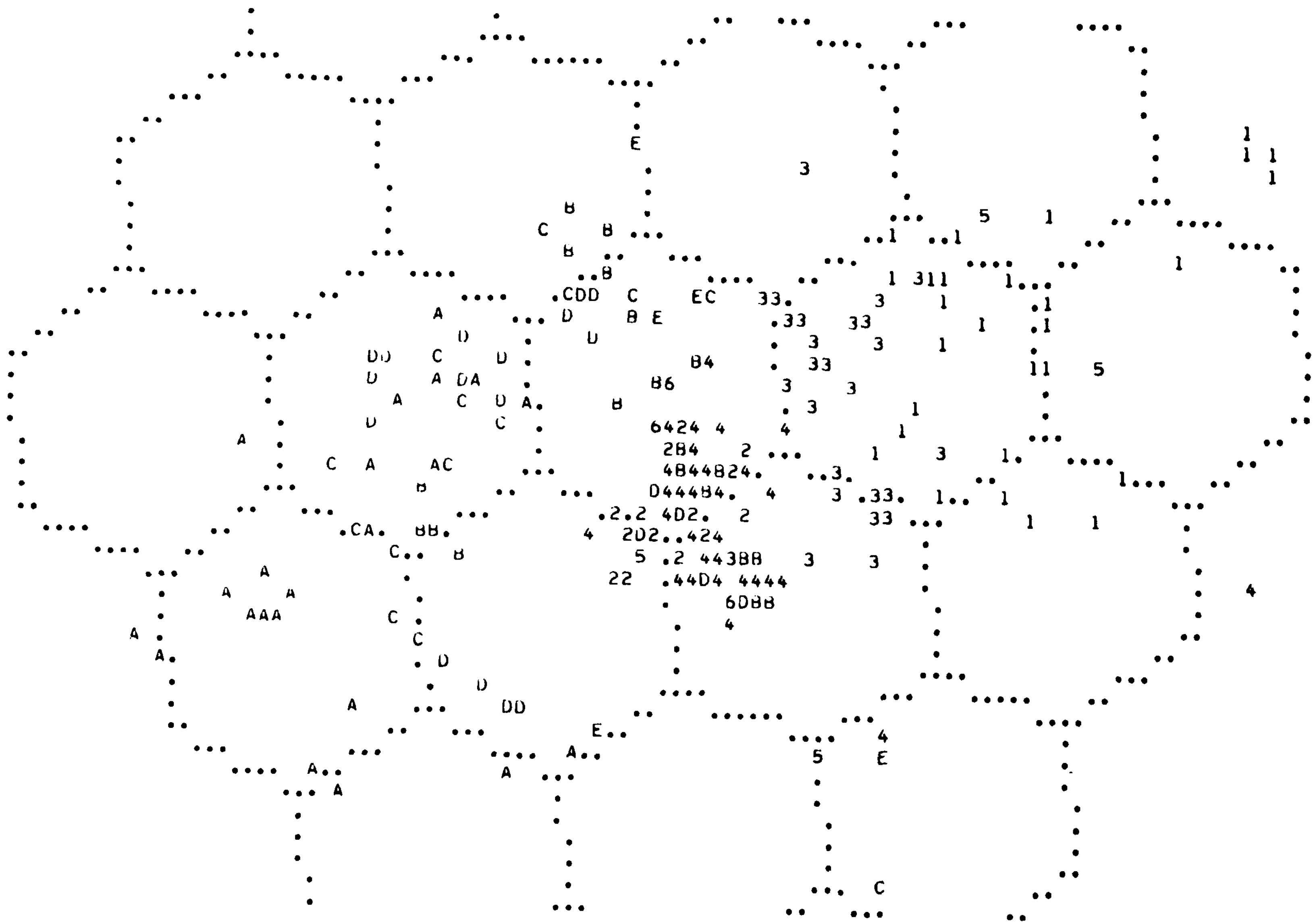


Figure K-8. Case IV-FP unit positions at 03:30 hours.

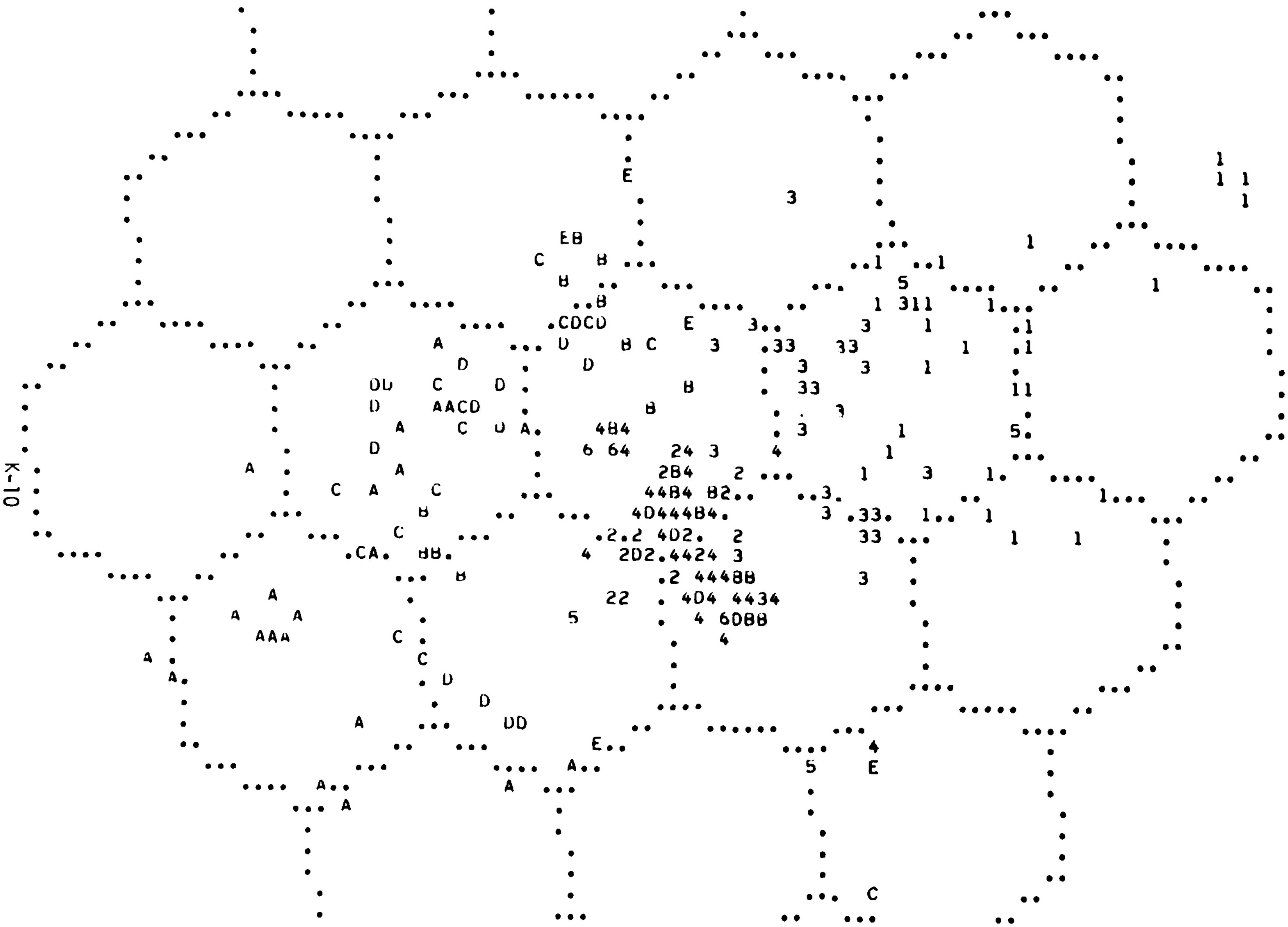


Figure K-9. Case IV-FP unit positions at 04:00 hours.

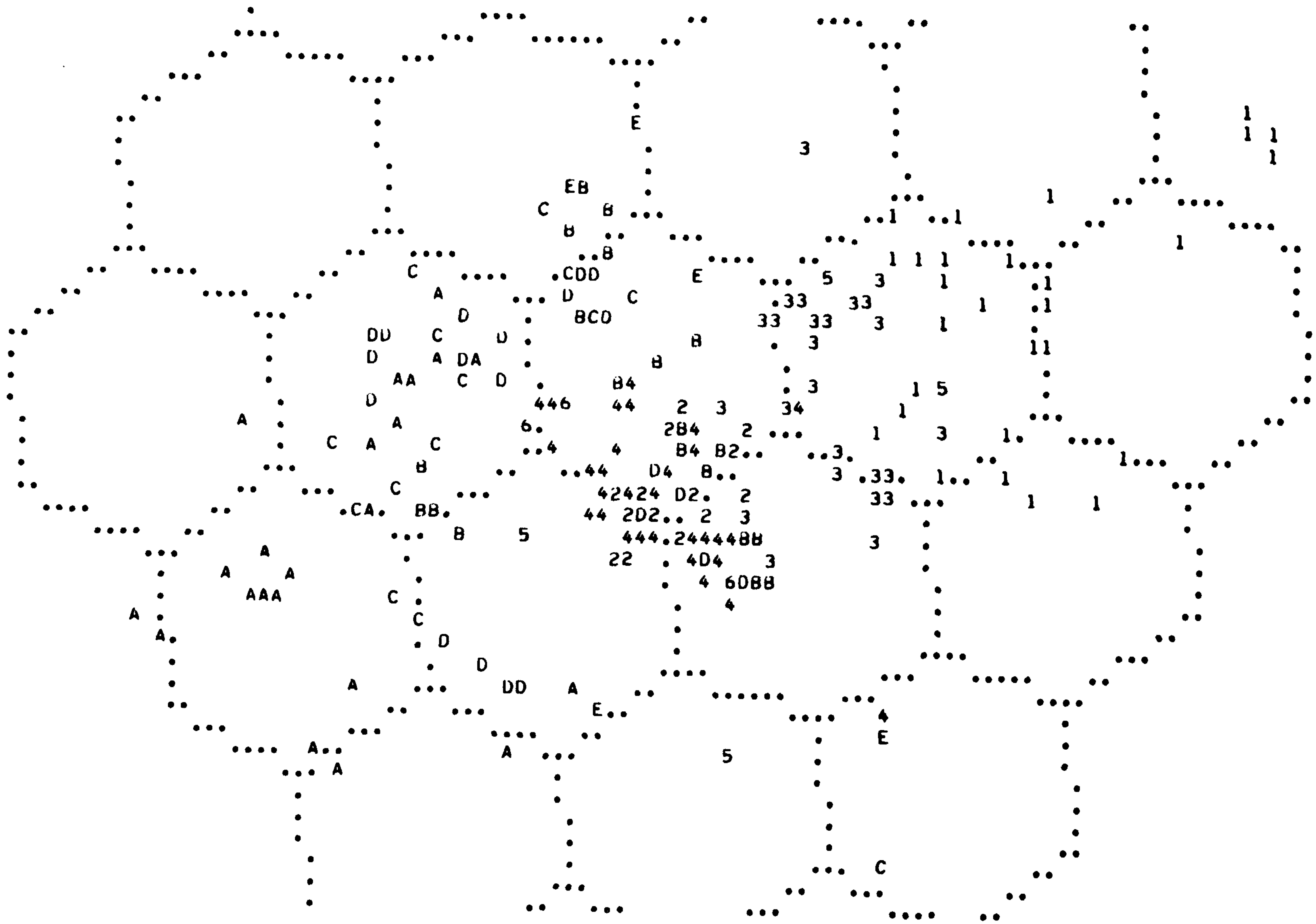


Figure K-10. Case IV-FP unit positions at 04:30 hours.

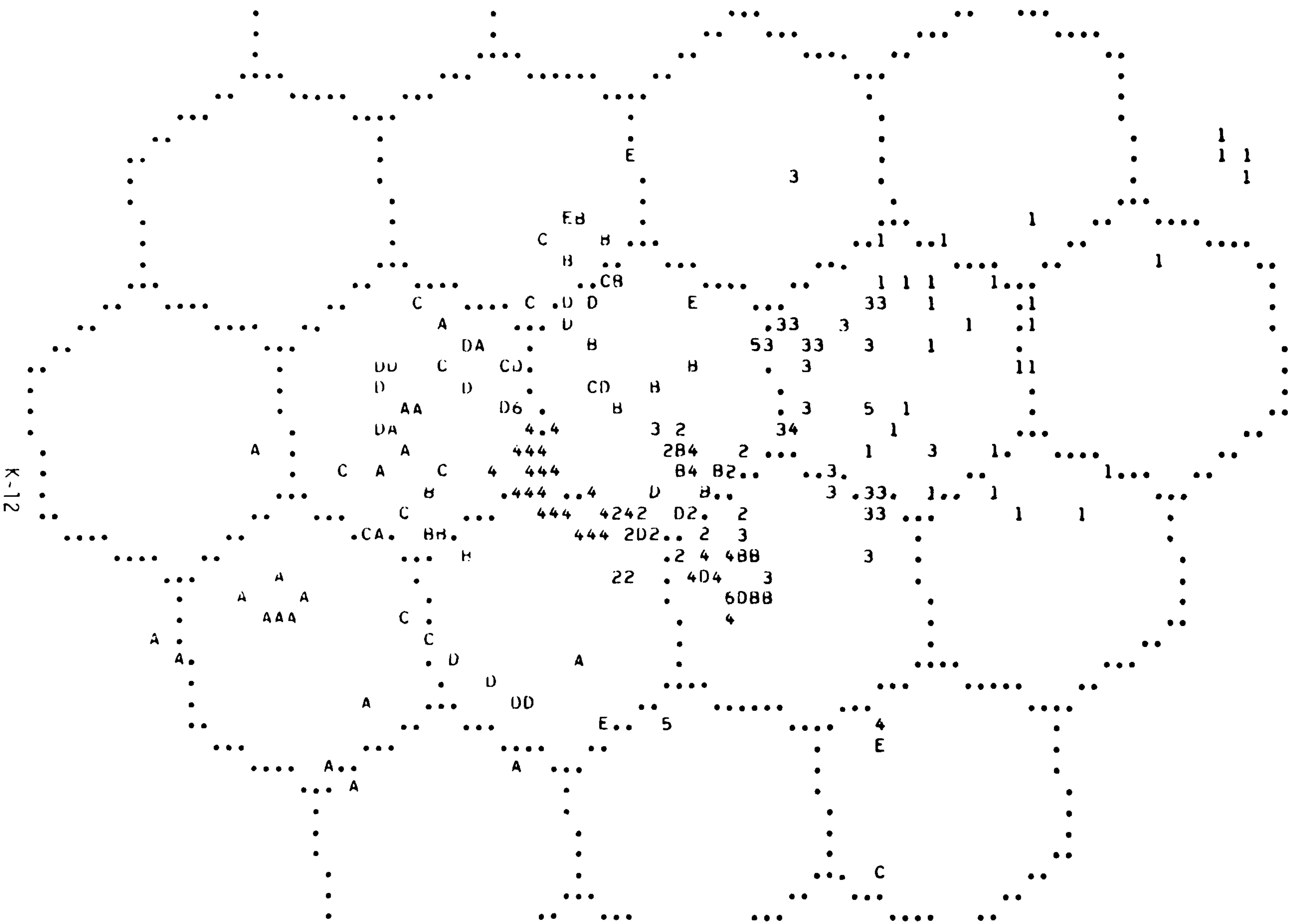


Figure K-11. Case IV-FP unit positions at 05:00 hours.

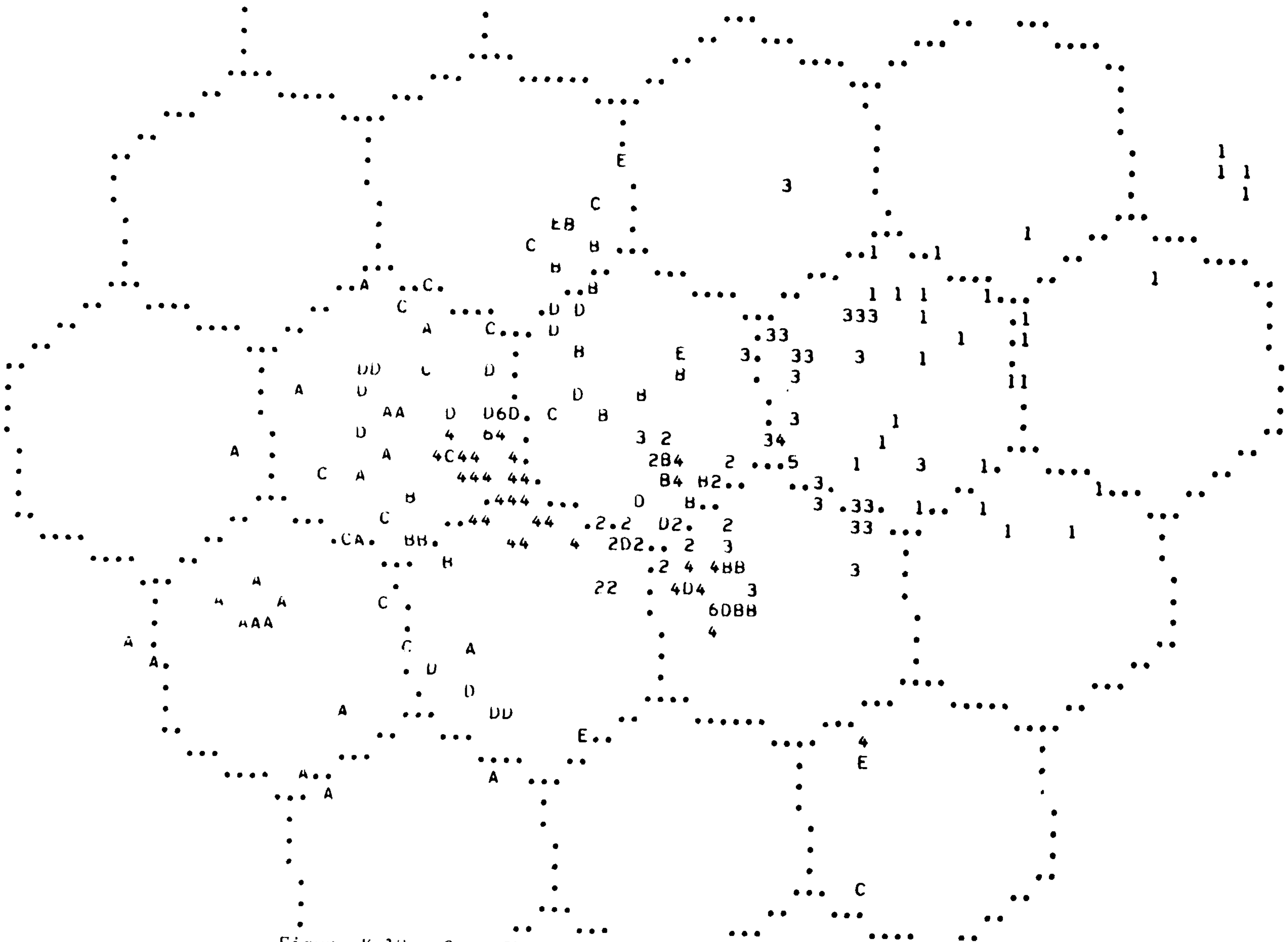


Figure K-12. Case IV-FP unit positions at 05:30 hours.

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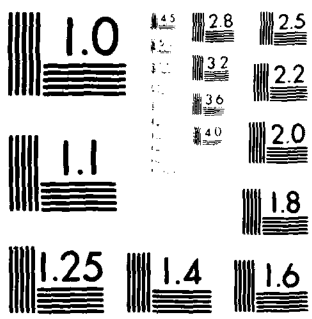

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NATIONAL BUREAU OF STANDARDS 1963-A

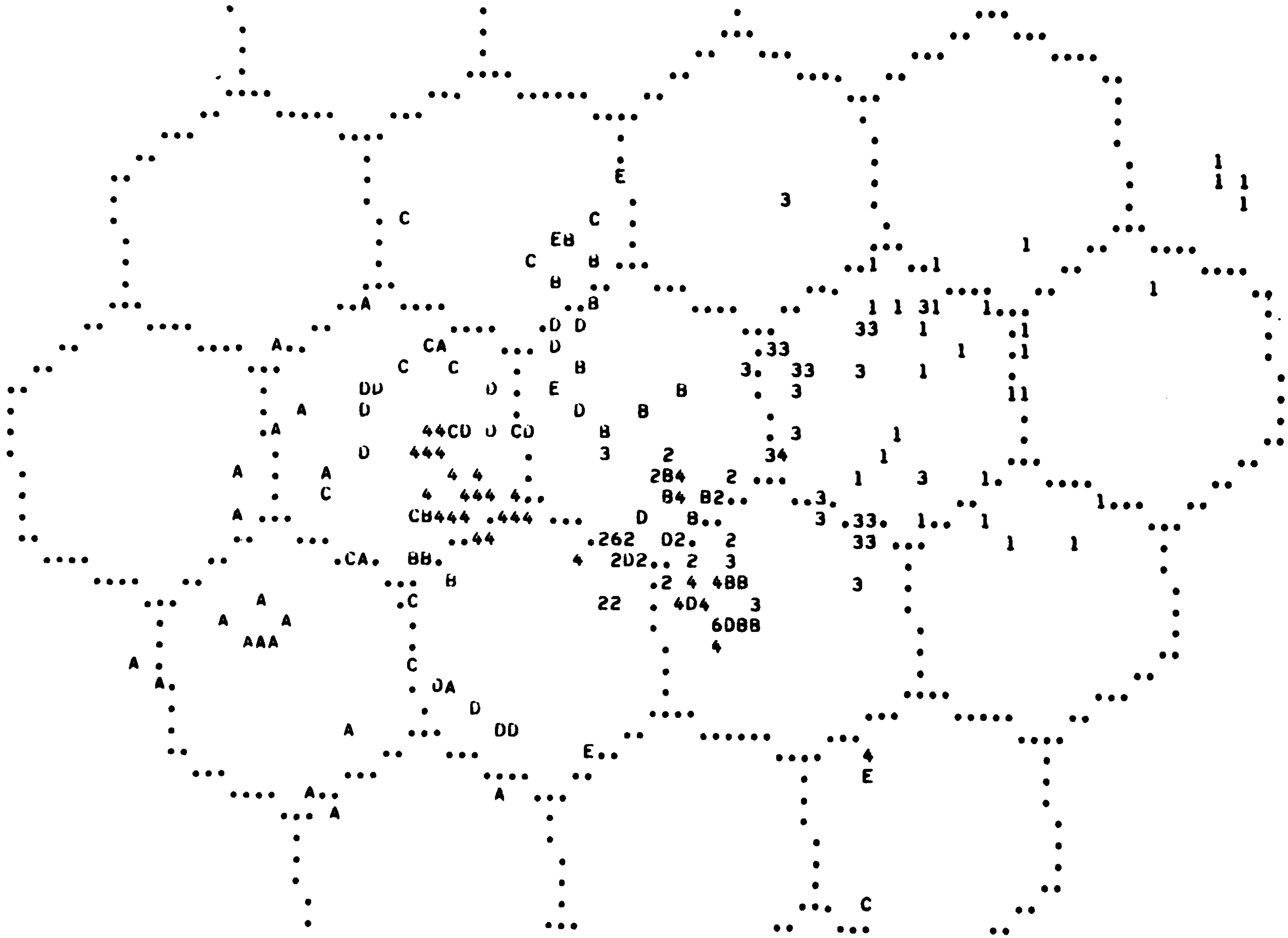


Figure K-13. Case IV-FP unit positions at 06:00 hours.

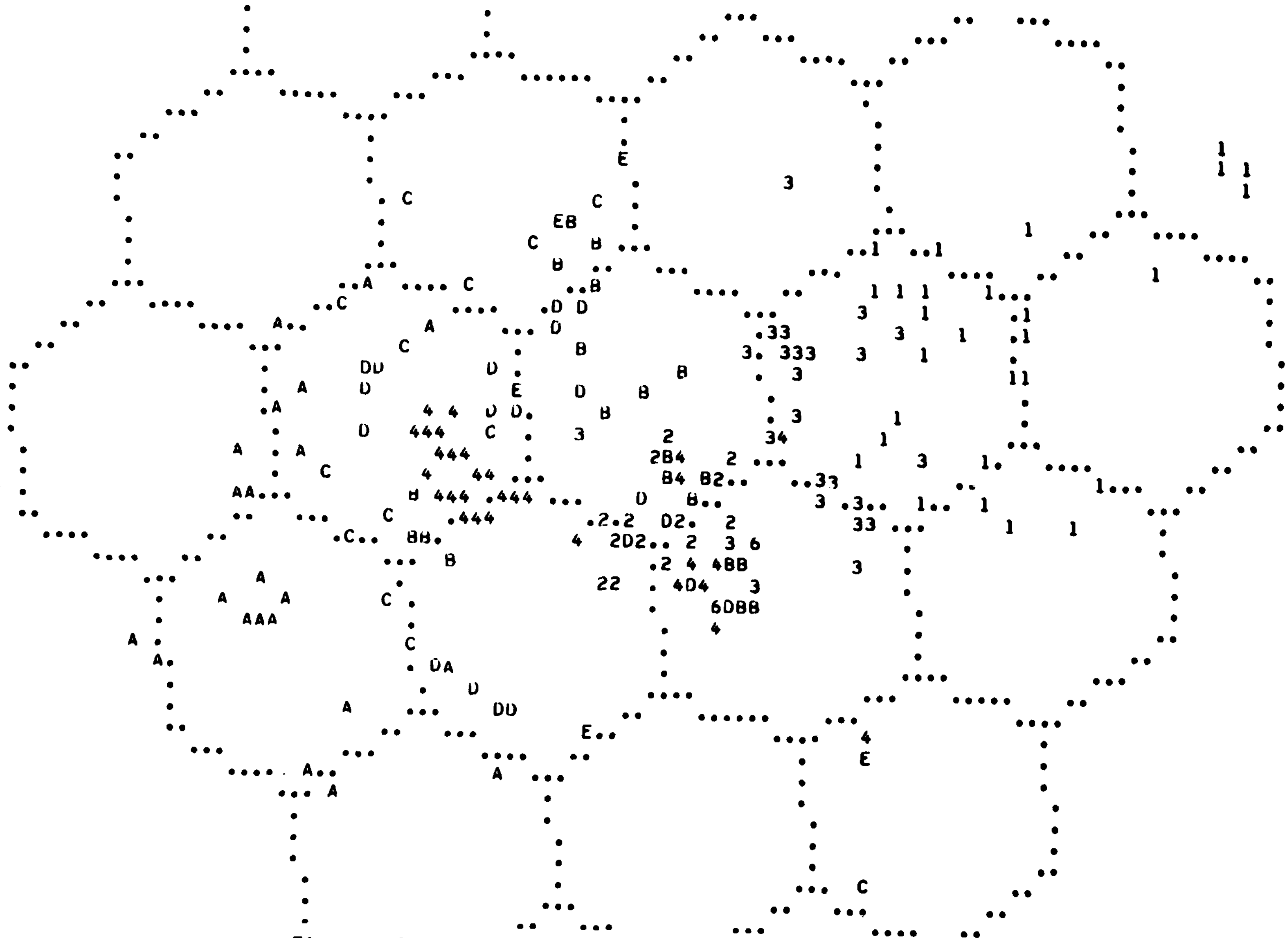


Figure K-14. Case IV-FP unit positions at 06:30 hours.

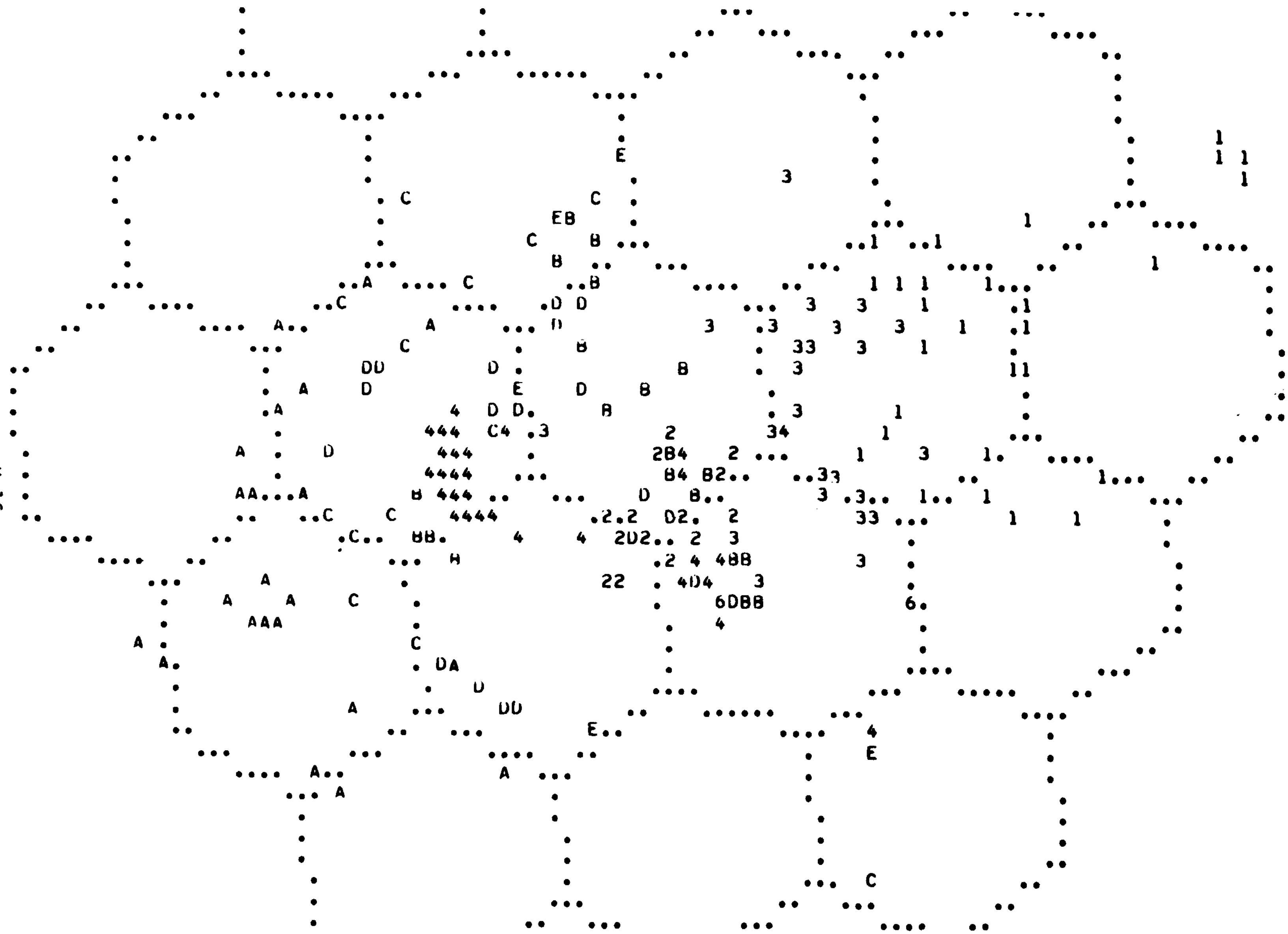


Figure K-15. Case IV-FP unit positions at 07:00 hours.

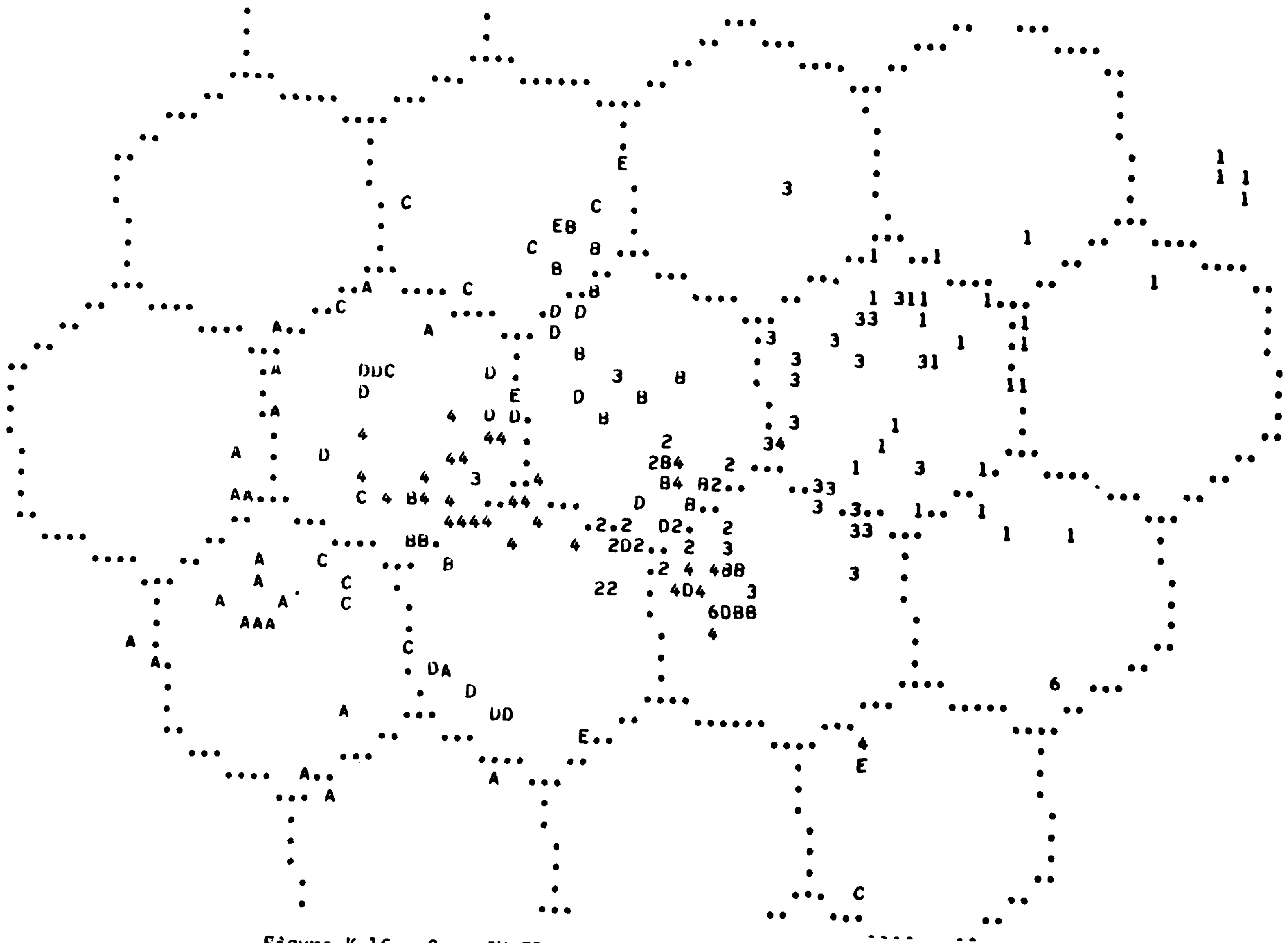


Figure K-16. Case IV-FP unit positions at 07:30 hours.

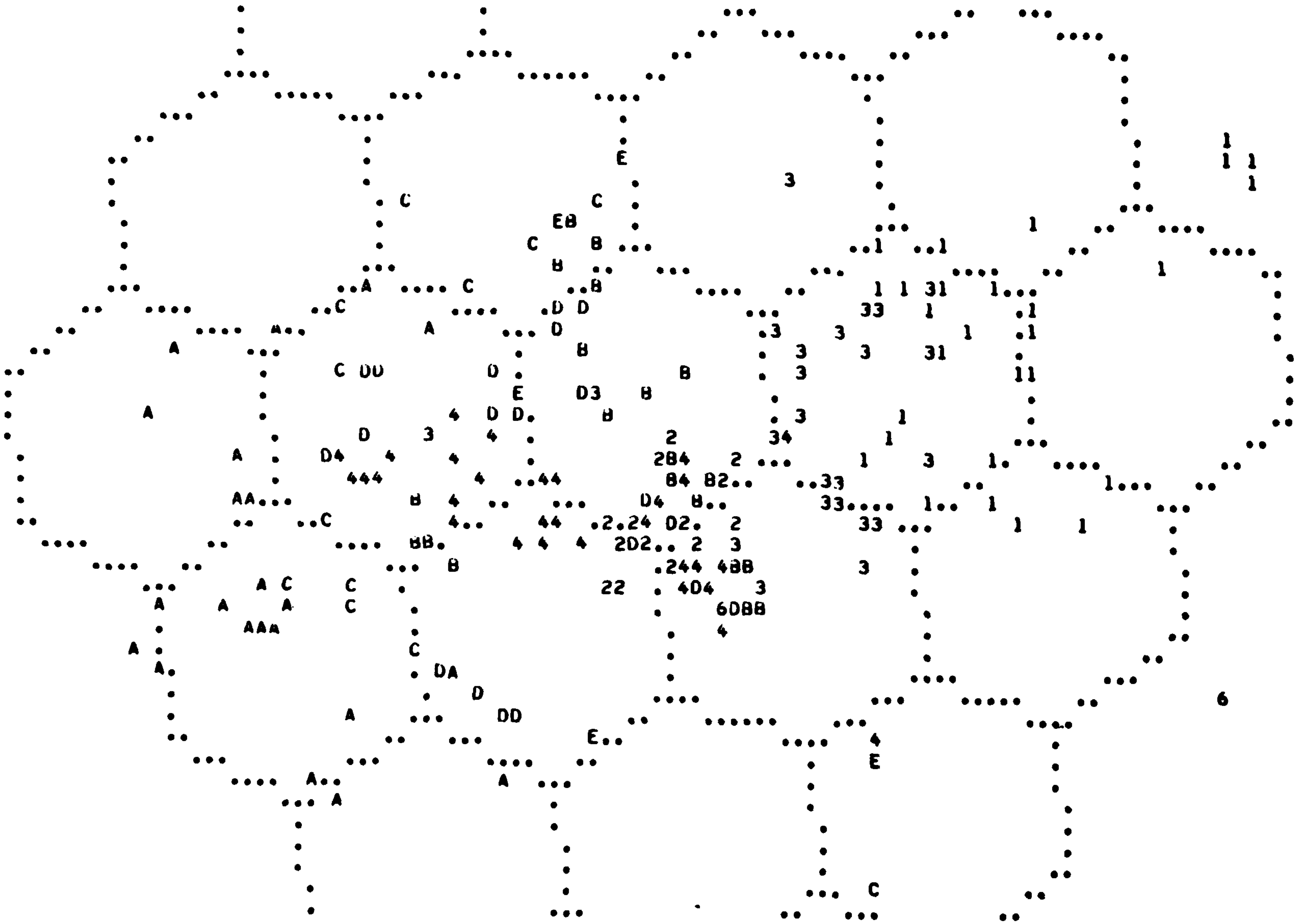


Figure K-17. Case IV-FP unit positions at 08:00 hours.

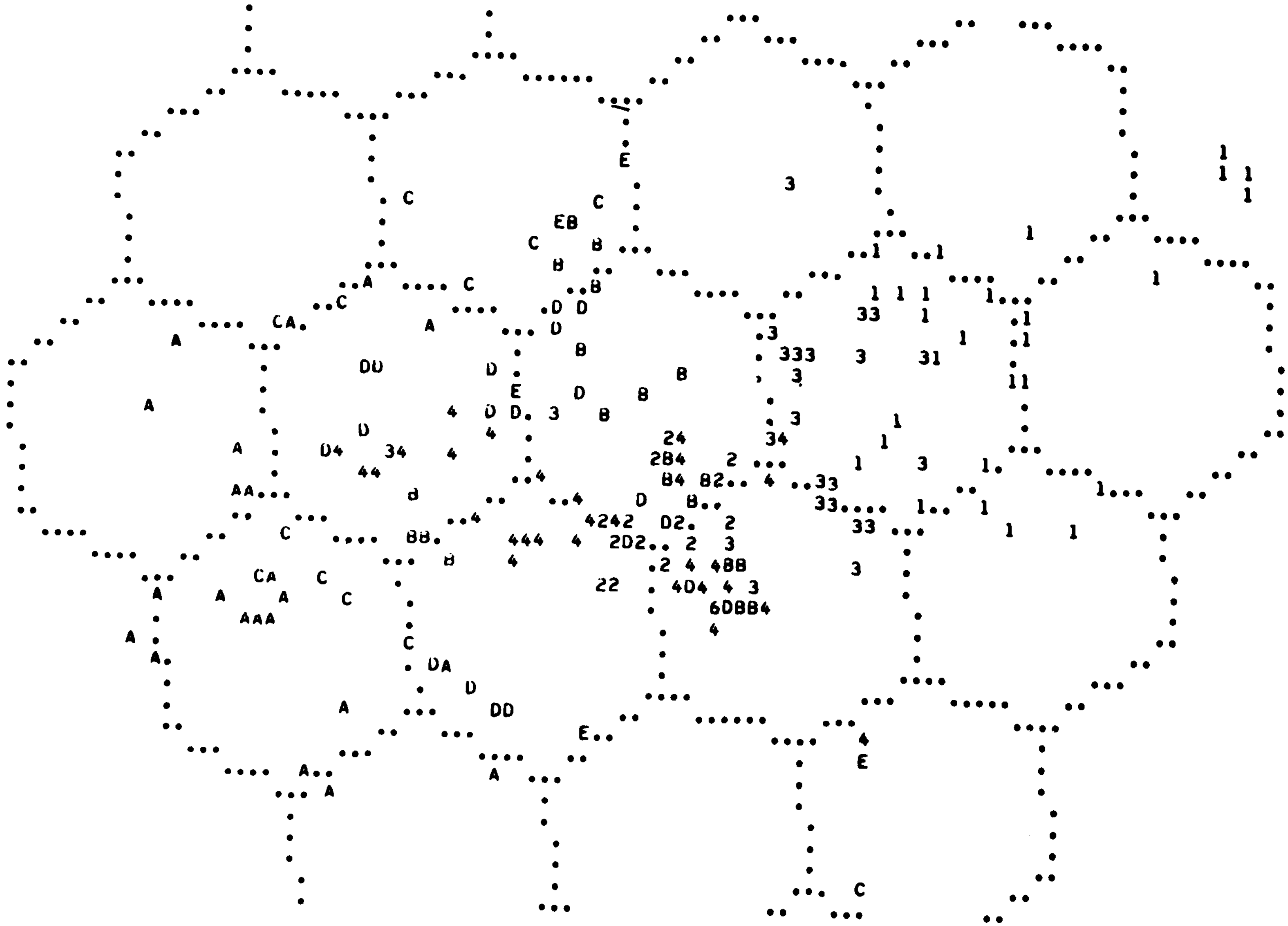


Figure K-18. Case IV-FP unit positions at 08:30 hours.

APPENDIX L
GROUND EXCHANGE MAPS

The 19 maps in this appendix were used to obtain a measure of the ground gained (or lost) by the Red advance and penetration of the Blue defenses. For each of the six TRACE cases there are three maps at 02:30, 05:30, and 08:30 hours respectively, and one map (Figure L-1) showing the initial deployment of Red and Blue forces. These maps are duplicates of those found in Appendices F through K.

The initial positions of Red and Blue force units were separated by an arbitrary boundary as shown in Figure L-1. Specific points of the hexagons were chosen to construct this boundary from three straight lines thus allowing precise placement of the same boundary on all other unit position maps. The boundary effectively represents the forward edge of the battle area at the beginning of the conflict.

The curved line on each map encloses the land area occupied by or effectively controlled by Red forces. Although some Blue force units appear within these boundaries, they have been neutralized (but not killed) by the Red forces. The lines were intentionally drawn quite closely to the Red controlling units to assist consistency from map to map. Since it is the relative change between cases that we seek, the exact absolute placement of the lines is not as important as consistent placement. Finally, the area occupied/controlled by the Red forces was determined by direct manual integration of these maps with a planimeter.

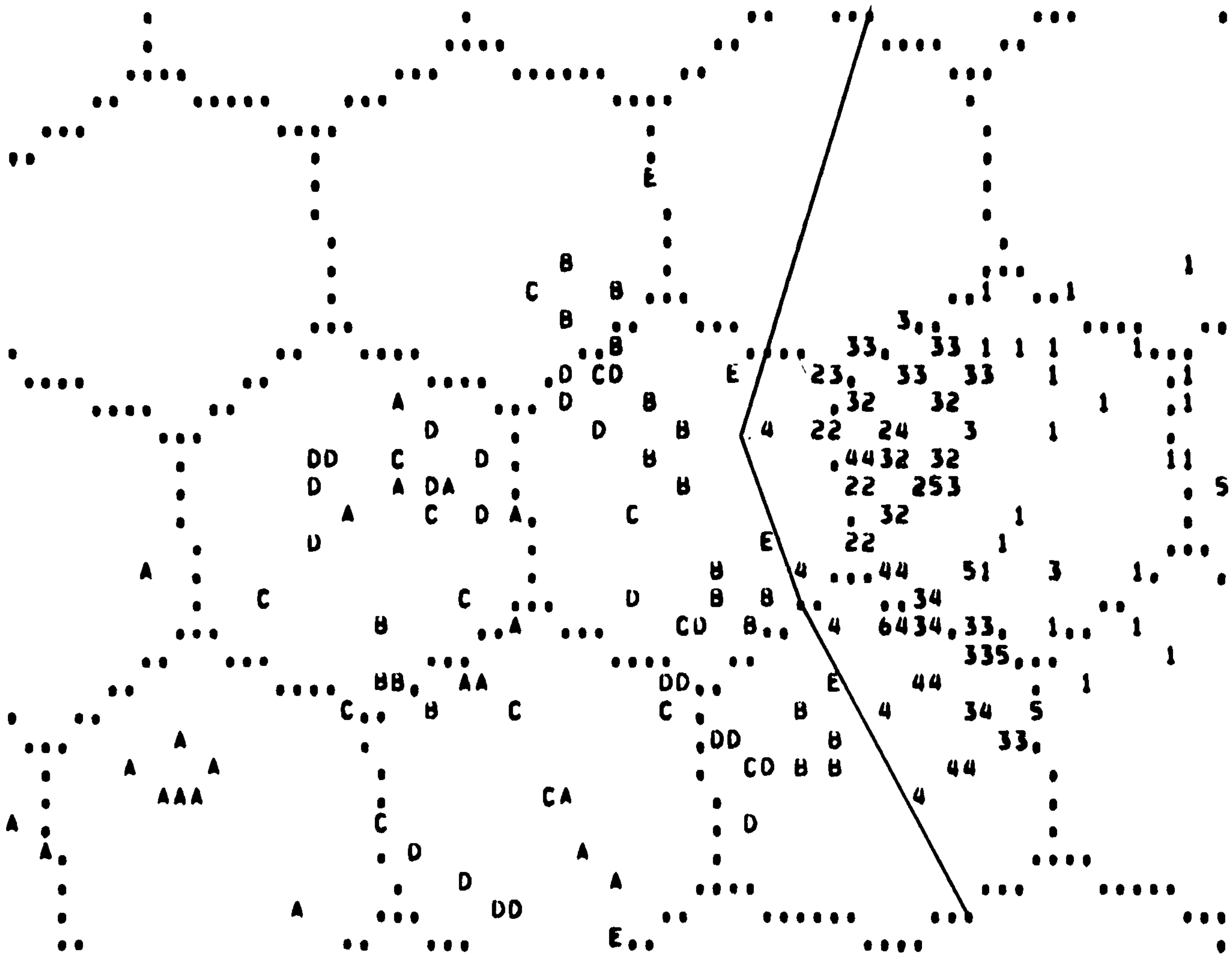


Figure L-1. Initial unit positions and side separation boundary.

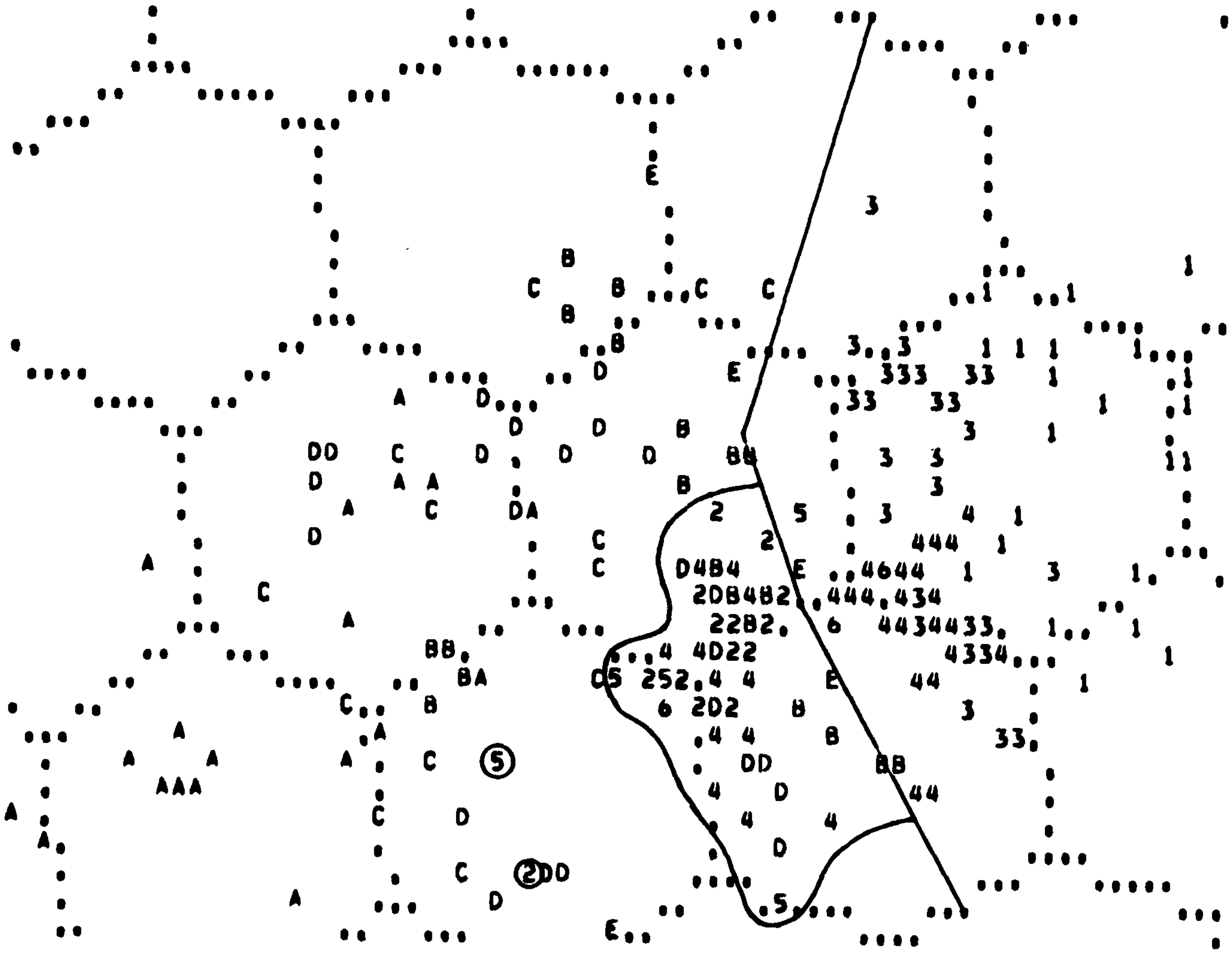


Figure L-2. Case I ground change at 02:30 hours.

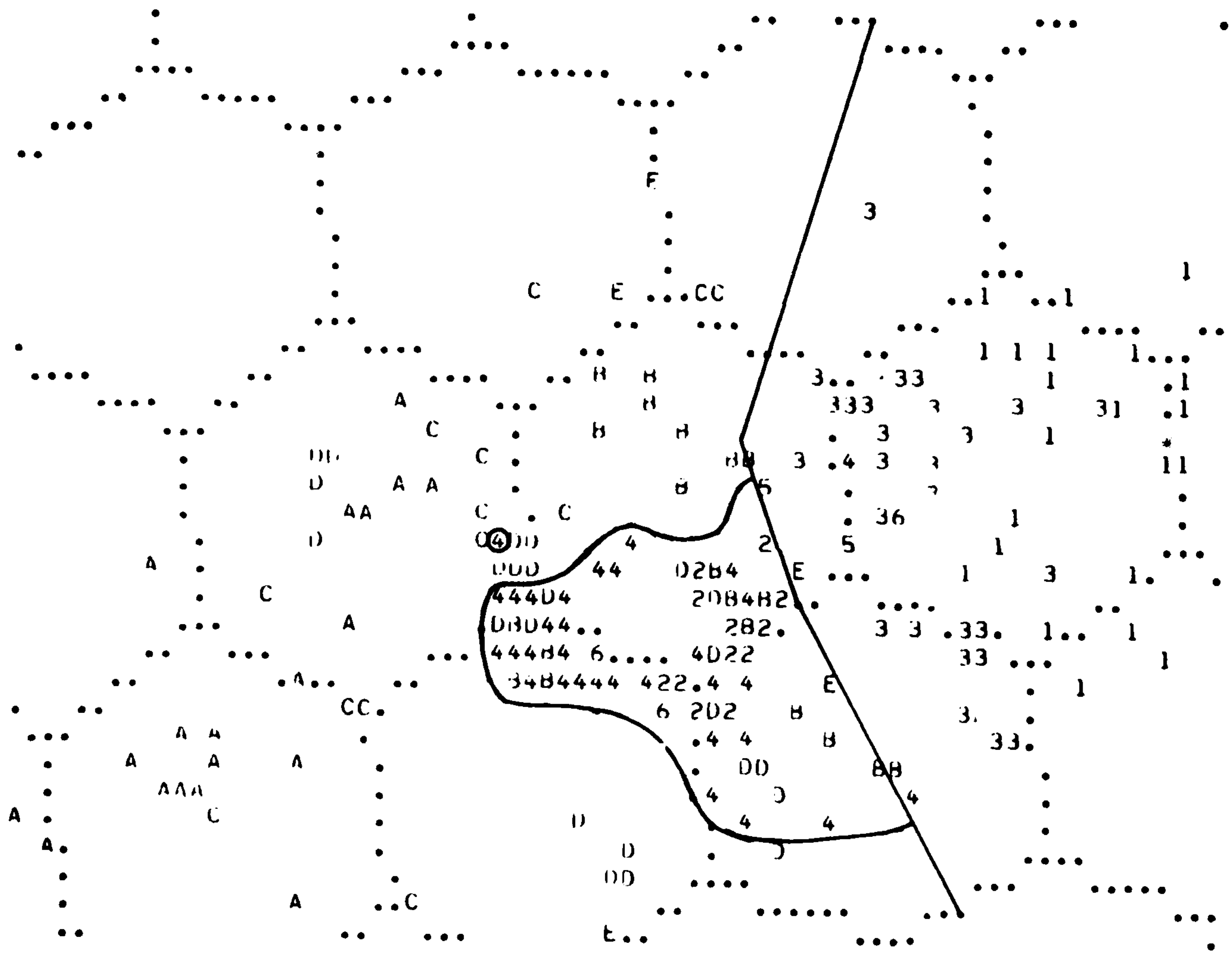


Figure L-3. Case I ground change at 05:30 hours.

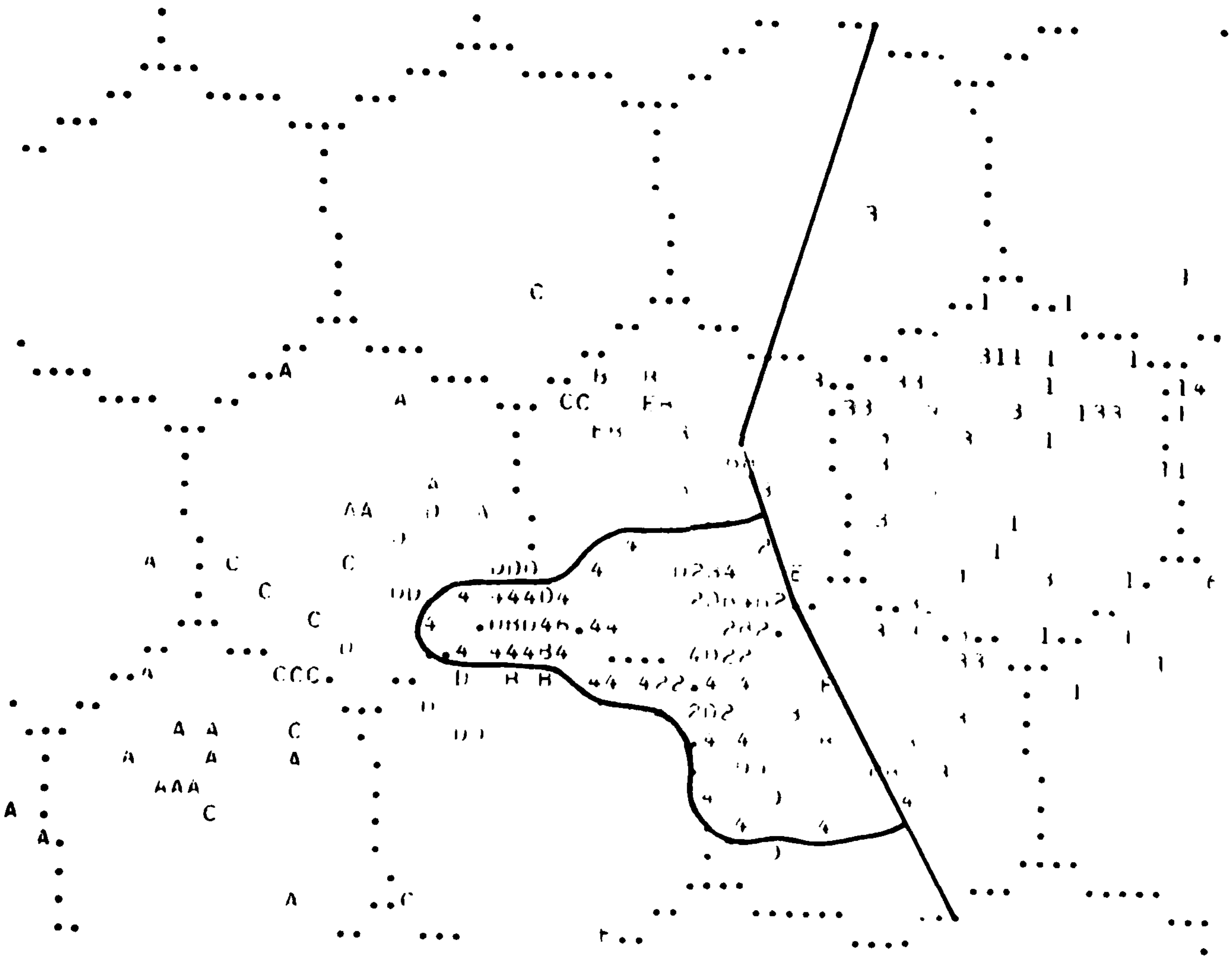


Figure L-4. Case I ground change at 08:30 hours.

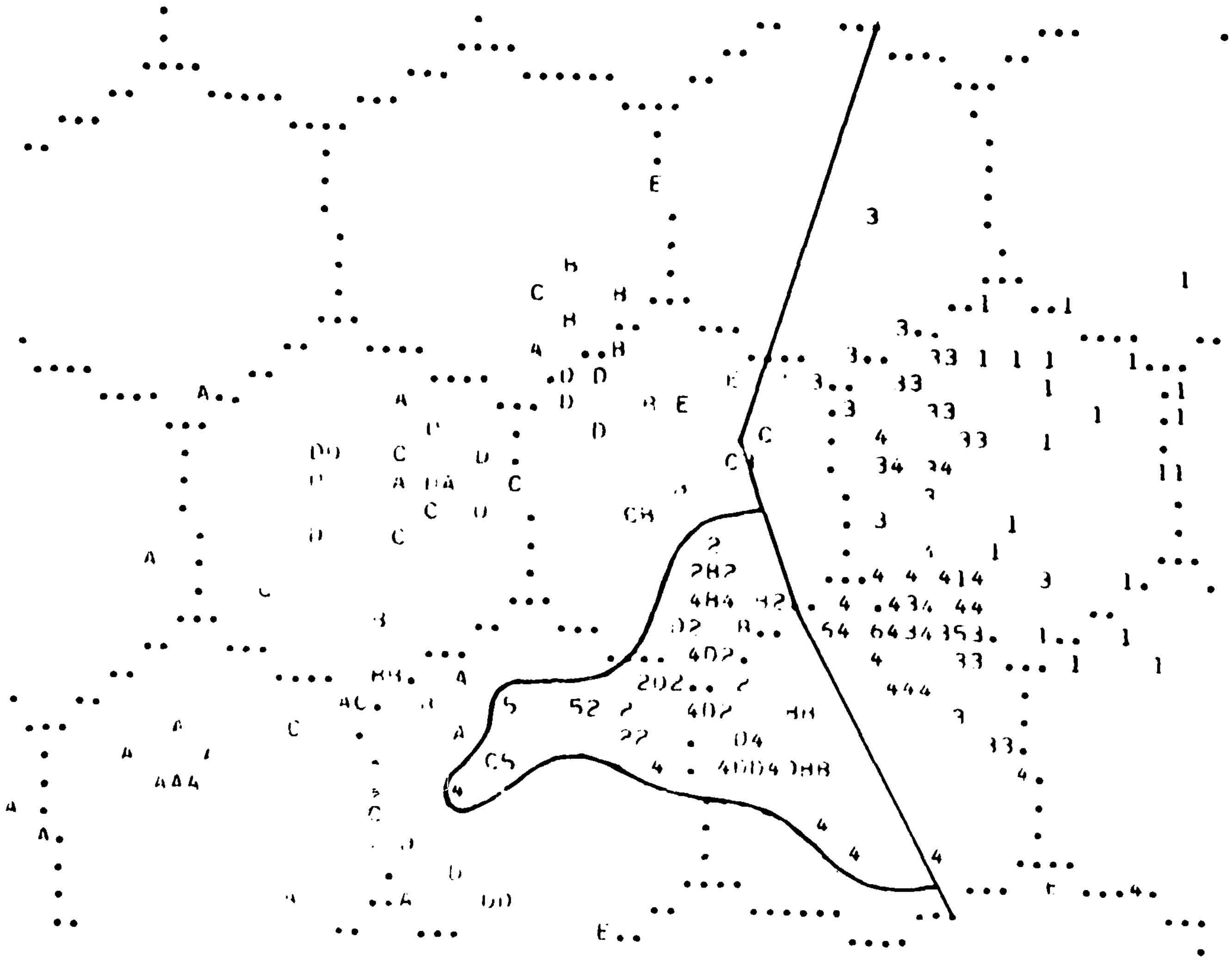


Figure L-5. Case II ground change at 02:30 hours.

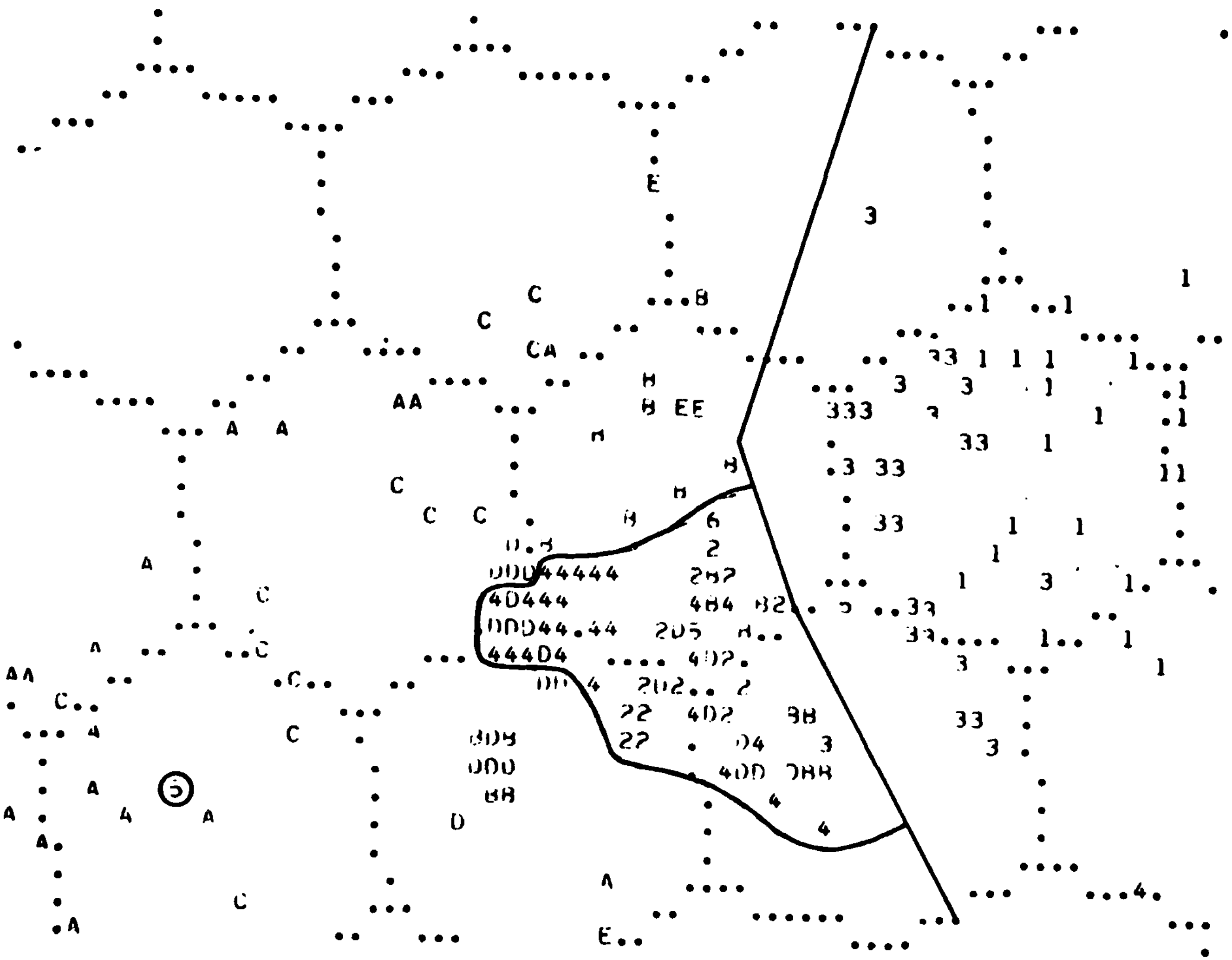


Figure L-6. Case II ground change at 05:30 hours.

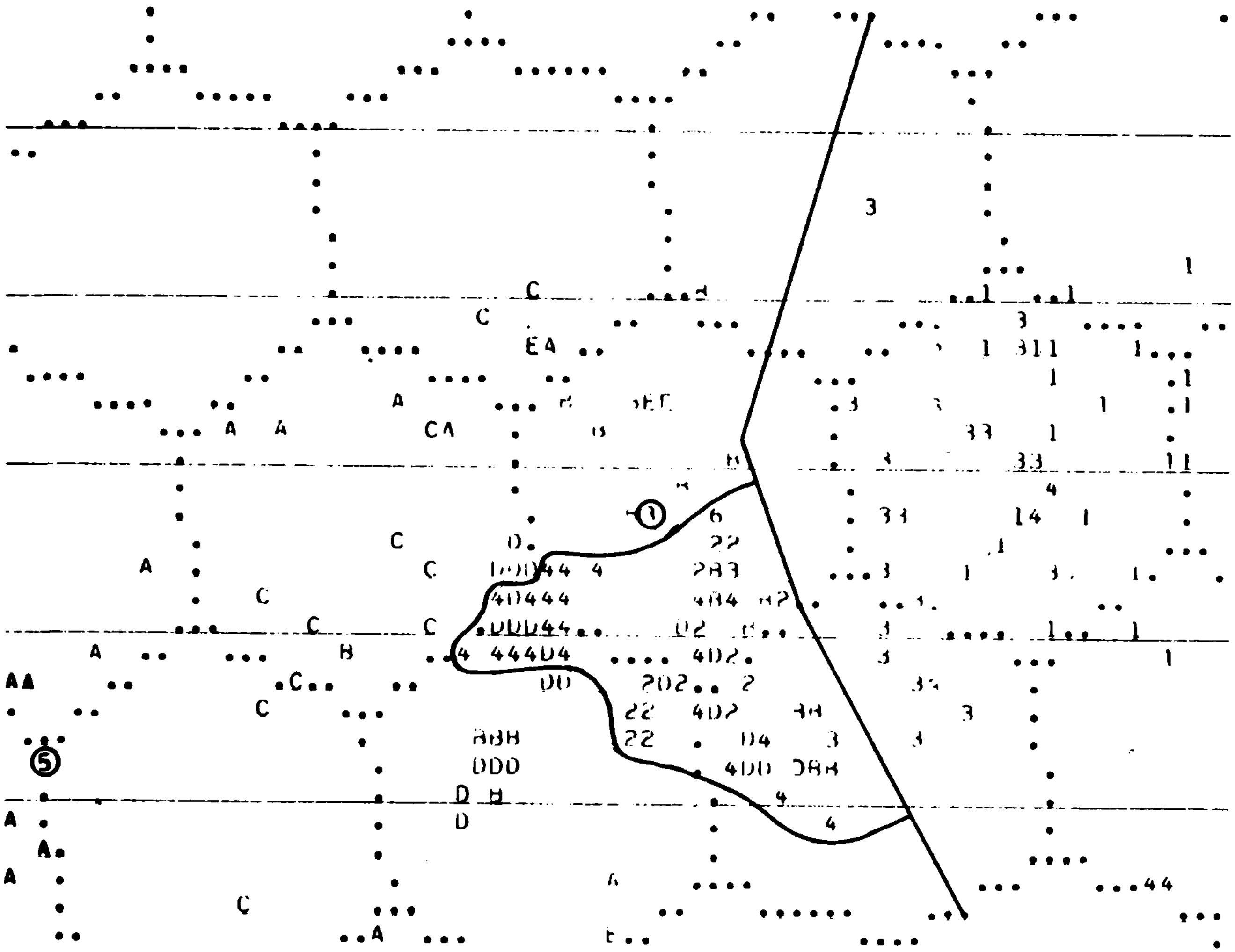


Figure L-7. Case II ground change at 08:30 hours.

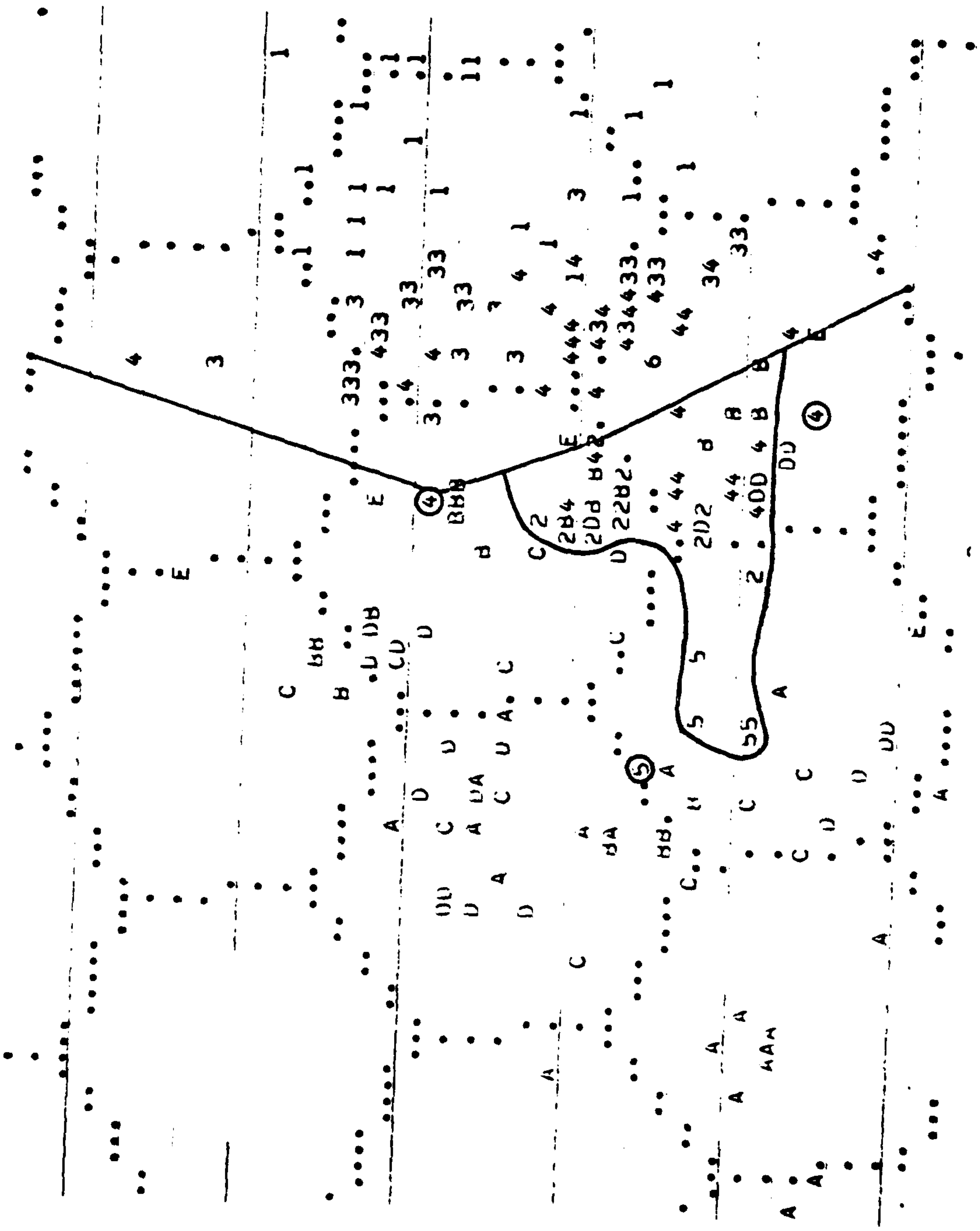


Figure L-8. Case III ground change at 02:30 hours.

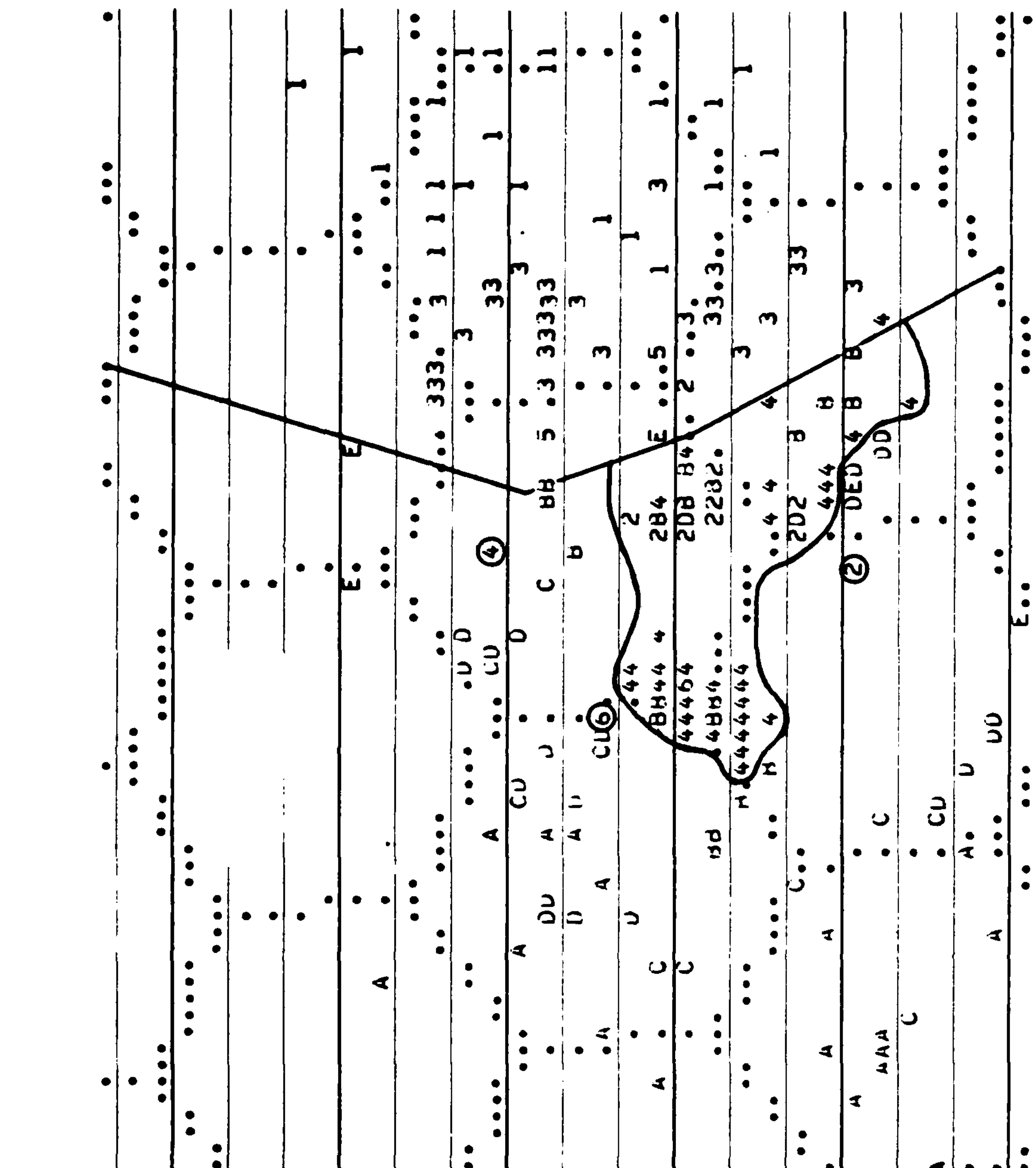


Figure L-9. Case III ground change at 05:30 hours.

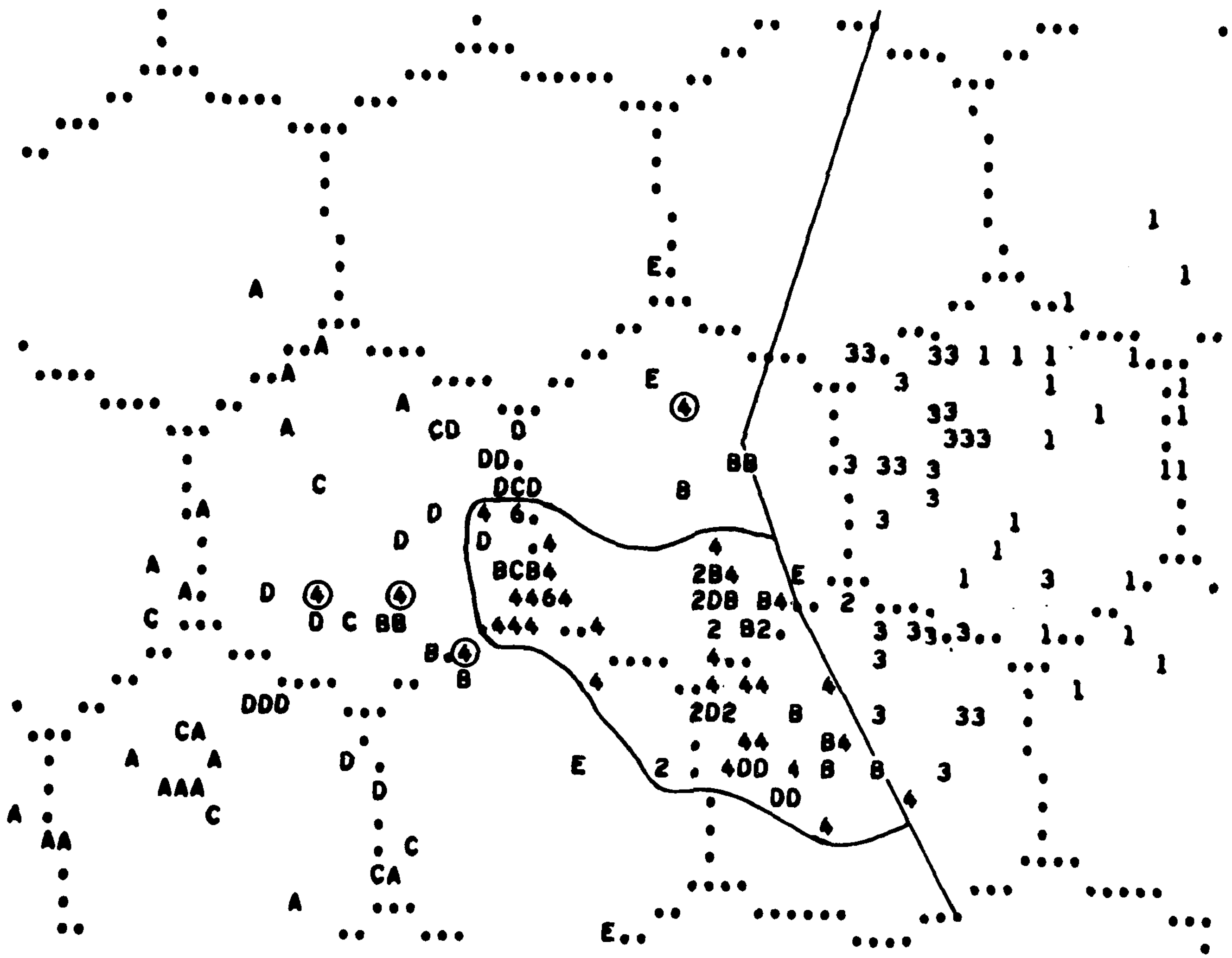


Figure L-10. Case III ground change at 08:30 hours.

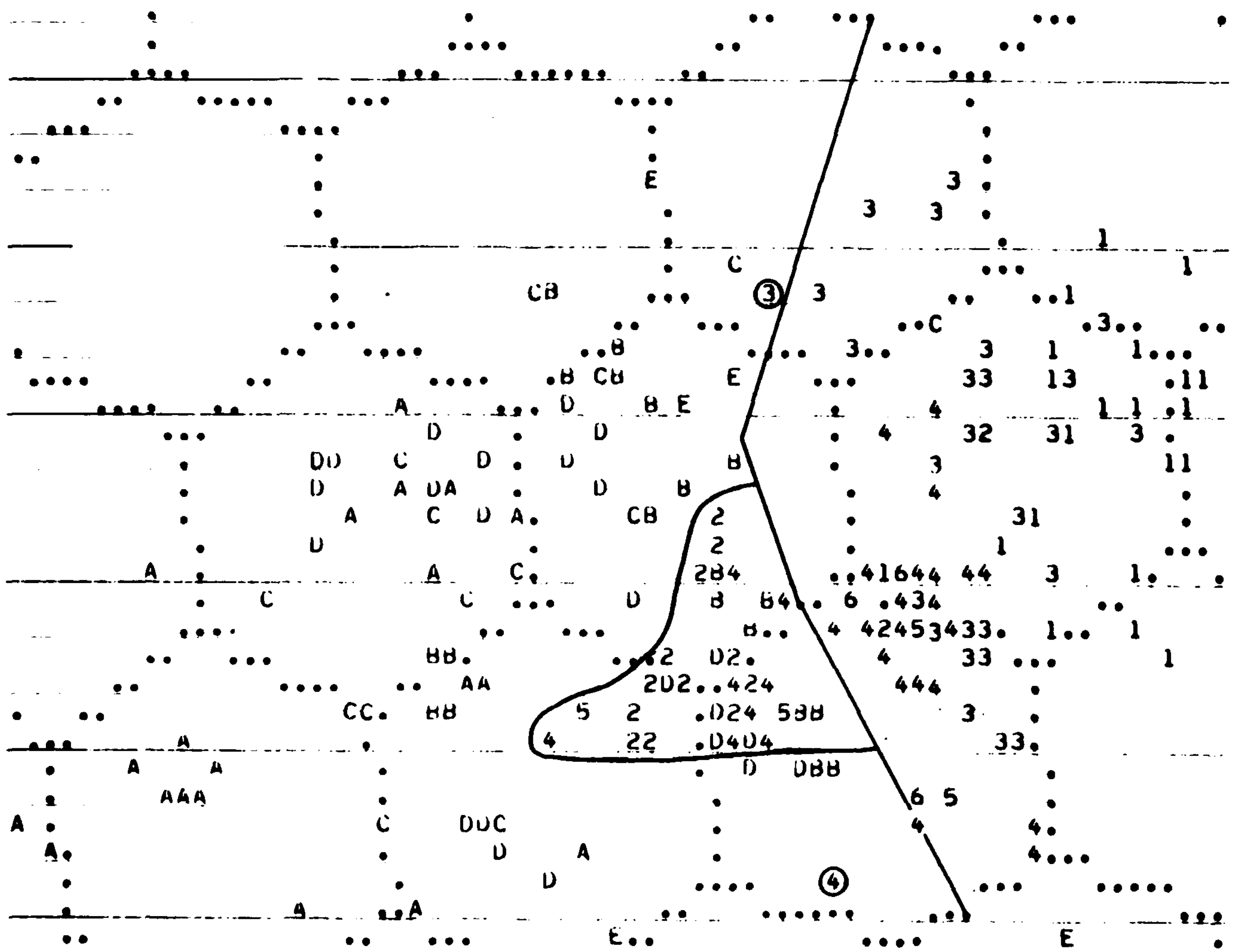


Figure L-11. Case IV ground change at 02:30 hours.

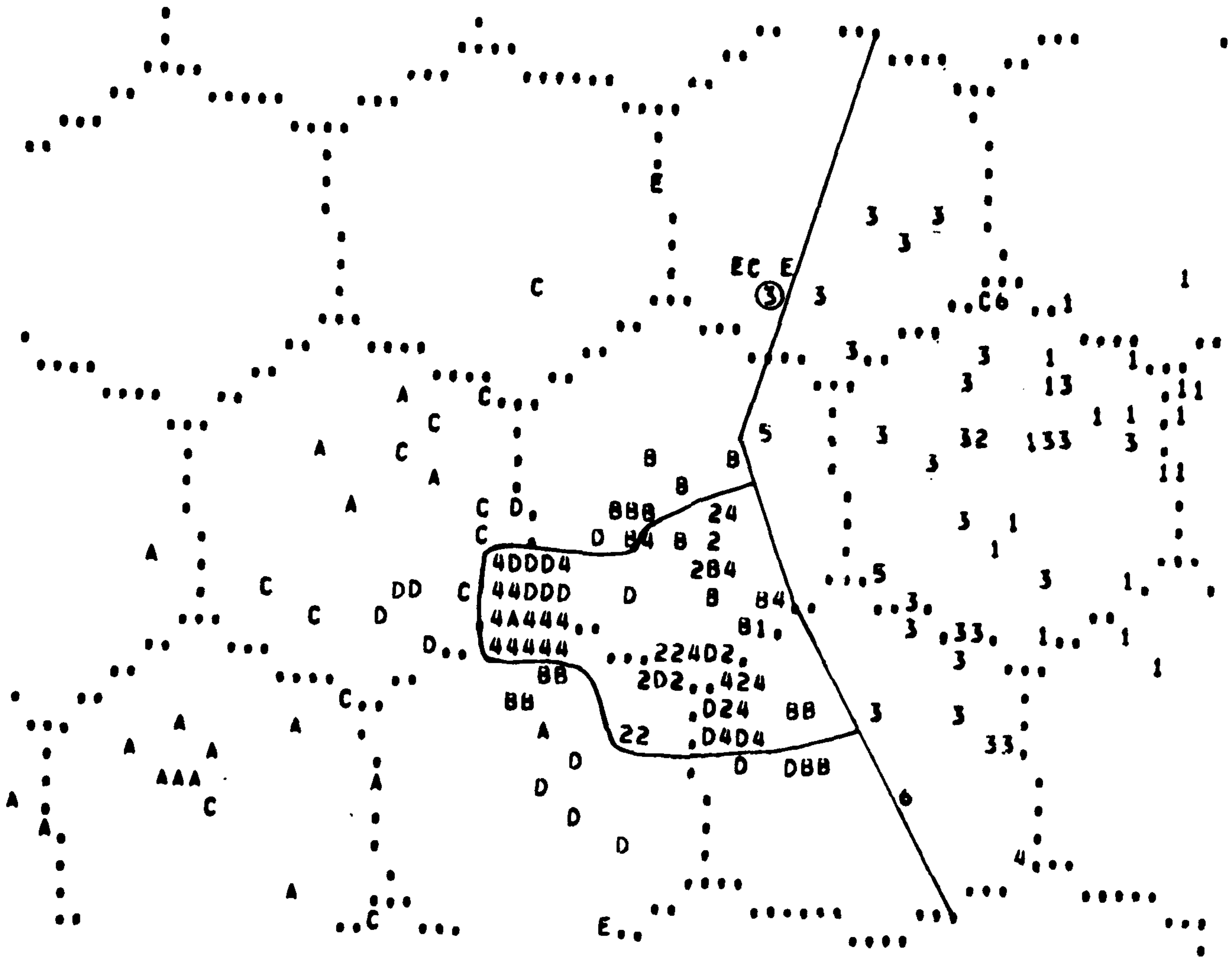


Figure L-12. Case IV ground change at 05:30 hours.

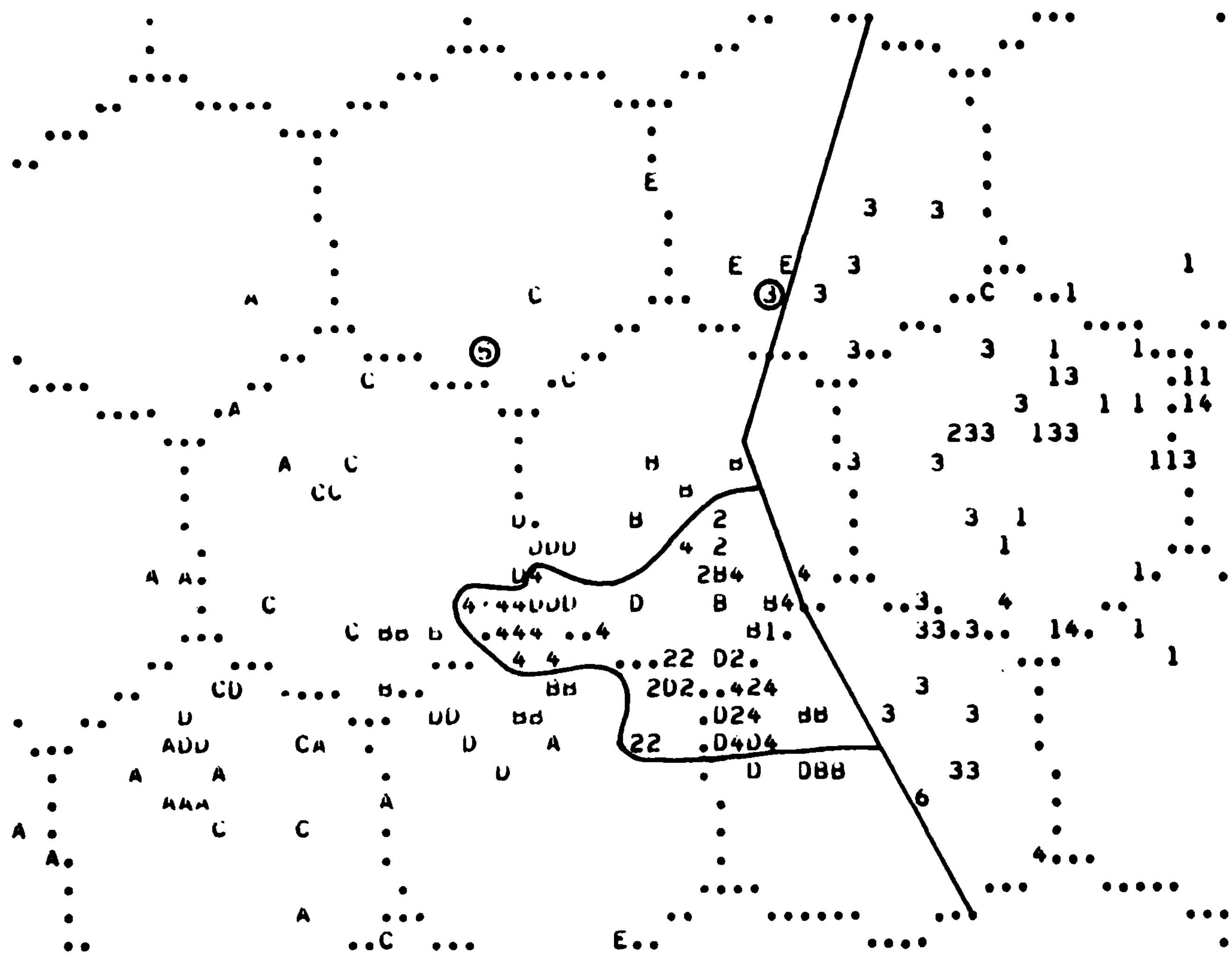


Figure L-13. Case IV ground change at 08:30 hours.

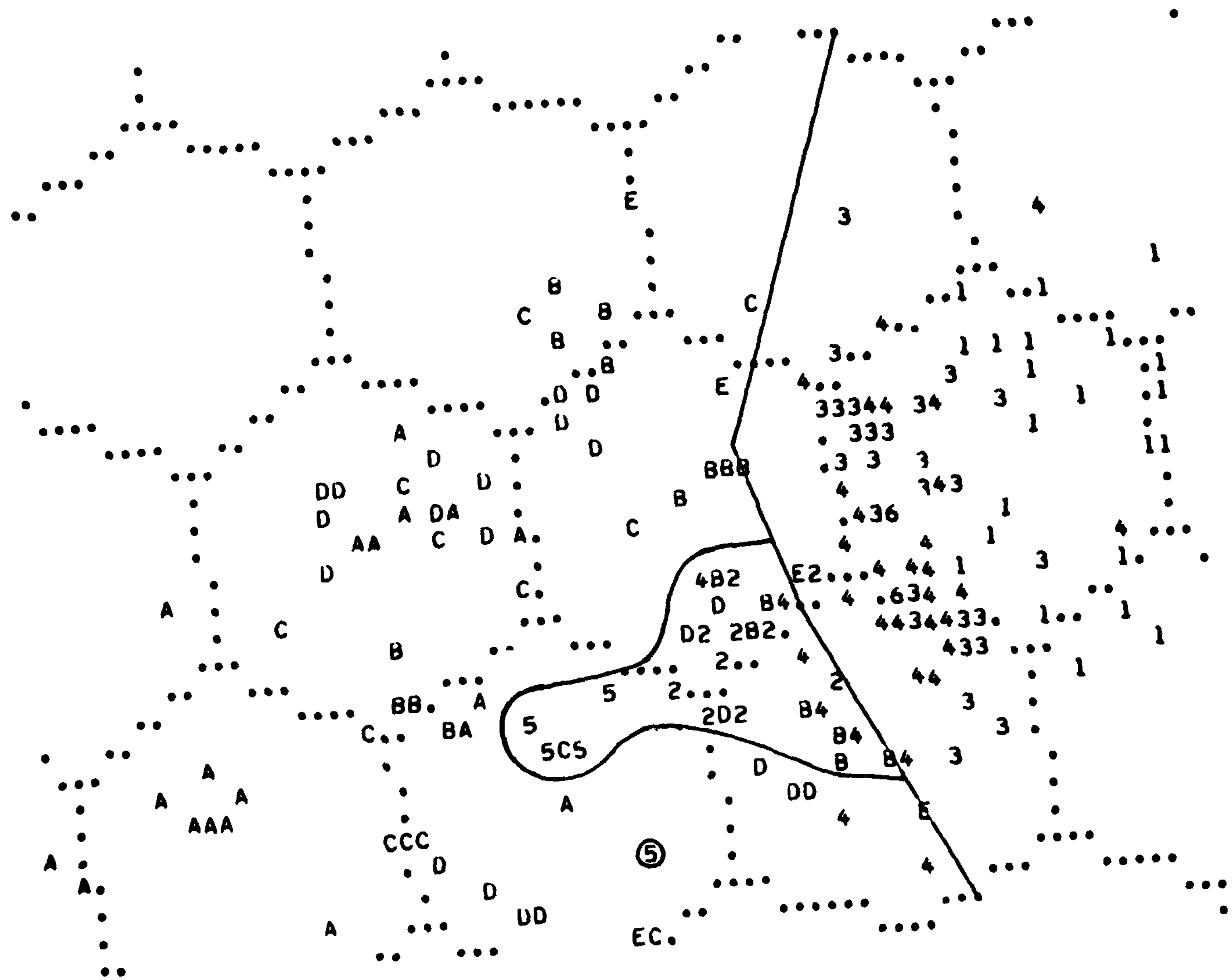


Figure L-14. Case III-FP ground change at 02:30 hours.

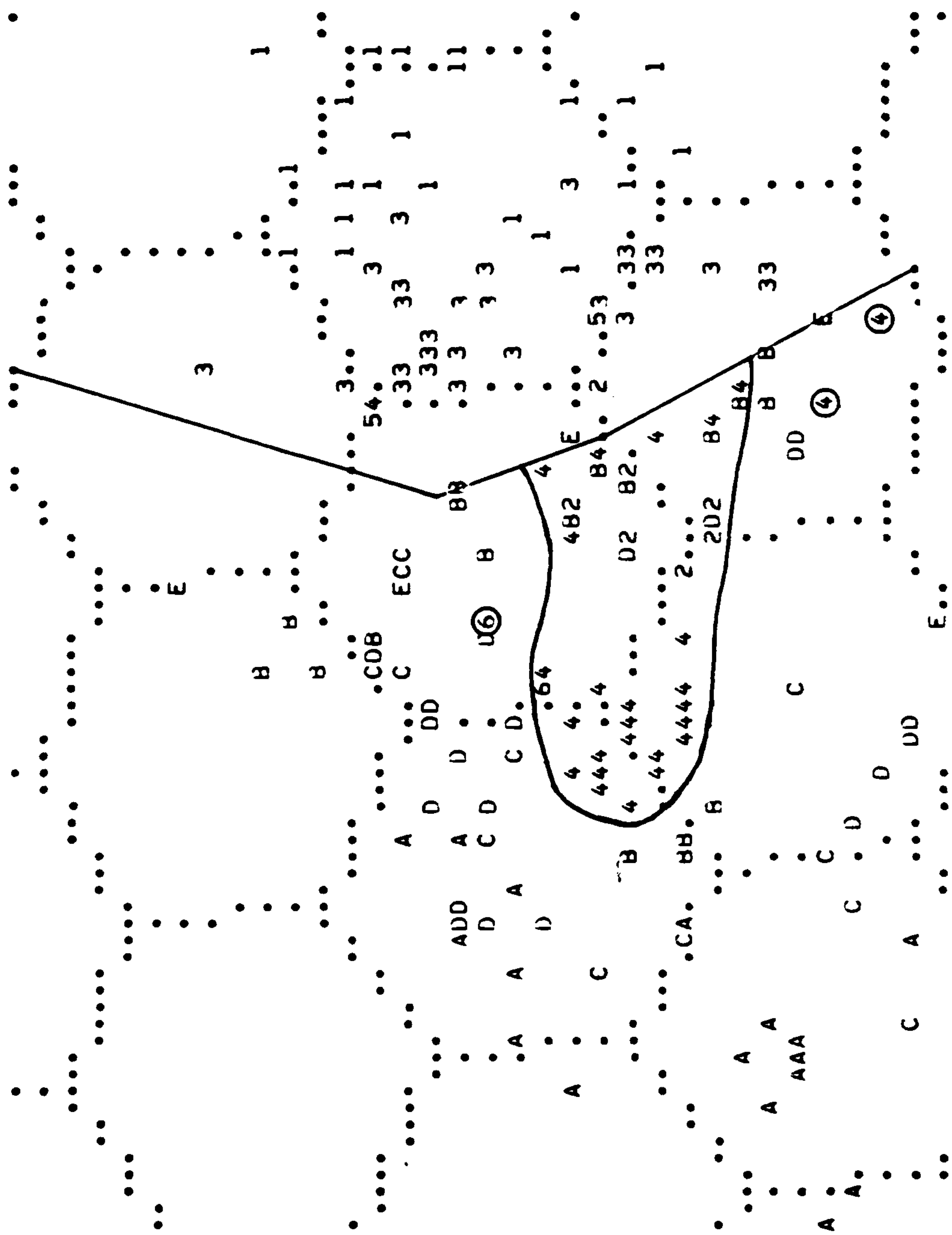
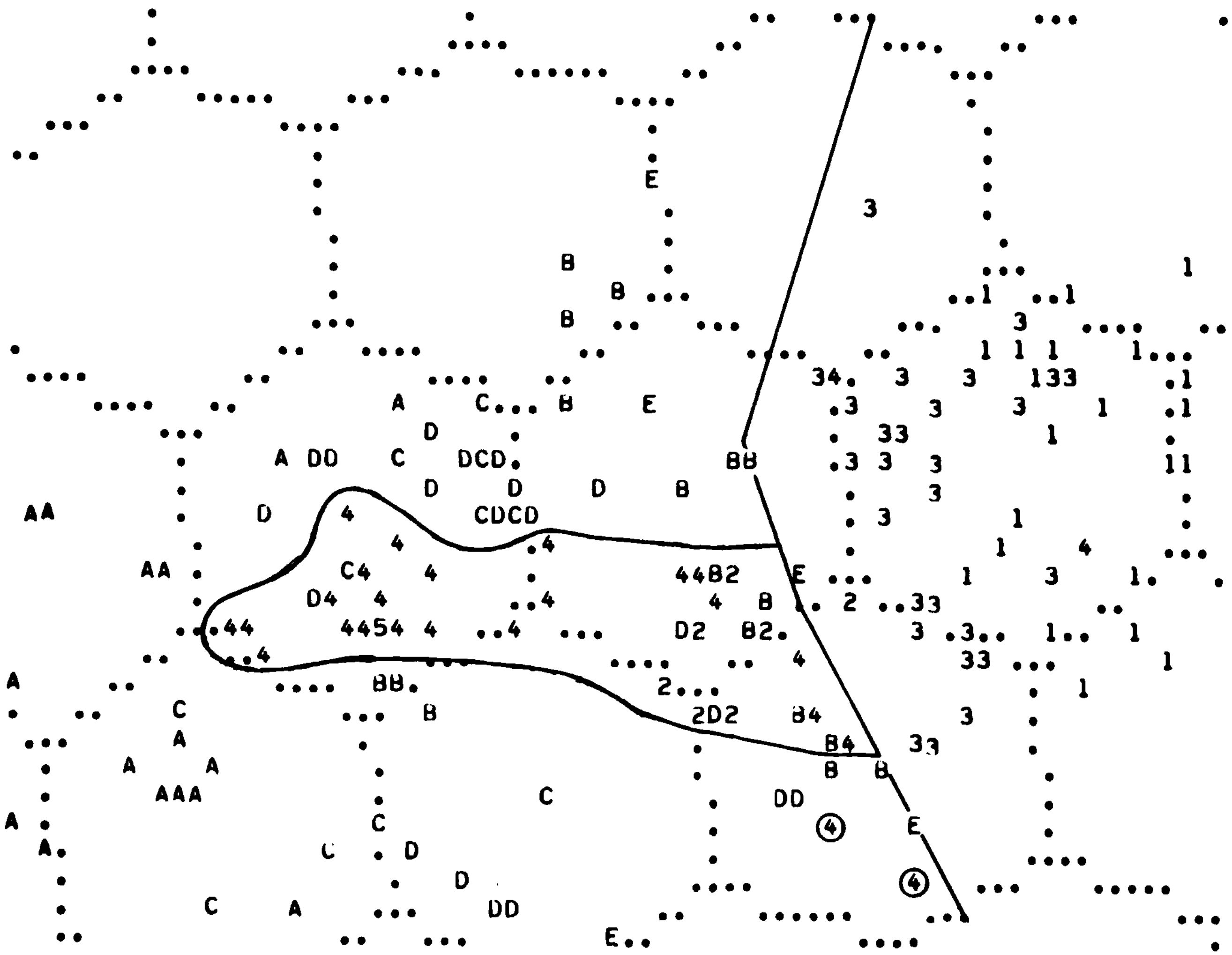


Figure L-15. Case III-FP ground change at 05:30 hours.



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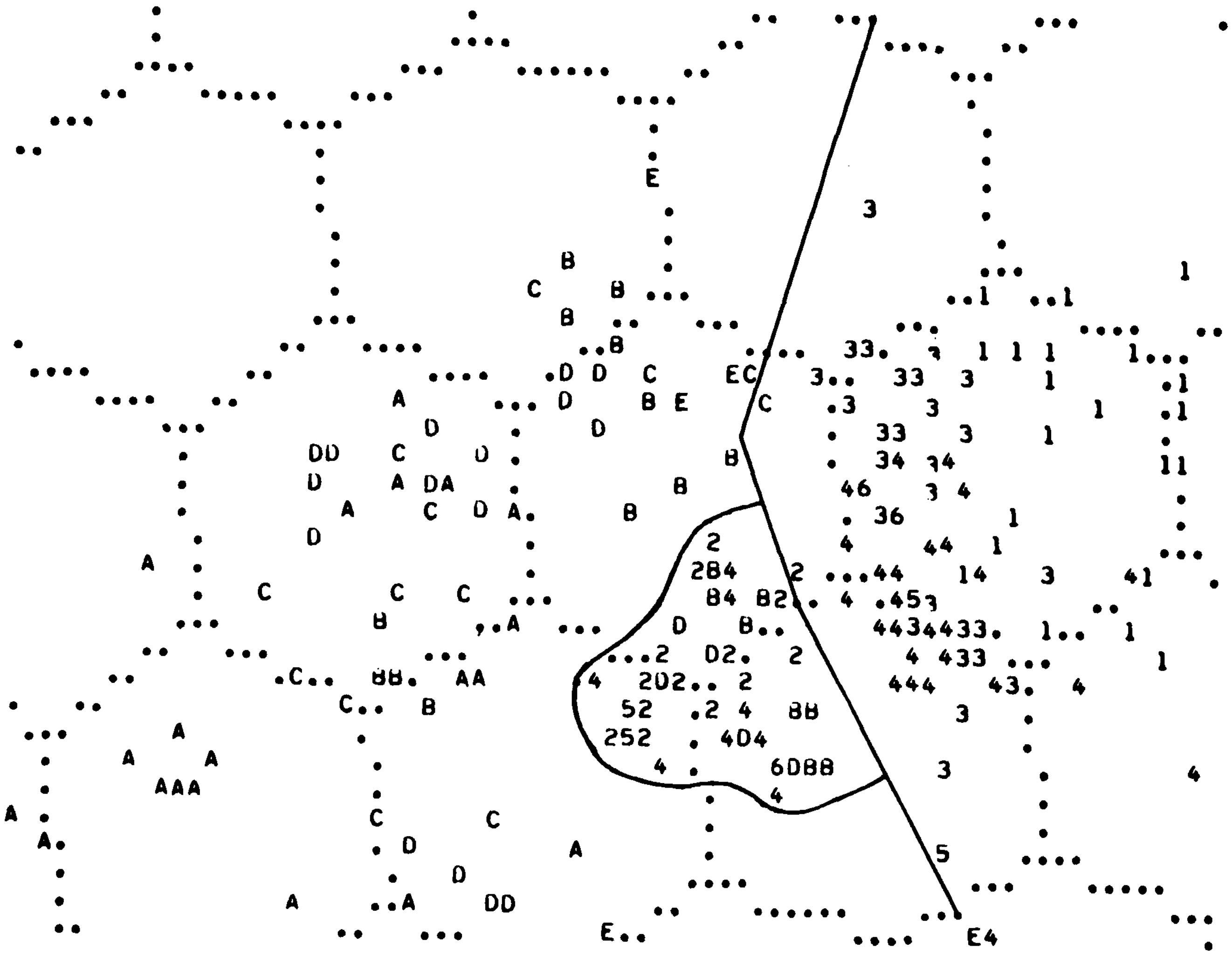

Figure L-17. Case IV-FP ground change at 02:30 hours.

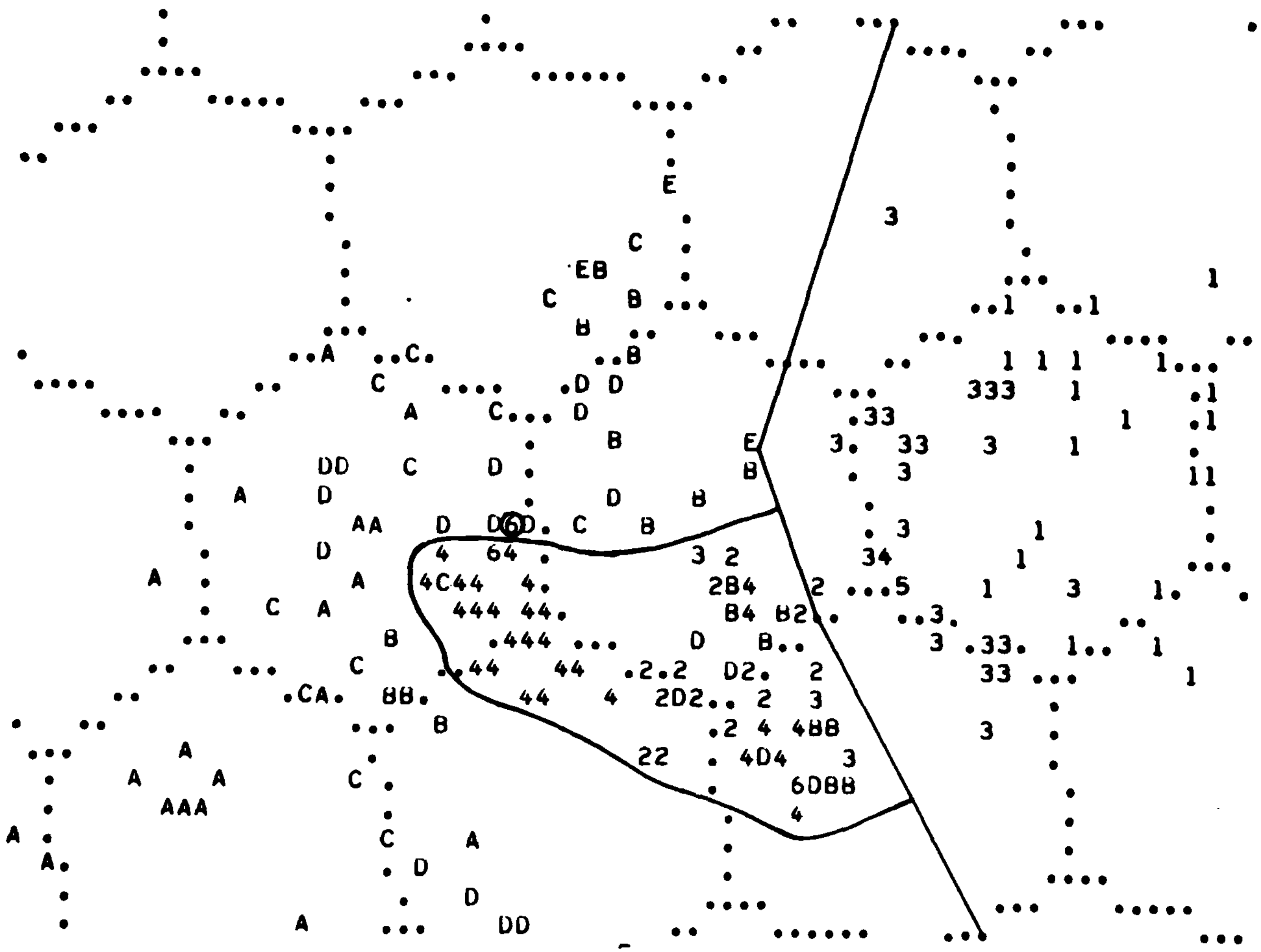

Figure L-18. Case IV-FP ground change at 05:30 hours.

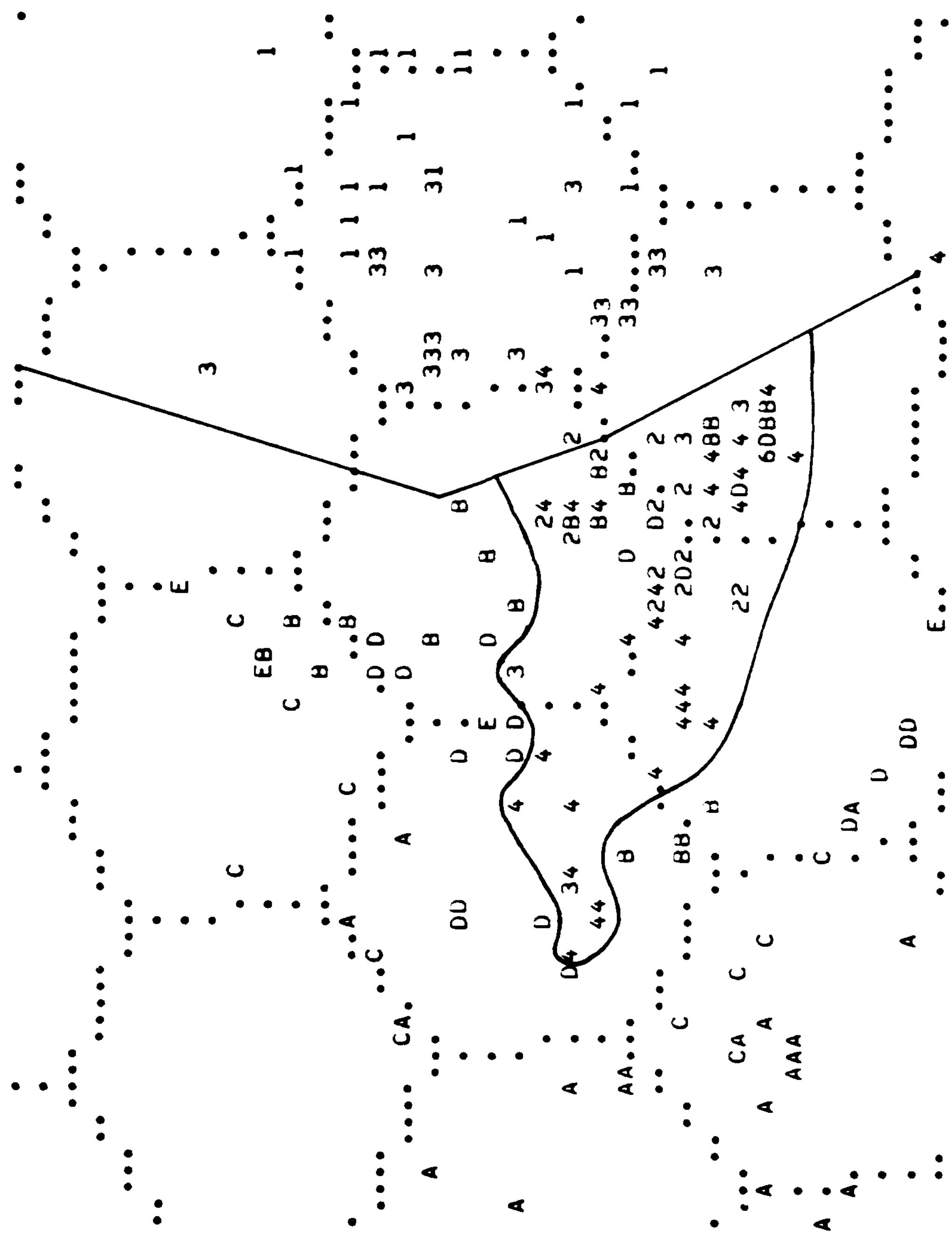

Figure L-19. Case IV-1P ground change at 08:30 hours.

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